WIK-Consult • Report

Study for ECTA

Wholesale pricing, NGA take-up and competition

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Executive Summary

1. Europe has formulated far reaching and ambitious targets for Next Generation Access in its Digital Agenda for Europe. A widely available and competitively fast and ultra-fast broadband access - as it is best provided over FTTH networks - is considered as a cornerstone to meet these ta rgets. Given the low coverage and penetration of fibre networks in Europe up to now, fostering fibre deployment requires large-scale infrastructure investments. In order to facilitate the deployment of NGA and to encourage market investment in open and competitive networks the Commission has adopted the NGA Recommendation to provide appropriate access remedies for an NGA environment.

2. Less attention has been given to the transition from copper to fibre access networks. What are the regulatory conditions that favour the transition and which conditions discourage it? In this study we will primarily focus on the impact of access charges on the switch from copper to fibre. We will show that not only the fibre access charges have an impact on the incentive to invest in fibre. It is also the copper access charge which has a major influence on the transition to fibre.

3. In this study we will deal with cost methodology issues for determining access charges. Special emphasis will be given to the challenge of regulatory costing and pricing in case of a declining demand as can be observed for the copper access network. We characterize current regulatory policy and practice as regards ULL pricing for copper and fibre. In addition to giving an European overview we also present several case studies on countries, which represent a certain uniqueness in their approach so that a comprehensive picture of regulatory policy is emerging. We calculate the relevant costs for copper and fibre networks and the cost drivers for a representative European country which we call "Euroland". The fibre cost model informs about profitable coverage and critical market shares for a viable business model. Network costs are derived for the investor and for competitors which base their business model on the unbundling approach. In a variety of sensitivities we show the impact of Brownfield assumptions for fibre deployment on costs, coverage and competition. Furthermore, we show the impact on costs and competition of different assumptions regarding the WACC and economic lifetimes of network assets. We present similar sensitivities for the copper access network. In addition we show the cost impact of a decreasing demand. In an innovative approach we then model the impact of wholesale prices on competition, investment and consumer welfare by means of a strategic competition model that we specifically developed for this purpose. It shows the results of the strategic interaction of market players for various performance variables. The study ends with regulatory policy conclusions.

Current pricing approaches in Europe

4. Most NRAs in the EU are still applying the Forward Looking – Long Run Incremental Cost (FL-LRIC) cost standard to determine the wholesale price for copper Local Loop Unbundling (LLU). FL-LRIC pricing has a long tradition as a pricing principle to provide economic efficiency for regulated services. FL-LRIC pricing has a lot of attractions for regulators: Prices on that basis reflect the competitive standard and consumers get the best deal. Incumbents get correct signals regarding investment decisions and competitors get the proper signals for their make-or-buy decision.

5. The prices for the monthly rental per fully Unbundled Local Loop (ULL) in the EU vary in the range of 6 to 16 Euro per month with an average of 8.55 €. These price differences are not (only) due to national differences in costs, e.g. the WACC. They reveal quite different applications of cost methodologies like cost standard, depreciation method, asset lifetime and averaging of costs as applied by NRAs.

6. Given that the market and demand is changing over time, some insight into regulatory policy is provided by the development of ULL prices over time. Three different patterns of price paths can be identified from a benchmark covering 13 European countries over the period from 2005 to 2011:

   (1) Some NRAs have set a price path with relative stable but slightly declining ULL wholesale prices. France, Germany and to some extent Portugal fall into this category. They have reduced prices by less than 10% over that period.

   (2) A second group of NRAs has set a more aggressive path of a steady price decline. Austria, The Netherlands, and Belgium belong to this category. ULL prices have been decreasing by 32% to 46% in these countries.

   (3) In a third group of countries, prices have been (sometimes strongly) decreasing in the first part of the period considered and have been increasing or are beginning to increase again in the last few years. Spain, Sweden, the UK and Italy fall into this category.

7. Some NRAs control ULL wholesale prices ex ante, others only ex post or set rate ceilings. The accounting lifetime of assets varies from 15 to 25 years for copper cables and from 30 to 45 years for ducts. The relevant WACCs for the access networks are in a range of 7% to 13%. The ULL charge usually (with a few exceptions) represents a national average of the loop costs despite the fact that costs vary significantly according to access density and competitors' demand for ULL is focused on the denser part of a country. Asset valuation is at current cost, historic cost or a combination of both. Even more important are the differences in the way in which current costs are calculated; there seems to be a lot of discretion for incumbents and/or NRAs in this respect. Some NRAs apply the current cost

valuation on all network elements as installed in the access network; other NRAs apply efficiency considerations and only take into account those network elements and assets which are needed to run the access network efficiently. Some NRAs base their cost calculation on bottom-up cost models, others on top-down models, a third group just relies on accounting information provided by the incumbent. Also the depreciation methods vary from straight line to economic depreciation where the latter is often made operational by a tilted annuity approach.

8. The vast majority of NRAs is not yet addressing the costing and pricing implications of decreasing demand for copper access lines properly. Some NRAs increased ULL prices in their latest decisions (like the UK and Spain) even though (and sometimes because) demand is decreasing. In Italy the NRA even switched from HCA pricing to CCA with a major price increase in a moment in time where this switch is most questionable. Some NRAs are beginning to identify and to address the issue that certain costing methodologies may lead to over-recovery of the relevant cost and therefore may distort competition between the incumbent and its competitors. Not all NRAs seem to apply systematic margin squeeze tests to check the appropriateness and consistency of wholesale and retail prices. In Austria the systematic application of a margin squeeze test has led to a retail minus rule as the effective calculation method to determine the adequate level of the wholesale price.

Pitfalls of applying LRIC and alternatives

9. Applying FL-LRIC to copper-based ULL at this time of competition from upgraded cable networks and substitution of copper by fibre becomes fraught with at least three potential difficulties:

   (1) FL-LRIC is conceptually based on an expanding market, where additional capacity is being installed. The market for copper-based access, however, is shrinking and leads to excess capacities. Competitive markets would lead to price reductions in that situation. FL-LRIC would, instead, signal increased costs and prices.

   (2) Access-related costs are increasing over time (e.g. copper, labour cost). This would signal c. p. higher ULL prices.

   (3) FL-LRIC is based on a replacement by the most modern technology. This is no longer copper access.

10. Copper access prices regulated at FL-LRIC will lead to inefficiencies and welfare losses in such a market environment. We would even argue that FL-LRIC is not defined in case of shrinking demand. Increased copper access charges would foster even further volume decline and would induce unnecessary over-capacities and allocative inefficiencies in copper networks. The competitive position of the

copper access network against cable and fibre networks would be artificially weakened and distorted.

11. The proper pricing principle and price level has to be derived from the more general opportunity cost-based pricing principle. This pricing principle finds the efficient pricing in a band which is determined by a lower and an upper limit. The upper limit is given by the conventional FL-LRIC as accurately determined before demand actually declined. The lower limit of the price band would be determined by the short-run incremental cost of operating the copper access network in case all the copper access network elements are sunk, network-specific and cannot be used for other purposes. If the price fell below that level, the incumbent would no longer run the network and close it down, because it no longer provides any contribution to profit. The exact point in the relevant range has to be determined based on demand and competitive conditions in the retail market. One implementation approach relies on the retail minus concept. It is however necessary to clearly define the upper boundary, since reliance on retail minus alone will deliver excessive retail and wholesale charges in the absence of effective competition. If LRIC has been correctly calculated in the past, the ceiling could be fixed at the level of the last calculated value – this would have the advantage of predictability and maintaining the status quo. If, however, LRIC for copper has not been correctly calculated such that copper access charges are excessive, the ceiling should be newly calculated on the basis of an appropriate LRIC approach using parameters relevant at the moment before volumes were declining.

12. Some NRAs determine the ULL price on a valuation of the network assets at historic costs. In case of Ofcom in the UK only parts of the access network assets are valued at historic cost. Historic cost pricing addresses the potential cost over-recovery problem better than FL-LRIC pricing and also takes better care of the actual depreciation of the assets. Historic cost pricing does, however, not meet any efficiency standard. It does, however, have the advantage that the resulting prices fall into the range of efficient opportunity cost-based prices as proposed here. This means that wholesale prices determined on the basis of historic cost only coincidentally will meet the efficient price point in the relevant price range.

13. In a situation of a shrinking copper access market incumbents face stronger incentives to engage in margin-squeeze activities: To be competitive in the retail market with cable, they tend to lower prices without changing the level of wholesale charges. NRAs usually impose a margin-squeeze test. When the margin squeeze condition is breached, wholesale access charges must be increased to remove margin squeezing. This in turn leads to higher retail prices and increases excess capacity even more. The more efficient approach is to set the wholesale price such that it is at a given level of retail prices margin-squeeze free. Depending on the retail price level this may lead to wholesale prices below the level of FL-LRIC. Lower access charges resulting from such a margin-squeeze adjustment would not

impose additional regulatory risk on incumbents. Rather, they would only reflect the market risk from declining demand for copper-based services.

14. We cannot recommend NRAs to distinguish between “bad” and “good” margin squeezes and to allow “good” margin squeezes. Bad margin squeezes have the intent of hurting rivals depending on wholesale access. Good margin squeezes are a response to outside competition from alternative technologies (such as cable). We do not see that the market power in the copper access market will be vanishing in situations of declining demand which is in our view a prerequisite for allowing good margin squeezes.

LRIC for fibre networks

15. Since fibre access is a growing market, cost-based pricing on the basis of the FL-LRIC principle is the correct approach for access to fibre networks. The fibre wholesale price should appropriately reflect the fibre-specific investment risk. The fibre-specific risk premium as part of the capital costs and as a mark-up on the risk of the copper access business has to be determined carefully. Even small deviations from the risk premium as applied for the legacy network today negatively impacts on retail prices, competition and consumer welfare. In case the incumbent's fibre deployment benefits from Brownfield savings due to usable assets of the legacy network, these savings should be properly reflected in the wholesale price; otherwise competition would be distorted to the detriment of users and competitors.

16. To determine the relevant cost of the fibre network we have used an engineering bottom-up modeling approach. We calculate the cost of a FTTH network following a Greenfield approach. This means that the investor will construct a new, efficient state of the art network from scratch, assuming that currently existing infrastructure, if included in the new network, has to be considered at (full) cost. We also calculate a Brownfield scenario where the incumbent can make use of available infrastructure from legacy networks to deploy the fibre network.

17. The NRA in The Netherlands has applied a discounted cash flow (DCF) method of determining the ULL charge for fibre where the wholesale price is derived from the business case of the investor. We have shown in this study that this approach is equivalent to calculating the FL-LRIC on the basis of a bottom-up cost model if economic depreciation is being used. The DCF method has the advantage that it explicitly takes care of the increased fibre penetration over time.

Our modeling approach

18. For purpose of this study we did not want to model a specific European country but chose settlement structures which are typical in European countries. We designed a hypothetical country for approximately 22 million households and business users or a population of around 40 million inhabitants. This country is referred to as "Euroland". We have defined 8 clusters (geotypes), each having typical structural access network parameters derived from detailed geo-modeling of access networks in several European countries on a nationwide basis. The geotypes characteristics rely on concrete data from several countries. In that sense, Euroland is a generically representative country. Because a fibre network is not viable in all clusters we focused the competition analysis on Cluster 1 to 4 of Euroland.

19. For competitors using wholesale access we have considered a fibre unbundling scenario for the P2P network architecture in which a competitor rents the unbundled fibre loop, places an additional Optical Distribution Frame of his own at rented collocation space in the MPoP where he operates his own Ethernet Switch. Wholesale prices for the competitor's business case have been determined as LRIC of the network elements of the incumbent which are used for wholesale access, i.e. they are directly based on the cost determined for the incumbent.

20. For the copper network we have chosen a different approach. To approximate the relevant LRIC we started from the European average of monthly LLU charges as a proxy for the incumbent's LRIC in Euroland. This value was broken down to cluster-specific monthly copper network costs by using relevant cost drivers; this way we were able to determine the production cost of the first four clusters only. However, the incumbent's decision to switch from a copper to a fibre network does not depend on the so determined LRIC replacement cost but on the cost of operating and maintaining the copper network. These short run incremental costs are approximated as 20% of the fixed cost defined by the LRIC determination above.

21. Our innovative approach towards market modeling combines our cost modeling results with a model of competition between copper and FTTH with multiple competitors ("entrants" who purchase wholesale access) in order to show aspects of the transition from copper to FTTH, in particular how the transition depends on

    - the regulated copper access charges for copper unbundling
    - the regulated FTTH access charges for fibre unbundling
    - whether there is a single integrated incumbent potentially offering both copper and FTTH or two separate network operators for the respective technology

    The objective is to generate and compare the (potential) coexistence and relative shares of copper and FTTH and to determine market equilibria with end-user prices, consumer and producer surplus (for both incumbent(s) and other firms) and ultimately welfare results.

22. Our modeling approach captures essential aspects of competition in FTTH or copper-based markets, both on the wholesale and retail side. In our main model one firm (the "incumbent") owns and invests in a copper and/or FTTH access network, to which other firms ("entrants") must obtain access in order to provide copper-based or NGA-based services. Entrants are assumed to be specialized in copper or fibre services and are otherwise symmetric. They need to make their own investments in order to provide retail services based on copper or NGA wholesale access products. In a second model the incumbent is restricted to a copper access network, while an independent fibre investor (which could be an alternative telecommunications operator or an energy company) may or may not invest in fibre, thereby potentially driving out the copper incumbent. In both models we consider a third vertically integrated broadband infrastructure ("cable"), to which no other firms have access.

Modeling results

23. In the case of an integrated incumbent the decision to switch to fibre is driven primarily by the access charge differences between copper and fibre relative to their respective costs. Obviously, the incumbent's profits are influenced by many factors (e.g. costs, market share, retail prices), wholesale access charges being only one of them. Our results, however, suggest that their influence can be substantial. The relative wholesale charges determine the profitability of one technology compared with another.

24. Our modeling results show that a (long-term) coexistence of copper and fibre networks is possible but unlikely and also undesirable. It takes the combination of very high copper and fibre access charges to make the joint provision more profitable than the most profitable single network investment alternative. Access charges have to be high enough to generate monopoly profits for both networks and to keep entrants virtually out. Such a coexistence scenario would then lead to high retail prices, low competition and low consumer surplus.

25. Once fibre is on the market, there is a strong rationale from the operator's as well as from the overall economic perspective for a forced migration strategy to fibre. Regulatory interventions and obligations which make migration more difficult or costly can therefore generate negative incentives to invest in fibre.

26. Considering all our model runs there are three relevant scenarios of wholesale access charge combinations that stick out when analyzing the incentive for fibre investment:

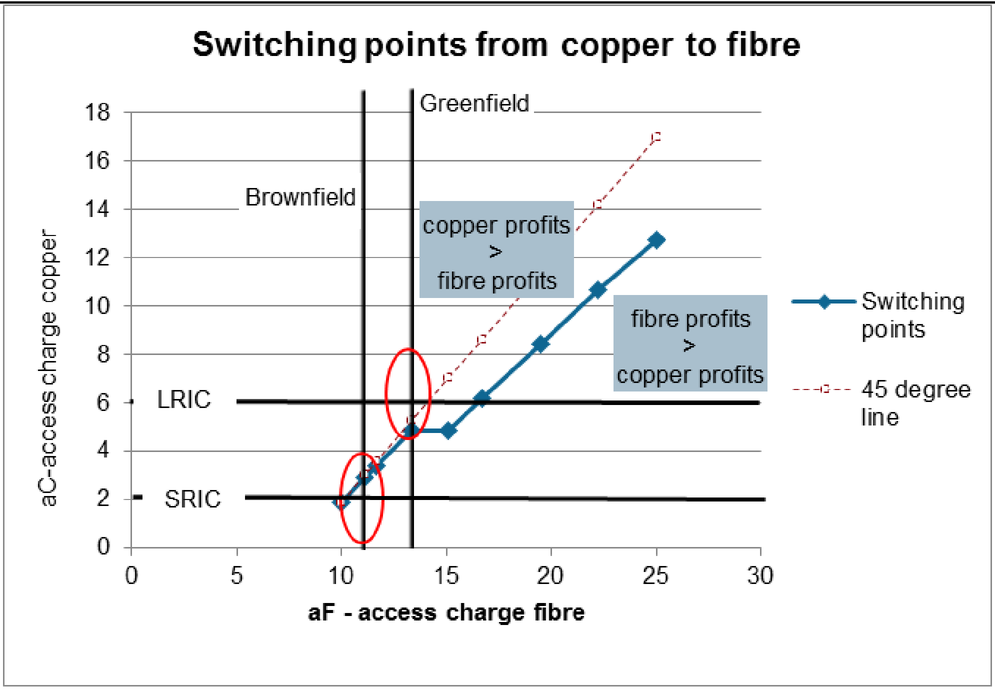
- At the current European national average copper access charge of aC = 8.55€ a fibre access charge of €19.49 (significantly above the cost-based rate) would be needed to induce investment in fibre. At these wholesale rates, fibre ARPUs would be approx €42 compared with copper rates of €29. Consumer welfare under copper would be 18% lower than in the consumer surplus maximising case. This scenario is unlikely to reach the Commission's Digital Agenda ultra-speed broadband targets.

- If fibre unbundling charges are set on a Brownfield LRIC basis of €11.65 per month as calculated through the Euroland model, the corresponding copper charge at which fibre would be more profitable than copper would be €3.42. In this scenario fibre ARPUs would be €36 compared with copper ARPUs of €21. Consumer welfare would be maximised.

- If Brownfield adjustments do not apply (for example if existing ducts cannot be re-used for fibre), then Greenfield LRIC for fibre would be €13.92 per month and copper prices would need to be set at €6.06 in order to stimulate fibre investment. In this scenario copper ARPUs would be €27 and fibre ARPUs €38.

The following figure demonstrates the switching points to fibre.

Figure 1: Access charge combinations, for which a switch from copper to fibre has occurred



27. An integrated incumbent will switch from copper to fibre, when copper profit is below the expected fibre profit. Since higher copper access charges increase profits from copper but leave fibre profits unaffected, high access charges for copper reduce the incentives for a switch. In particular, at today's nationally averaged copper access charge of 8.55 € there would be little incentive for the incumbent to invest in fibre. High levels of copper access charges generate negative incentives for incumbents to invest into fibre because of profit cannibalization.

28. Under a Brownfield LRIC scenario in which fibre access charges are €11.65 and copper prices are set at or below the switching point of €3.42, the market supports one "cable" operator with 28% market share, the fibre incumbent with 23% and 3 unbundling-based entrants with 16% market share each. With copper charges at today's average rate of €8.55, no fibre investment would occur, and the market would support one cable operator with a market share of 33%, and incumbent with 20% and 3 entrants with just over 15% market share each. Such a market structure does not exist in many markets today and reflects an assumption of perfect regulation with no possibility of margin squeeze or discrimination. In practice, incumbents in Europe maintain an average of 45% of retail market.

29. Our model results clearly demonstrate that a switch to fibre networks has the potential to increase welfare significantly, in particular if users recognize the potential of fibre and value services provided over fibre correspondingly relative to services provided over copper networks. The higher the valuation of fibre in terms of willingness to pay from users becomes, the lower the necessary difference of copper and fibre access charges in order to trigger a switch from copper to fibre.

30. An independent fibre investor requires special cost savings or other advantages in order to outcompete the copper incumbent (who has such advantages investing in fibre). On top of that such an investor may face the threat of the incumbent pre-empting its investment thereby rendering it unprofitable. Our model shows that only under rather high access charges would it be viable for an independent investor to install fibre alongside the existing copper network – the investment would be justified in this case on the basis that both the copper incumbent and fibre entrant would enjoy a monopoly on the respective technologies. The incumbent will only exit, leaving the access market to such an alternative investor, if both continuing copper and investing in fibre appear unprofitable for him. This appears unlikely in most cases.

31. Our results show that a switch from copper to fibre may be accompanied by a retail price increase of about 11- 16 € per month. This gap could be bridged by

- a differentiation of retail prices by product, allowing for "virtual copper" products to be delivered at much lower prices than the fibre average. This could be consistent with profit maximization and be feasible for the incumbent. However, unless equivalent wholesale options are available, it could be difficult for entrants. Such wholesale options could include

- two-part access tariffs that would facilitate differentiation by entrants. However, such tariffs may reduce the number of entrants and favor the competitive position of the incumbent.
- an offer of a low-price “virtual copper” access product on bitstream basis in addition to ULL. This requires an increase of the fibre ULL charge to compensate the incumbent and may lead to a delay of the switch to fibre. This option could be limited to a transitional period.

32. Our modeling favours an approach to avoid a rate shock, under which regulators signal that they plan to decrease copper prices through a glide-path to the relevant levels, but would allow rapid switch-off of copper if fibre is installed on fair terms and conditions with LRIC-based unbundling charges. In this scenario investment should be triggered and a potential rate shock would be limited to the gap between current ARPUs of approx €29 to the marginally higher fibre Brownfield ARPUs of €36 associated with LRIC fibre unbundling charges. Consumers would immediately benefit from higher capacities offered by fibre.

33. We have included cable as a player within our base case scenario. We assume that this technology offers capabilities which lie between copper and Point-to-Point fibre and that consumers’ willingness to pay for cable is determined accordingly. Whilst the retail prices for the market as a whole are strongly influenced by the underlying wholesale charges, the presence of cable adds an additional constraint in that higher copper (and/or fibre) charges will in the presence of cable, cause some customers to migrate away from the incumbent towards what is viewed as a superior (or cheaper) technology. Other things being equal, lower profits for copper and fibre will result from the presence of cable.

34. Competition in any network is advantageous not only for the economy but also for incumbents. Entrants help the incumbent of a particular technology because they take away customers from the other technology and because they buy access at wholesale charges that contribute to cover fixed network costs.

Introduction

Europe has formulated far reaching and ambitious targets for Next Generation Access in its Digital Agenda for Europe. The need for a widely available and competitively fast and ultra-fast broadband access as it is best provided over FTTH networks is regarded as a key to meet these targets. Given the low coverage and penetration of fibre networks in Europe up to now, fostering fibre deployment needs heavy investments to emerge. To foster the deployment of NGA and to encourage market investment in open and competitive networks the Commission has adopted the NGA Recommendation to provide appropriate access remedies for an NGA environment.

Less attention has been given to the transition from copper to fibre networks. What are the regulatory conditions which favour the transition and which are discouraging it? In this study we will primarily focus on the impact of access charges on the switch from copper to fibre. We will show that not only the fibre access charges have an impact on the incentive to invest in fibre. It is also the copper access charge which has a major influence on the transition to fibre.

It has been a long tradition in regulatory economics to derive the Forward Looking Long-Run Incremental Cost pricing principle as the one which best fits with established principles and objectives of regulation. Forward looking costs are the on-going costs of providing the relevant service in the future using the most efficient means possible and commercially available. This means in practice to base costs on the best in use technology and production operation and valuing inputs at current prices. Calculating forward looking costs also involves the cost providing the relevant services using modern equivalent assets (MEA). The LRIC costing and pricing methodology is assumed to provide efficient production, set the proper incentives to invest in new technology, enable the incumbent to compete against a new entrant who would set-up a new Greenfield network with the most efficient technology and set the proper incentives for the make-or-buy decision regarding the entrant's own network. Many (not all) European regulators apply the LRIC pricing principle based on current cost to calculate the wholesale price for the Unbundled Local Loop. Given the implied theoretical prerequisites of applying LRIC we will show in this study that none of the prerequisites for applying LRIC for a copper-based ULL holds anymore given the migration to NGA, to FTTH networks and generally to deploying fibre deeper into the network and closer to the end-user. There are indications that a further and simple orientation of ULL wholesale prices on current costs may cause inefficiencies. The efficient pricing of the copper ULL needs a new platform and new answers in the process of migrating the access network to a new technology.

This study is organized as follows: In Chapter 1 to 3 we will deal with cost methodology issues for determining access charges. Special emphasis will be given to the challenge of regulatory costing and pricing in case of a declining demand as can be observed for the copper access network. In Chapter 4 we characterize current regulatory policy and practice as regards ULL pricing for copper and fibre. Besides giving an European overview we present several case studies on countries, which each represent a certain unique approach so that a comprehensive picture of regulatory policy is emerging. In Chapter 5 cost modeling approaches for copper and fibre networks are being developed. We calculate the relevant costs and the cost drivers for a representative European country which we call "Euroland". The fibre cost model informs about profitable coverage and critical market shares for a viable business model. Network costs are derived for the investor and for competitors which base their business model on the unbundling approach. In a variety of sensitivities we show the impact of Brownfield assumptions for fibre deployment on costs, coverage and competition. Furthermore, we show the impact of different assumptions on the WACC and economic lifetimes of network assets on costs and competition. We present similar sensitivities for the copper access network. In addition we show the cost impact of a decreasing demand. In Chapter 6 we model the impact of wholesale prices on competition, investment and consumer welfare by means of an oligopoly model which we have developed for this purpose and which shows the results of the strategic interaction of market players. The task is to develop a model of competition between copper and FTTH with multiple competitors („entrants") in order to show aspects of the transition from copper to FTTH, in particular how the transition depends on

- the regulated copper access charges for copper unbundling,
- the regulated FTTH access charges for fibre unbundling, and
- whether there is a single integrated incumbent potentially offering both copper and FTTH or two separate network operators for the respective technology.

The objective is to generate and compare the (potential) coexistence and relative shares of copper and FTTH and to find in a market equilibrium end-user prices, consumer surplus and producer surplus (for both incumbent(s) and other firms), leading to welfare results.

The study concludes with some regulatory policy conclusions in Chapter 7.

1 The theoretical foundation of FL-LRIC pricing[1]

1.1 Characterization of FL-LRIC pricing

The provision that the wholesale bottleneck services are to be offered at a cost-oriented basis has been implemented under the so-called FL-LRIC (Forward-Looking Long-Run Average Incremental Costs)[2] standard within European Member States.[3] FL-LRIC as a long-run measure aims at the costs of efficient production of units where those variable and fixed costs are included which are essential for a group of services.[4] Consequently, outdated technologies and inefficiently incurred costs like redundant manpower are not reflected.

„Forward-Looking Long-Run" means that the time span of new investments is included in the cost consideration. It also means that all inputs are generally considered as variable. The long-run nature of costs is justified by the infrequency of regulatory price changes (FCC, 2008) and, at least implicitly, by the difficulty regulators face in determining correct short-run costs, both in cases when these are to reflect short-run bottlenecks (risk of exploitation) or temporary low demand (risk of margin squeeze).

In the forward-looking approach only the actual (forecasted) operating costs are considered, hence the equipment is assessed at the replacement value and over-capacities are usually not taken into account.[5] The costs also include a reasonable profit depending on the risk of the investment. In order to calculate the *average* incremental costs per minute (or per loop), the sum of the costs considered are divided by the (actual or forecasted) traffic minutes or loops. From an economic perspective, FL-LRIC results in wholesale access charges above short-run marginal cost (which are near zero for variations occurring between services within capacity constraints), since adequate fixed and common costs of production are also included. Overhead costs at the enterprise level are not considered as part of the LRIC of a particular service but a mark-up for them is usually added on the grounds that operators also need to recover overheads in order to continue staying in business.

In assessing FL-LRIC and potential alternatives we use the following criteria. First and second, the use of FL-LRIC for wholesale pricing should lead to competition and lead to efficient market entry. Third and closely related is static efficiency with particular emphasis on low/affordable end-user charges and adequate quality of service. Fourth, wholesale pricing should provide efficient investment incentives for incumbents and

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1 This and the following two sections draw, in part, on Vogelsang (2009), Briglauer and Vogelsang (2011), and Neu and Kulenkampff (2009).
2 The abbreviation FL-LRAIC would be correct but we use the more familiar FL-LRIC here.
3 See Cullen International (2007); the methodologies mandated by European regulators differ somewhat with respect to cost bases and cost standards.
4 See IRG (2000).
5 See Evans/Guthrie (2005) for the inclusion of optimally planned excess capacity under the heading of “optimized deprival value”. Mandy/Sharkey (2003) calculate the effect of lumpiness on FL-LRIC.

entrants. This aspect includes reliability for investment planning. Dynamic efficiency is also largely included in the investment objective. Fifth, the concept has to be implementable in practice at reasonably low transaction costs. This criterion we will not address separately but rather where appropriate. Last, however, FL-LRIC as a cost standard breaks down, if demand for the bottleneck service for which it is to be applied steadily and structurally decreases so that overcapacities develop. In this case no new and replacement investments take place so that the current prices of the resources used to construct the bottleneck facilities lose their function as a normative yardstick.

1.2 FL-LRIC and the competitive standard

It is well-known that, in a perfectly competitive market, prices equal short-run marginal costs and, in the long-run, equal long-run average costs and long-run marginal costs. These conditions are not always feasible in markets with extensive economies of scale and scope. Nevertheless, achieving the next best to the perfectly competitive standard would be desirable. Markets characterized by scale and scope economies would yield long-run competitive prices between long-run incremental costs and long-run stand-alone costs (SAC).[6] FL-LRIC always fulfil this condition and in growing markets are therefore always compatible with this competitive standard. FL-LRIC will therefore allow as many entrants in the market as are warranted by economies of scale downstream in retail markets.

At the same time competitive pricing usually requires the flexibility to adapt prices to changing cost and demand conditions. Competitive market prices follow short-run (marginal) costs, particularly in capital-intensive industries. Prices at FL-LRIC will not usually reflect such short-run considerations. The long-term averaging implied by regulated wholesale charges lacks this flexibility.[7] This will lead to some allocative distortions by missing out on market opportunities (e.g., for higher capacity utilization in times of temporarily low demand). It will then lead to inter-modal distortions in competition. It may be no consolation for a competitor (or the incumbent) that FL-LRIC wholesale charges are correct on average if the current market conditions would warrant much lower (or higher) prices. This, however, is a problem of regulated prices that is thought to be more than compensated by the avoidance of strategic price setting through regulation. We will address these issues in the following section. As we will see, such fluctuating market conditions are major reasons why wholesale charges at FL-LRIC can be associated with margin squeeze, because incumbents would like to sell at low prices in weak markets. It can in principle be addressed through certain types of price caps.[8]

6 Stand-alone costs are the costs incurred by a firm producing only the single service in question (therefore not benefiting from economies of scope/synergies if any).
7 A similar tension regarding averaging also holds for geographic cost averaging.
8 See, for example, those suggested by Hogan, Rosellon and Vogelsang (2010) for electricity transmission.

A particularly relevant aspect of wholesale access pricing is competitive neutrality between alternative technologies for the same or related (competing) services. If both services are expanding, competitive neutrality is usually achievable if both technologies have comparable bottlenecks that are provided at FL-LRIC prices. If one service has such bottlenecks while the other does not competitive neutrality may not be assured, due to the superior flexibility of the service without bottlenecks to respond to market opportunities. This inflexibility of FL-LRIC therefore becomes more problematic under a certain degree of inter-modal competition if the other mode (e.g., CATV) is not subject to the same kind of wholesale regulation. Since also deregulating the bottleneck is not the option, some flexibility in setting access charges might thus after all appear appropriate even when applying the FL-LRIC cost standard.

Overall, purchasing access at FL-LRIC, the other competitors should be able to compete in the downstream markets, especially after any margin squeezes have been eliminated by regulatory intervention.

1.3 FL-LRIC and entry

Since market entry requires a long-run perspective and since entrants have to expect covering their costs, FL-LRIC will provide the lowest price, under which an entrant would enter an expanding market. The corresponding upper limit under competition would be SAC, under which entry would be possible for single-product firms only offering the bottleneck. SAC include all common costs that would be incurred by a multi-product firm. FL-LRIC, as calculated in practice, include some common costs and therefore lie in between theoretically pure FL-LRIC and SAC. In expanding or at least not declining markets, wholesale charges at FL-LRIC levels therefore give entrants competitive opportunities that resemble those of the incumbent. This will lead to efficient entry and efficient competition for end-users. As a result, investments downstream of the bottleneck will also be correctly incentivized for both incumbents and entrants.

The efficiency condition that wholesale access charges induce enough competition downstream cannot always be fulfilled because there may exist downstream economies of scale that severely limit the number of entrants. This can hold, for example, in rural markets. In this case, it is not only the wholesale access charge that matters but also the scope of the access product, which may have to be adjusted to assure enough downstream competition (like ULL vs. bitstream).

1.4 FL-LRIC and static efficiency

FL-LRIC are reasonable average prices, but usually overestimate short-run marginal costs relevant for static efficiency. However, provided FL-LRIC wholesale prices are able to induce sufficient competition by wholesale access seekers and other entrants (such as Cable TV) end-users will enjoy low prices and desirable qualities. In that case the level of wholesale charges will assure that the incumbent is charging adequately at the wholesale level and the competition will assure that downstream mark-ups are competitive. Ideally in this case consumer surplus will be close to the maximum without the incumbent or entrants incurring losses. It only comes close to the maximum because FL-LRIC access charges typically use mark-ups for fixed and common costs that are not differentiated by demand elasticities for the services. This is in contrast to Ramsey access prices which would allow for mark-ups reflecting such demand elasticities. Ramsey prices are, however, hardly used by regulators for a number of difficulties and will therefore not be considered here any further.[9]

1.5 FL-LRIC and incentives to invest

FL-LRIC will generally cover all costs that are expected over the lifetime of the assets and add mark-ups for common costs. Wholesale charges at FL-LRIC levels will therefore provide correct expansion and replacement investment incentives for bottleneck assets of the incumbent. Higher than cost-covering charges would lead to less investment because of the reduction in downstream demand associated with higher downstream prices that especially competitors would have to charge. Lower charges would lead to lower investments on the part of the bottleneck provider because of insufficient cost coverage. Under cost and/or demand uncertainty a buffer may be necessary to cover for estimation risks. It is usually assumed that investment risks of the incumbent are correctly covered in the WACC used for the FL-LRIC calculation..[10]

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9 The idea of Ramsey access pricing is to allow the regulated firm to recover fixed and common costs in such a way that overall welfare is maximized. In doing this, regulators would have to determine simultaneously optimal mark-ups for access and retail prices. In their construction, Ramsey prices refer to both cost and demand characteristics by which informational requirements become very high; regulators not only have to be informed about cost conditions but they are also supposed to estimate interrelated demand (super-) elasticities. Since regulators generally fail to calculate Ramsey prices directly, price-cap mechanisms – which delegate the pricing decision to the typically much better informed firm – have been initially developed to solve the Ramsey pricing problem. However, if price caps are targeted only towards specific wholesale access products, the regulated firm loses the flexibility to rebalance all its prices according to the required Ramsey mark-ups. This is, in part, why Laffont and Tirole (1996) suggest that a single ("global") price-cap should be applied to both wholesale and retail products, arguing that an incumbent maximizes profits with respect to all products. Global price caps would induce Ramsey prices if weights attached in the basket construction (ex ante) were exactly proportional to realized quantities of the services involved. Here realized quantities refer to the ex post profit-maximizing prices under the price-cap constraint. But deriving optimal weights of the global price-cap basket would become tantamount to solving the Ramsey problem. Furthermore, global price caps would combine markets with highly different competition intensities (e.g. access and calls markets) which might give rise to anticompetitive strategies on the part of the regulated firm as well as inefficient entry. It will also distort prices away from true Ramsey mark-ups. Since global price caps are incompatible with the European telecommunications framework's selective deregulation of telecommunications markets and since Ramsey prices are too hard for regulators to determine, the goal of setting regulated Ramsey prices is an unachievable standard. The distortion created by not achieving Ramsey prices is small if common costs are only a small fraction of total costs but could become substantial if most costs are common.

10 We are here only assessing the appropriate level of a regulated wholesale access charge that is levied on a wholesale access service on a pay-as-you-go basis. Alternative access arrangement, such

With the same risk proviso FL-LRIC also provide the correct incentives for bottleneck bypass investments of those alternative competitors that depend on bottleneck access. If wholesale charges are too high alternative competitors will invest in bypass even if their costs are higher than those of the incumbent. If wholesale charges are too low they will not invest in bypass even if their costs are lower than those of the incumbent.[11] But those desirable properties of FL-LRIC hinge on the assumption that regulated markets are expanding.

Alternative intermodal competitors (such CATV and FTTH), who are not dependent on bottleneck access, benefit from higher wholesale access charges imposed on access seekers because of less competition from entrants and/or because the incumbent must keep end-user charges high in order to avoid margin-squeeze allegations. Again, wholesale charges at FL-LRIC in principle provide competitive neutrality for intermodal carriers. The same holds for downstream investments of alternative competitors depending on bottleneck access. These competitors would invest too little downstream (i.e., in concentration and core networks) if bottleneck access charges were too high and would invest too much downstream if those charges were too low.

1.6 Conclusion

To conclude, FL-LRIC has proved to be quite valuable in setting regulated prices, in particular prices for wholesale services in markets under expansion. Conceptually, it is the cost standard on which, at least on average, prices are based that would obtain under effective competition. Prices set this way provide entrants with the necessary information in respect of buy-or-make decisions and at the same time provide incumbents with correct signals regarding their investment decisions. They assure (if properly applied) entrants the opportunity to take advantage of the business prospects offered by growing retail markets on essentially an equal footing with the incumbent. In the final analysis, they are one of the cornerstones assuring that consumers will get the best deal.

as investment sharing may or may not provide better investment incentives. See, for example, Nitsche and Wiethaus (2010).

11 See, however, Sappington (2006), who shows that the efficient make-or-buy decision can be quite independent of the level of access charges. In contrast, Mandy (2009) limits the generality of this view and states “The necessary condition shows that input prices are relevant for Make-or-Buy decisions except under restrictive and often unverifiable assumptions on the demand structure…”.

2 The pitfalls of applying FL-LRIC to copper-based ULL at this time

Applying FL-LRIC to copper-based ULL at this time of declining volumes due to substitution of copper by fibre and upgraded cable is made inappropriate by at least three developments. The first one is that the use of FL-LRIC is conceptually based on an expanding market, where additional capacity is being installed. The market for copper-based access, however, is shrinking and appears to continue to shrink, due to substitution from cable TV and, more recently, fibre. Since a large portion of the copper-related costs are sunk and therefore overcapacities develop, true forward-looking costs will therefore be much lower than FL-LRIC as traditionally calculated by NRAs. Some cost calculation approaches applied by NRAs signal increasing (unit) costs in case of decreasing demand. The second one, relevant if FL-LRIC are then still being used, is that increasing input costs (in particular copper) would lead to increasing charges for access. As a result, incumbents offering wholesale access under such charges would be over-recovering their investments, which have largely been incurred in the past at lower costs. Third, the notion of FL-LRIC is based on a replacement by the most modern technology. Copper access, however, does not appear to be the most modern access technology anymore. One can therefore argue that FL-LRIC should be calculated for a modern equivalent asset (MEA) rather than for copper. While one could think that fibre might fulfil this function this would throw up insurmountable information requirements as to how to establish the equivalence between a fibre and a copper cable.

2.1 Decreasing demand

2.1.1 Competitive standard

Decreasing end-user demand leads to excess capacities. In competitive markets this would lead to price reductions which should not only hold at the retail level but also at the wholesale level, because wholesale demand is a derived demand. Also in this stage of the market an operator in a competitive environment would wish to take advantage of wholesale demand to defend its position against competing technologies. But if FL-LRIC were still applied this would, as argued below, lead to price increases because of the smaller quantity base over which then fixed costs would have to be spread. Thus entrants that for their offerings have to rely on regulated wholesale prices would not be able to compete on terms that correspond to market conditions. In contrast, incumbents can respond to the pressure by reducing their retail prices so that relative to FL-LRIC margin squeezes result. If then there is no corrective action on the part of the regulator, FL-LRIC would prevent competitive results from being achieved.

2.1.2 Static efficiency

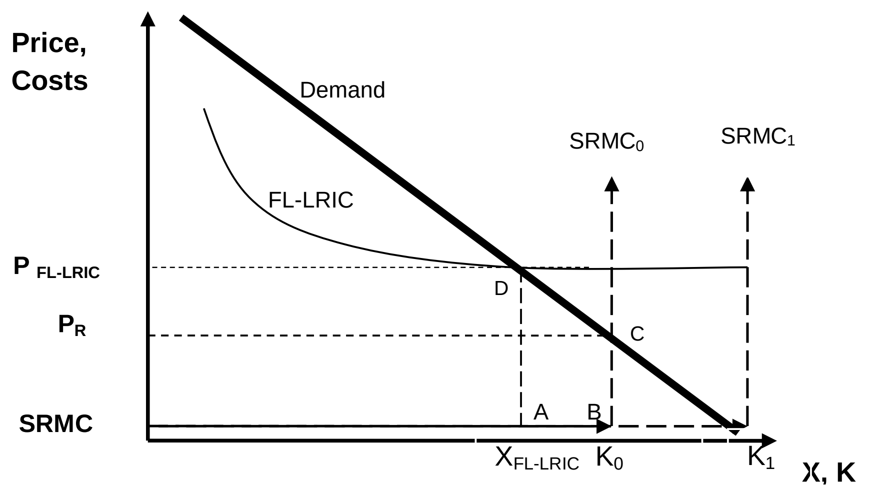
Given that FL-LRIC are based on average costs and that economies of scale prevail, a long-term or permanent reduction in demand would conceptually lead to an increase in wholesale access charges when the regulator takes into account this average volume decline. Such access charge increases based on declining volumes have already occurred in Germany and Austria.[12][13] The resulting feed-back mechanism would foster even further future volume decline, not least because the freedom for competitive price decreases on the retail level is typically also limited on the part of the regulated (incumbent) firm. In order to protect intra-modal competition, NRAs sometimes apply a margin-squeeze test, according to which prices (P) must satisfy $P_{Retail} \geq P_{FL\text{-}LRIC}$ + *retail costs and other wholesale costs*. When the margin-squeeze condition is binding and if such a margin-squeeze test was effectively applied, higher wholesale access charges would lead to higher retail prices, increasing excess capacity. Otherwise, a margin squeeze would result.

Figure 2-1 shows the extent of allocative inefficiencies (area ABCD) when cost-based access charges ($P_{FL\text{-}LRIC}$) are to be maintained with excess capacities ($K_0 > X_{FL\text{-}LRIC}$). As Figure 2-1 indicates, there might be a positive rationing price $P_r < P_{FL\text{-}LRIC}$ where existing capacity (K_0) is fully employed. But in fixed-networks one might also end up in a situation with capacity exceeding demand at any positive rationing price ($K_1 > Demand(P_r = 0)$). Allocative inefficiencies thus increase with the amount of excess capacity. In a situation where there was fierce inter-modal competition retail prices would be driven down to short-run marginal costs (*SRMC*), which is, as mentioned above, usually prevented by some form of ex ante regulation / margin-squeeze tests. But even at these prices, as just mentioned, excess capacity may prevail. Incumbents can respond to this downward pressure on retail prices because of the typically high share of sunk investments in network industries such as communications. Given the long-run market demand decline, sunk costs have then become irrelevant for pricing decisions, both from the point of view of fixed-network operators and that of efficiency considerations.

12 Final decision of the German regulator is available at: http://www.bundesnetzagentur.de/enid/BK3c-_8-ss37/BK3c-_8-ss37_E_56f.html. For the recent decision of the Austrian regulator see: http://www.rtr.at/de/tk/Z_9_07_100.

13 In the decision mentioned above RTR increased the local termination charge by 37%, the single tandem termination charge by 23% and reduced the double tandem termination charge by 4%. These rate changes go together with a decline of fixed network minutes by 7% in 2008 and by 35% in 2009 (see RTR Telekom Monitor 1/2011).

Figure 2-1: Welfare loss under excess capacity when access is regulated at FL-LRIC



2.1.3 Incentives to invest

Generally, there is little need for investment under decreasing demand. While FL-LRIC wholesale access charges may, under decreasing demand, provide enough contributions to enable an incumbent to make bottleneck investments, they would, by driving up prices, increase the problem of excess capacity and therefore would tend to lead to too little investment in replacement and maintenance. While the incumbent could channel the liquidity generated into investments for alternative technologies, this raises the question whether this would be in line with efficiency and competition given that the incumbent would effectively be able to leverage this advantage into these technologies undermining the potential for fair competition and foreclose the chances for competitors to invest in these alternative technologies.

2.2 Entry and exit

If demand for copper-based access lines is decreasing and NRAs still apply their previous method of calculating the wholesale prices according to FL-LRIC at current costs, wholesale prices will not decline but probably increase due to reduced volumes and increasing input prices. In such a case the margins of competitors will decline up to the point where they become negative. Without regulatory intervention entrants face a loss due to a margin squeeze situation. Entry and competition will be discouraged.

More concretely, in a situation of long-term decreasing demand there is little incentive for new firms to enter. This would per se be true for new firms that would erect new networks, but it would probably also hold for new firms that use, for example, the copper ULL as an input. The situation should in particular arise if a new market is emerging that is replacing the shrinking one. On the other hand, however, it is questionable whether exit of existing firms should be induced. Such exit is nevertheless likely if wholesale access charges continue to be based on FL-LRIC so that alternative providers cannot adjust their retail prices downwards (or even force them to increase their retail prices) in response to declining demand.

In an environment of shrinking demand, normal notions regarding the effects of the scale of output on cost become meaningless. This is due to the presence of sunk costs which are no longer decision relevant. For existing firms, previously relevant economies of scale for given outputs lose importance. This raises the question regarding the appropriate prices for the inputs for alternative providers since there is no a priori or efficiency reason for their exit. It is unambiguous, however, that diseconomies of scale and average costs faced by new firms entering with new assets would increase so that new entry would make little or no sense. Competitors already in the market may face the situation of becoming unprofitable and having to leave the market.

2.3 Cost recovery

A standard argument by incumbents has, until recently, been that FL-LRIC wholesale prices do not allow them full cost recovery because network costs are declining over time so that FL-LRIC because of the forward-looking nature do not allow the incumbents to recover the higher costs they incurred in the past.[14] Today the most relevant bottlenecks are ULLs, for which it is rather the case that costs are increasing due to economies of scale and increasing input prices (e.g. copper) so that forward-looking costs would be higher than the costs incurred by incumbents in the past. This would hold to the extreme if the network is not expanded or replaced at all so that high FL-LRIC were applied to investments that all were made in the past. In addition to being an efficiency issue, it is primarily one of equity between incumbents and entrants.[15] Given the long lives of the copper access network and given that pricing in the past has only relatively lately started to be determined according to appropriate cost standards, this could mean that the incumbent has already been fully compensated or even been overcompensated for the actually incurred cost. This would come in addition to the fact that entrants would overpay for access to a network that is not being expanded and was acquired at the lower costs in the past.

Equity or fairness has always been viewed as a legitimate issue in regulatory practice. However, from a perspective of economic analysis one should pursue equity objectives

14 This argument actually is based on an application of FL-LRIC where not all forward-looking information normally available is taken into consideration. See Neu and Kulenkampff (2009) for a demonstration of how both expected future price and growth developments can appropriately be rolled into the FL-LRIC calculations.

15 See, however, Guthrie et al. (2006).

with policies that are also associated with superior efficiency. In case of copper ULL and fibre ULL this seems to be the case. Copper ULL has the problems discussed in Section 2.2 above so that a forward-looking approach should not include sunk costs from an efficiency perspective. From an equity perspective, incumbents have until now benefitted from higher access charges compared to lower actually incurred costs in the past. Fibre LLU is largely new so that all costs would be due to new construction. To the extent that existing ducts etc. are used an opportunity cost approach may be warranted (see our argument in Section 3.2).

2.4 MEA and fibre technology

The modern equivalent asset (MEA) approach would imply that one determine the cost of that part of an equivalent technology that equivalently replaces copper. This approach is conceptually feasible but very hard to make operational, because it would require translating differences in QoS and capacity into cost equivalents. The difficulties would already start in identifying an appropriate bandwidth for a copper line. Do we start at the MDF location and allocate an ADSL 2+ bandwidth equivalent? It is unclear how large this would be, since the bandwidth transferable depends on the copper line length. The bandwidth equivalent of the sub-loop from the street cabinet to the customer premise may be determined by VDSL2, but which concrete standard shall be taken? VDSL bandwidth also depends on the copper line length. Is a mixture of ADSL2+ and VDSL2 the proper MEA concept in this case?

Even if such information is available and the FL-LRIC for fibre is properly determined, there remains the question of consumer valuation of any equivalent capacity if it is provided over copper compared with the case where it would be provided over fibre. In sum, the MEA value of the copper network is relatively low given the potential capacity differences between copper and fibre. A calculation approach in detail, however, can only be materialized with arbitrary assumptions.

2.5 Conclusions on the deficiencies of FL-LRIC pricing

Relying on the FL-LRIC standard alone would induce unnecessary over-capacities and allocative inefficiencies in copper networks. Furthermore, such an approach is likely to lead either to margin squeeze and the exit of competition or distortions between different technologies. To avoid such a “vicious circle“ one has to look for more suitable forms of access regulation which allow for a lowering of wholesale charges and increased pricing flexibility at the retail level.

3 Alternatives to FL-LRIC pricing

3.1 Pricing according to historic costs

Historic costs of assets equal their original purchase price minus accumulated accounting depreciation. Using historical costs as the relevant asset base avoids over-recovery or under-recovery of “actual” costs and thereby balances the interest of access provider and access seeker. It has, however, two drawbacks. The first is that the relationship between historic costs and the value relevant for suitable wholesale access pricing is purely coincidental and varies from jurisdiction to jurisdiction and from carrier to carrier, due to different asset age structures and depreciation methods. The second is that decisions about investment, shrinking and abandonment of copper networks must be forward looking. Historic costs do not inform about the future. As mentioned earlier their main value is in their equity properties.

This comes out clearly in Frontier (2010) who suggest that historic costs should be used as the asset base and that the gross historic costs should at the relevant point in time be adjusted by the compensation received by the incumbent against those assets (where it is not clear whether this compensation refers to actual and imputed wholesale charges only or also to retail charges) (p.21). Thus, the idea is to generate cost coverage for the access provider largely independent of efficiency aspects.

If one uses a historic cost base for equity reasons efficiency aspects (among others) are going to suffer or one needs additional instruments besides access charges for serving the goals besides equity.[16]

3.2 Opportunity cost-based pricing

Opportunity costs differ essentially from FL-LRIC in that the yardstick for the cost of the service is not anymore the cost of the resources with which the service could currently be produced, but exclusively the valuation by demanders of the types and volumes of services that could be produced by the existing capacity.

To make this point more precise, consider that a competitor would be willing to pay for the existing copper infrastructure. The hypothetical scenario for this case could be that of a switched local and long-distance network that intends to add an access network, believing that it can serve the market even with a copper network. In this case the increment would be the whole access network, and the price that the competitor is willing to pay would represent its opportunity cost. A proviso would be that this price

16 One way of doing that is the use of two-part access tariffs, in which the fixed fee reflects the equity aspects and the variable or marginal price competitive and other aspects. This can be a suitable approach to the extent that the fixed fee remains competitively neutral (does not affect entry or exit of competitors).

would not reflect prices at the retail level that the competitor expects to be able to charge that include monopoly rents from selling to customers with high switching costs.

In the absence of additional costs for giving up a service (such as social costs of laying-off personnel or of tearing down lines or buildings) the floor of opportunity costs is given by the short-run marginal costs (or short-run avoidable costs), because below those costs the service would be abandoned. These short-run costs include the rental value of assets that could be sold in a (second-hand) market, such as real estate. A ceiling for opportunity costs would be given by conventional FL-LRIC because at that price a competitor would be induced to build the infrastructure herself (although, in the short term or medium term the ceiling could be higher).

In case of long-term declining demand we can expect that the opportunity cost floor will be relevant. When that happens the access provider may end up receiving nothing for the use of her existing assets. This may be viewed as inequitable and may deprive the incumbent of her ability to finance new services, such as fibre. It may therefore be appropriate to consider a wholesale access price that exceeds opportunity costs in order to provide liquidity for risky investments. The adequate or efficient mark-up on the price floor is, however, hard to determine. The competitive model developed for this report serves as a tool for such a determination based on performance criteria, such as the effect of alternative wholesale access charges on consumer surplus and welfare.

In competition with fibre the relevant cost base for copper may well be short-run avoidable costs as the lower limit, while for fibre, as already pointed out, it would be FL-LRIC. The reason is that copper should only be definitely abandoned if it can no longer earn its short-run avoidable costs while investment in fibre should only definitely occur if it earns its full investment costs. Exceptions from this rule (hence the “definitely”) can occur when part of the copper network can be used to build fibre access or when the build-out of fibre leads to increased value of fibre (because of learning and network effects).

There is one particular implication if ducts as an important part of the copper network can be used to build the fibre access network and these are in oversupply due to the fact that fibre needs less than the capacity being released by the decline in the copper network. If this oversupply is not of a temporary nature and expected to exist in future, the argument developed above for the whole copper network would also apply to ducts as a component of the fibre network. Also in this case one could ask in a thought experiment what fibre network providers would be willing to pay for the part of ducts that they could use to roll out their fibre networks. Practically, it would be very difficult to get this answered non-strategically. Again, in competition the relevant cost base for these ducts may well be short-run avoidable costs.

To conclude the discussion on opportunity cost-based pricing, the notion is also fairly well known from the debate about the efficient component pricing rule (ECPR).[17] According to this rule the relevant costs of wholesale access include the marginal (or incremental) costs of producing it plus the downstream margin that the access provider foregoes by not selling the resulting service herself in the downstream market. The problem with this notion of opportunity costs is that the access provider might set a price downstream that reflects market power so that the ECPR may include monopoly rents. A proper definition of economic opportunity costs therefore would only allow for the inclusion of a competitive downstream margin and therefore be based on competitive retail prices. This would require something like a “hypothetical competition test”. If done correctly the test should lead to opportunity costs that are consistent with those that one would obtain in the hypothetical scenario discussed earlier in which a competitor bids in an auction for the whole copper access network.

3.3 Pricing and margin squeeze

We have already alluded to the margin squeeze issue, which has gained importance by decreasing demand for copper-based services. What relevance has this test in the context of determining the cost of the ULL in the presence of declining demand? The test may actually serve as an alternative for the relevant cost standard for the ULL, given that in this case FL-LRIC is not applicable any more. The proviso would be that observed retail prices are reflective of a competitive situation and that the competitive margin for selling at the retail level is known. What would then perhaps be called a "margin test" would determine what the relevant cost of wholesale access should be. The approach is conceptually similar to the ECPR discussed above in the context of the opportunity cost concept. There we argued that the definition of economic opportunity costs would only allow for the inclusion of a competitive downstream margin and therefore be based on competitive retail prices.

There have been some recent contributions in the literature that eventually lead to the same result as just derived. Some authors (Nitsche and Wiethaus, 2010 and forthcoming; Briglauer, Götz and Schwarz, 2010) have argued that regulators or competition authorities should distinguish between bad and good (efficient) margin squeezes. The bad margin squeezes have the intent of hurting rivals depending on wholesale access, while the good margin squeezes are a response to outside competition from alternative technologies that do not depend on the wholesale access. Presumably, “good” margin squeezes would not violate competition policy principles. This conclusion would be easy to follow if market power of the access provider actually had vanished in this situation. That is, however, rarely the case in situations of declining demand. On the contrary, many customers remain stuck with the old technology and

17 See, for example, Vogelsang (2003) for an overview of the debate.

therefore at the mercy of the copper provider(s).[18] Vogelsang (2009) and Briglauer and Vogelsang (2011) have therefore suggested a regulatory response that would eliminate the “good” margin squeezes as well. It is that an incumbent, who wants to lower retail prices in such a way that at ruling wholesale prices a margin squeeze would occur, would have to reduce its wholesale price until the margin squeeze vanishes. Provided prices at the retail level are determined competitively, the resulting wholesale price would correspond to the valuation placed by users on this input or, in other words, correspond to its opportunity cost. At the same time there is pricing flexibility for the incumbent at the retail level.

3.4 Opta's discounted cash flow approach

The Netherlands’ NRA Opta applies a price-cap approach to regulate the price of NGA access for which the starting price has been determined on the basis of a discounted cash flow (DCF) model based on the business case of the investor.[19] We will focus here exclusively on the DCF approach.

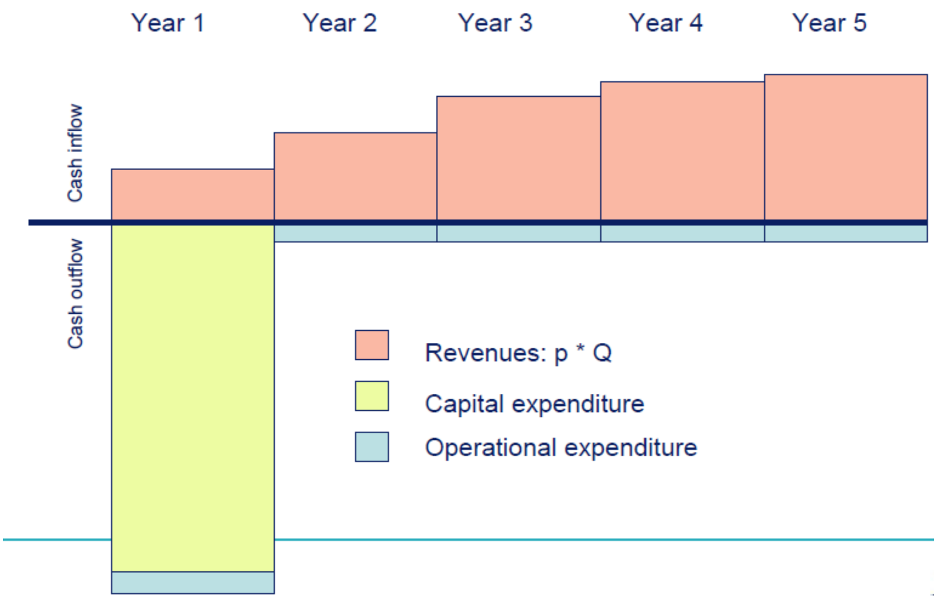
Opta's use of this methodology is best explained with the help of Figure 3-1 taken as it is shown from a presentation by an Opta representative.[20] In it, the initial capital expenditure plus operating expenditures over the economic lifetime of the NGA assets are set against expected revenues over the lifetime. Expenditures are shown as negative cash flows and revenues are shown as positive cash flows. Applying the condition that the operator must recover its costs and earn a reasonable profit, the initial price that supports this revenue stream is determined. Ingredients in this net present cash flow calculation are the actual capex, a fibre-specific WACC, a payback period of 25 years, an expected CPI of 1.5% per year, and so called genuine expectations regarding volumes of sales over the relevant time period. Note that the picture designates the red columns as revenues being equal to quantity times price (p*Q). The process of determining these revenues must, however, have started from projections of sold volumes for the various periods, for which the revenues/prices are then determined given the constraints that their net present value equal the net present value of the expenditures and that the price increases from year to year develop according to the projected change in CPI of 1.5 % per annum.

18 The retail markets for fixed line copper-based access services remain in the inelastic region of demand, indicating that market power could be exercised by a monopolist (Briglauer, Schwarz and Zulehner, 2011).

19 See Muselaer and Stil (2010) and Stil (2010).

20 See Stil (2010), slide 10.

Figure 3-1: Opta's discounted cash flow model



Quelle: Stil (2010)

This DCF model is essentially equivalent to the calculation of FL-LRIC by means of a bottom-up cost modeling approach, as for example applied in the cost models that WIK has developed. In these cost models, the capex for an asset, e.g. a line in the NGA network, is transformed into annual costs on the basis of an annuity formula of the following form:

$$I = A_1 * [1 + q + q^2 + \ldots\ldots + q^n]$$

where

$$q = (1+g)*(1+\Delta p)/(1+WACC) .$$

In the annuity formula, I stands for capital expenditure (the yellow negative column in Opta's figure), A_1 for the amount to be amortised in period 1 (corresponding to the expected revenue for that period, i.e. the first red column in Opta's figure), q for the discount factor and n for the number of years in the economic lifetime of the asset. The formula for the discount factor q contains beside the WACC and Δp, the expected average input price change, an additional "tilt" in the form of the average growth rate g. This factor takes account of the fact that demand for unbundled fibre lines is growing and will generate correspondingly more revenues in the following years. Thus $A_2 = (1+g)* A_1$, $A_3 = (1+g)* A_2$ and so on. In other words, $A_2 > A_1$ corresponds to the sold volume shown in Opta's figure for year 2 and $A_3 > A_2$ to the sold volume for year 3. The difference to Opta's DCF model is that an average growth rate *g* is used while Opta apparently uses a growth model with varying growth rates over time. This could also be introduced into the annuity formula, it would require that each A_i gets its own individual value; WIK has abstained from this approach using instead the more easily determinable average growth rate *g*.

To recapitulate, both approaches start from a knowledge of initial expenditures for the asset, a knowledge of what current demand (that in year 1) is in physical terms, an expectation of how this demand will develop over time, an expectation of how input prices develop over time (represented in the Opta approach by the consumer price index, CPI), then apply a discounting procedure on the basis of a given WACC and determine from that what the revenue/price in period 1 should be. (Opta then applies a price cap formula for the periods 2, 3, etc., applying an annual change in the CPI of 1.5 %, to determine the prices for the following periods; here we are primarily interested in how the amount for period 1 is determined.)

While we focused in the above discussion on the relationship between capex, volumes of demand and required revenues, the effect of operating expenditures on revenues/prices would in the bottom-up cost model also essentially be determined in an equivalent way.

There is one advantage in Opta's approach in that it focuses explicitly on and visually presents the revenues that are to be generated by the asset over its economic lifetime. If one is able not only to estimate the current and expected volumes demanded (as is assumed in above discussion) but also to estimate what the revenue in money terms will be, it is possible, instead of determining the price (or revenue per line), to determine the value of the asset. In other words, this way the question to be answered is reversed. It is not the question for the price of a fibre line – knowing the initial investment, the initial demand and the development of demand over time – it is the question for the current value of the asset. The informational requirement is that one can form expectations over both the demand in terms of physical units and in terms of revenues, which would then contain the answer to the question for the price and thus allow to answer the question for the current value of the asset.

As presented in the preceding paragraph, the DCF methodology could thus be an alternative method for determining the current value of an unbundled copper loop. Remember that in Chapter 2 we argued that due to declining demand this value cannot be determined anymore on the basis of the current prices of the inputs used to construct them. Instead, as shown in the preceding paragraph, this value could be determined on the basis of expectations formed over current and future revenues earned with these assets that are then discounted to obtain their net present value. Once one has identified this value – which is analogous to the value obtained on the basis of the prices of the inputs in case of a growing market – one can proceed with transforming this value into costs, as is done in conventional costing exercises.

There is one final observation. Plum Consulting suggests in their recent report for ETNO[21] that the DCF approach be used for the determination of the cost of the fibre unbundled local loop. We have shown that the approach is essentially equivalent to determining FL-LRIC on the bases of a bottom-up cost modeling. They go on to suggest that for the copper unbundled local loop the bottom-up cost modeling approach based on current replacement prices for inputs be used. We have shown that, on the contrary, that for the copper unbundled local loop the DCF approach could be an alternative with, however, the question to be answered to be reversed. From estimates both of future volumes demanded and revenues obtainable from selling these loops the value of a line could be determined and thereby the basis of appropriate costing of that asset.

3.5 Practical implementation

Above we have argued that when there is decreasing demand the FL-LRIC cost standard is not applicable any more for the setting of the price for a regulated product. In particular this means that NRAs need to adopt a new methodology. This holds in particular for the copper ULL, the demand for which is in decline throughout the EU.

Part of the new methodology has essentially already been presented in the preceding section. Provided there is effective competition at the retail level, prices for the copper ULL should reflect users' valuation of the retail service that still depends on this wholesale product. Given that the demand for it would be a demand derived from the retail market, the corresponding price for it would have to be determined from the retail price minus the competitive margin required to sell the product on that market. The procedure will be like that for a margin squeeze test with the difference, however, that not the competitive compatibility of the retail price is to be tested but rather the wholesale price for the copper ULL be determined from the retail price. Obviously, one need to be assured that there is effective competition on that market.

A costing methodology needs to be in place for determining the competitive margin. One can expect that NRAs that carry out margin squeeze tests have this methodology at their disposal. It should be further developed and staff be trained to routinely collect the relevant information and apply it for the given purpose.

The proviso that the market is in fact effectively competitive is a precondition. When demand is declining and overcapacities develop, competition will have its effect and drive retail prices down so that also wholesale prices derived from them will fall. Unfortunately, effective competition cannot be assumed as a given. In some markets, incumbents may still have SMP to such a degree that they have large degrees of freedom in setting retail prices. Deriving in such situations the wholesale price from the retail price harbours the risk that the latter reflect the market power that the provider still exercises in the retail market. Giving up the FL-LRIC cost standard in favour of an

21 Plum Consulting (2011).

approach based on the outcome in the retail market would then lead to wholesale prices that do not reflect the true valuation of users and would thus fail the objective. In particular, it may be the case that the resulting wholesale price is higher than before when it was derived on the basis of the FL-LRIC standard.

The appropriate safeguard for such a situation is to set a ceiling for the wholesale price, where the natural candidate for this ceiling is the price that would be determined on the basis of an accurate application of the FL-LRIC standard when that was the relevant approach. If correctly calculated in the past, this could be the previous LRIC calculation, or otherwise could be set on the basis of a properly applied LRIC methodology using parameters relevant to the period before demand was declining. Any price above that value coming out of the margin squeeze-test would have to be rejected. The price would then have to be set at the level of the ceiling as determined by the last costing exercise based on FL-LRIC before demand was declining. Presumably, the first time when the new approach is applied, the ceiling would be the ruling price as that would likely still have been determined on the basis of FL-LRIC.

The floor for the wholesale price should be the short-run incremental cost (SRIC) of providing the copper ULL. The SRIC consists of the out-of-pocket expenses for continuing to offer the product. If retail prices fall to such a level that the derived wholesale price of the copper ULL falls below the level of SRIC, the incumbent would lose money even in the short run. When prices reach that level the rational business decision then is to take that network out of business. In any case, at such prices the incumbent would actually be motivated to cease offering the service altogether, both at the retail and wholesale level, and in general such a shut-down of operations should not be prevented by regulatory intervention. It would in any case hold that by this time the migration from copper access to fibre access would for all intent and purposes have been complete. Maintaining an offer of copper ULL under these circumstances would then not be justified any more.

In sum, efficient wholesale prices should reflect a pricing policy that maximizes economic welfare. This requires an approach to practically determine this pricing policy. Our market modeling approach below in Chapter 6 aims at doing just this. Prices should lie between LRIC as calculated the last time before declining demand (upper limit) and short run incremental cost (lower limit). LRIC would appear to be the appropriate cost standard for fibre (not copper) ULL. Fibre access fulfils all the prerequisites for applying a FL-LRIC approach to determining the regulated wholesale prices. Fibre access is a growing market, incumbents and access seekers get the proper signals for making their investment decisions if that pricing principle is being applied. In practical terms LRIC-based prices can either be calculated by using a bottom-up cost model or be using a DCF approach based on the business case of the investor. Both methods lead to equivalent results if properly applied as we have shown. Brownfield savings of the incumbent, however, have to be properly reflected in determining ULL cost for fibre.

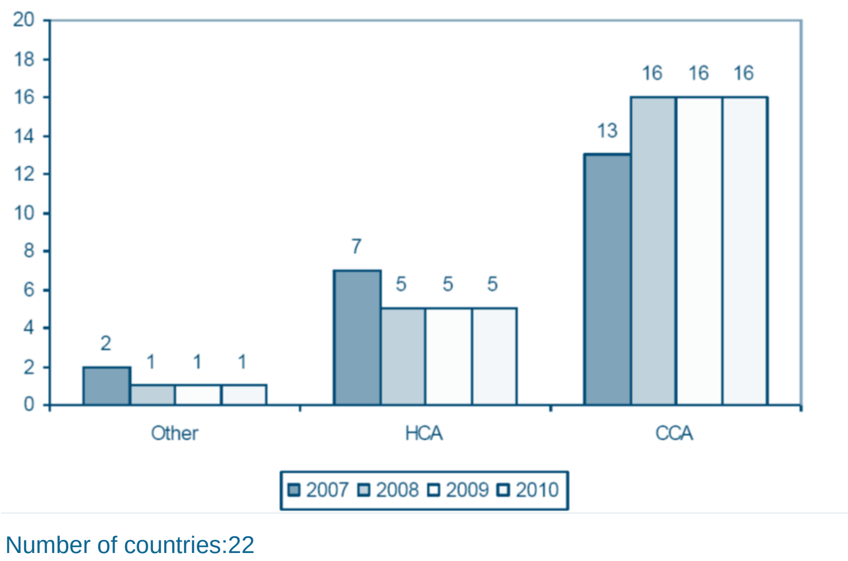
4 Some important case studies

4.1 Current regulatory practice on ULL pricing in the EU

European NRAs show relatively clear preferences regarding price control methods, cost base and accounting methodologies for regulating the ULL wholesale charge. The degree of harmonization of methodologies for key wholesale markets seems high as BEREC (2010) points out in its latest Regulatory Accounting report. The analysis shows a clear preference for cost orientation, a trend towards using current cost accounting (CCA) and a fairly even distribution of LRIC and FDC accounting methods.

26 countries[22] participated in the BEREC survey for the year 2010. 19 NRAs out of the 26 countries reported CCA to be their cost base for unbundled access. 6 NRAs reported HCA as their relevant cost base and 1 NRA reported to use a different cost base. Figure 4-1 gives an insight into how the choice of the relevant cost base has changed over time, taking into account only data provided by those 22 NRAs which consistently reported since 2007. Figure 4-1 shows a quite stable and sustainable choice of the cost base made by the NRAs. CCA is by far the most commonly used cost base methodology applied. Both, the number of NRAs using HCA and those using CCA has been stable since 2008.[23]

Figure 4-1: Cost base unbundled access wholesale (Market 4, previously Market 11)



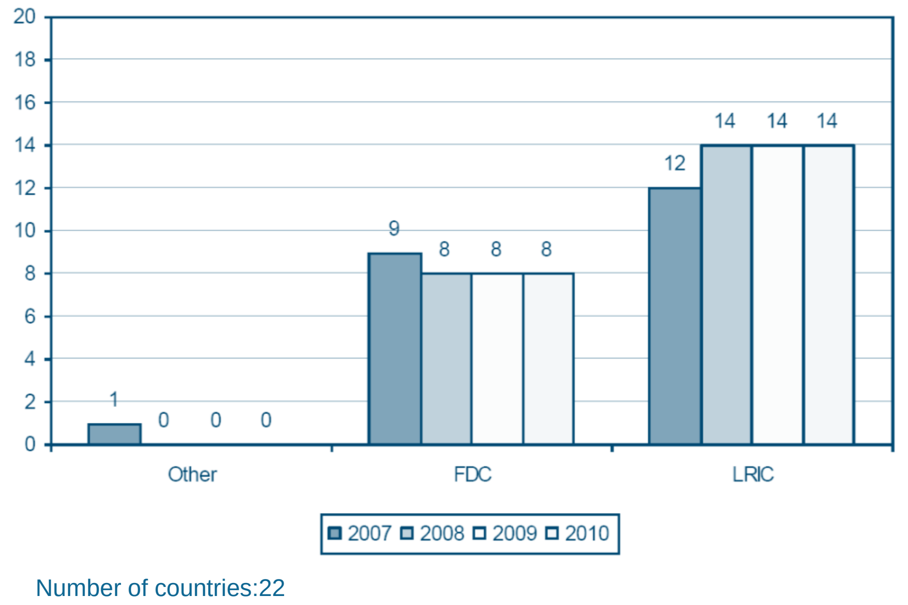
Source: BEREC RA – PT 2010

22 The countries contributing included the 27 EU Member States plus Iceland, Norway, Switzerland and Croatia.

23 These and the following references are provided by BEREC. However, one cannot discern to what extent this includes NRAs using mixed approaches. In addition, in 2010 Italy switched from HCA to CCA which apparently has not been reflected in these numbers.

As shown in Figure 4-2, the most commonly used accounting methodology in 2010 and in the previous years is LRIC. 64% of the NRAs are applying LRIC for wholesale products in market 4 and 36% are applying FDC.

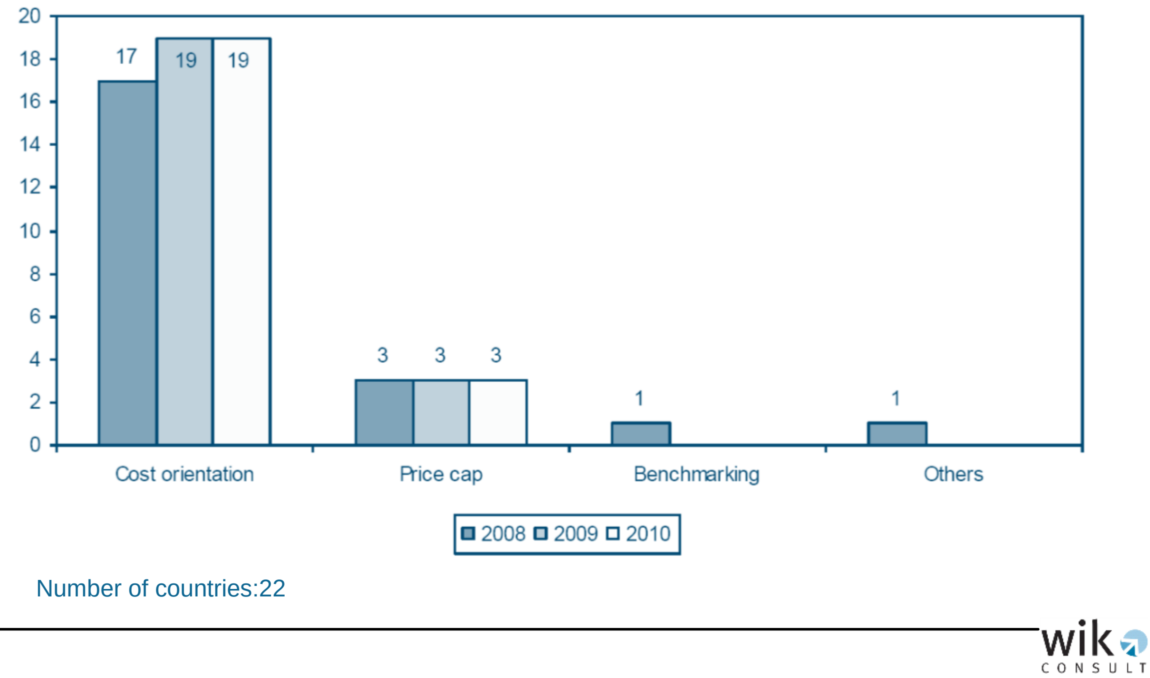
Figure 4-2: Accounting methodology unbundled access wholesale (Market 4, previously Market 11)



Source: BEREC RA – PT 2010

As Figure 4-3 shows, the most commonly used price control method in the unbundled access wholesale market is by far cost orientation. 21 NRAs apply cost orientation although for 5 NRAs it is combined with price cap. From Figure 4-3 it can be observed that between 2008 and 2009 two NRAs moved from benchmarking or another type of price control to cost orientation.

Figure 4-3: Price control method unbundled access wholesale (Market 4, previously Market 11)



Source: BEREC RA – PT 2010

European NRAs so far prefer CCA as a cost base combined with LRIC as the costing methodology and cost orientation as the price control method for unbundled wholesale access.

Although the cost and pricing methodology looks rather harmonized in Europe, the resulting range of actual ULL prices seems to speak a different language. As of October 2009 ULL prices are in a range of 6 to 16 € in the Member States with an average of € 8.55.[24] This price range cannot be explained by country-specific cost differences but indicate relevant methodological differences in using cost parameters and calculation approaches.

Given that the market and demand is changing over time, some insight into regulatory policy is provided by the development of ULL prices over time. Table 4-1 provides a benchmark for 13 countries over the period from 2005 to 2011 recently used by the Spanish NRA CMT. Three different patterns of price paths can be identified from that benchmark:

24 See Figure 5-2.

(4) Some NRAs have set a price path with relative stable but slightly declining ULL wholesale prices. France, Germany and to some extent Portugal fall into this category. They have reduced prices by less than 10% over that period.

(5) A second group of NRAs has set a more aggressive path of a steady price decline. Austria, The Netherlands, and Belgium belong to this category. ULL prices have been decreasing by 32% to 46% in these countries.

(6) In a third group of countries, prices have been (sometimes strongly) decreasing in the first part of the period considered and have been increasing or are beginning to increase again in the last few years. Spain, Sweden, the UK and Italy fall into this category.

The other countries not attributed to one of the three groups do not reveal a clear price path pattern like Ireland where prices firstly increase sharply and then decrease sharply.

Table 4-1: ULL price benchmark over 13 countries (2005-2011)

	2005	2006	2007	2008	2009	2010	2011
Austria	10.90	10.70	10.70	9.33	6.35	5.87	5.87
The Netherlands	9.59	8.34	8.00	7.83	7.83	6.53	6.53
Belgium	11.62	11.26	9.29	9.29	9.29	7.78	7.78
Spain	11.35	9.72	9.72	9.72	7.79	7.79	8.32[1)]
Greece	8.01	8.66	8.48	8.70	8.27	8.51	8.51
Sweden[2)]	10.31	10.31	7.95	7.56	8.34	8.72	8.72
UK[3)]	7.32	7.32	7.32	7.32	7.90	8.84	8.91
Portugal	9.72	8.99	8.99	8.99	8.99	8.99	8.99
France	9.50	9.29	9.29	9.29	9.00	9.00	9.00
Italy	8.30	8.05	7.81	7.64	8.49	8.70	9.02[4)]
Denmark[5)]	8.99	8.62	9.2	9.74	9.96	9.32	9.17
Germany	10.65	10.65	10.50	10.50	10.20	10.20	10.20
Ireland	14.65	15.09	15.68	16.43	16.43	12.41	12.41

1) Proposal of CMT
2) 1 € = 10.189 SEK
3) 1 € = 0.91085 £
4) 9.28 for 2012
5) 1 € = 7.449 DKK

Source: CMT (2011) from implementation report of the EU (for 2005-2009) and Cullen (for 2010-2011)

4.2 Guidelines from the NGA Recommendation

The NGA Recommendation tries to find a balance between optimal incentives to invest in NGA and to keep competition in service provision in the NGA world. The system of remedies to guarantee competition in the area of copper networks are transposed into fibre-based networks and the transition from copper-based to fibre-based networks. The following basic principles of the Recommendation are of particular importance for the subject matters of pricing in this study:

(1) Mandating access to civil engineering is only regarded as effective, if the SMP operator provides access under the same conditions to its own downstream arm and to third party access seekers.[25]

(2) When investments in non-replicable physical assets such as civil engineering infrastructure are not specific to the deployment of NGA networks, their risk profile should not be considered to be different from that of existing copper infrastructure.[26]

(3) Access prices in the NGA context should reflect the costs effectively borne by the SMP operator, including due consideration of the level of investment risk.[27]

(4) The cost of capital in setting access prices should reflect the higher risk of investment in NGA relative to the risk involved in current copper-based networks.[28]

(5) Non-linear access prices which diversify the investment risk between the investor and the access seeker should not lead to a margin-squeeze preventing efficient market entry.[29]

(6) A margin squeeze can either be demonstrated on the basis of an equally efficient competitor test or on the basis of an reasonable efficient competitor test. In the context of ex ante price controls the Recommendation regards the reasonably efficient competitor test as more appropriate.[30]

More specifically, the NGA Recommendation prescribes the following pricing rules for NGA wholesale products:

(1) The price of access to the unbundled fibre loop should be cost-oriented. The relevant cost of capital should include a risk premium properly reflecting the fibre investment risk.[31]

(2) To create a genuine level playing field between the downstream arm of the SMP operator and alternative network operators, a consistent regulatory

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25 See Rec. 13.
26 See Rec. 14.
27 See Rec. 18.
28 See Rec. 23.
29 See Rec. 24 and 25.
30 See Rec. 26.
31 Se para. 25.

approach may imply the use of different cost bases for the calculation of cost-oriented prices for replicable and non-replicable assets.[32]

(3) Access to existing civil engineering infrastructure should be mandated at cost-oriented prices under the same methodology as for pricing access to the unbundled local copper loop. NRAs should in particular take into account actual lifetimes of the relevant infrastructure. Access prices should capture the proper value of the infrastructure concerned, including its depreciation.[33]

(4) Access prices to the unbundled fibre loop at the MPoP in the case of FTTH should include a higher risk premium than prices for access to the unbundled local copper loop.[34] The fibre ULL price charged to the SMP operator's downstream arm should be the same as the price charged to third parties.

(5) Regulated access prices for copper sub-loop unbundling should not be higher than the cost incurred by an efficient operator-based on bottom-up modeling or benchmarks.[35]

4.3 Country case studies

4.3.1 The UK

In 2005, Ofcom decided upon a major shift in the asset valuation of BT's copper access network and therefore on the cost standard to determine the LLU wholesale charge or more precisely a rental charge ceiling. Up to then Ofcom had applied a current cost accounting approach with fully allocated costs (CCA FAC). The major change was related to the regulatory asset valuation:

> "In the *Valuing copper access* statement, Ofcom concluded that it was no longer appropriate to value BT's pre-1 August 1997 copper access network assets on the basis of CCA FAC (or LRIC+). This was because to do so would have allowed BT to over-recover the costs of those assets which, until 1 August 1997, had been valued under the HCA convention. In order to avoid the potential for such over-recovery, and given that it is unlikely that any operator will build a new nationwide access network in competition with BT in the near future, Ofcom decided to create a regulatory asset value, or RAV, to represent the remaining value of the pre-1997 copper access network assets rather than continuing to value those assets at their current cost. The value of the RAV is set to equal the closing historical cost accounting value for the pre-1 August 1997 assets for the

32 See Annex I, para. 1.
33 See Annex I, para. 2.
34 See Annex I, para. 4.
35 See Annex I, para. 5.

2004/5 financial year and its value will be increased each year by the Retail Price Index ("RPI") to ensure it is not eroded by inflation. Over time the RAV will gradually disappear as the pre-1997 assets are gradually replaced with new ones. Post-1 August 1997 assets which have been valued consistently on a CCA FAC basis throughout their lives will continue to be valued using the CCA convention.

Therefore, the part of the LLU charge which reflects recovery of the costs of the local loop will reflect an average of the costs associated with pre-1 August 1997 assets, based on the RAV, and the costs associated with post-1 August 1997 assets, calculated using CCA FAC as described above. The other components of the fully unbundled rental charge are based on CCA FAC." [36]

This combination of valuation principles effectively means that the ULL rate ceiling will partially reflect historic cost and partially current costs. Given the deprecation periods of the relevant assets, this (in theory) would mean that the last remaining assets included in the RAV will become fully depreciated in 2037/8.[37] From this point onwards all assets would be treated again under a full CCA basis. BT will be required to maintain appropriate records to identify the relevant assets for the RAV to be distinguished from other access assets which are subject to a full CCA approach.

Ofcom regards the European Court of Justice decision in the Arcor case which we will discuss in more detail in the context of the German case[38], as less clear cut than presented by the stakeholder.[39] Ofcom reads the decision such that it implies a mix of HCA and CCA although it remains unclear how this should be applied in practice. Ofcom itself has placed greater emphasis on forward looking costs and, hence, CCA while the RAV approach does acknowledge historic costs.

As a consequence of this new policy approach BT "voluntarily" reduced the unbundled rental charge on 1 August 2005 from £ 105.09 to £ 80.00 (which means by 27%). Ofcom itself has set the unbundled rental charge ceiling at £ 81.69, which took effect from 1 January 2006.[40] This sequence also indicates that Ofcom effectively is not regulating the ULL charge. It is just setting a rate ceiling.

In addition to revaluing (parts of) the access asset base, Ofcom reviewed the accounting lives for duct and copper cables and the relevant WACC. Ofcom viewed BT's depreciation policy for ducts of a 25 year lifetime as too aggressive and not justified by actual use.[41] It is difficult to envisage any large scale technological development which will render the duct network obsolete. BT stated that duct has a

36 Ofcom (2005b), p. 9.
37 See Ofcom (2005a), p. 4.
38 See Section 4.3.3.
39 See Ofcom (2009), p. 62.
40 See Ofcom (2005a), p. 3.
41 See Ofcom (2005a), p. 41f.

book life of 38 years whilst the maximum book life is 45 years. Ofcom therefore adopted to straight line depreciation treatment for ducts within the regulatory financial accounts and to use an accounting life of 40 years.

Similarly, Ofcom regarded the lifetime which BT assumed for copper cables, namely 15 years as inappropriate.[42] BT has indicated that the design life for the cables is 20 years, the majority of European access network operators indicate a book life in the range of 16 to 20 years, actual lifetime is somewhere between 15 and 20 years. Ofcom therefore adjusted copper cable lifetime to 18 years.

Ofcom also reviewed the relevant WACC for the access network. In the 2004/05 accounts BT still applied a WACC of 13.5%. In its cost of capital review[43] Ofcom has concluded that a WACC of 10% is more appropriate for the access network assets.

Applying the changes as discussed above has led to major changes in the cost for the LLU service. Increasing the asset lifetime and moving to the RAB asset valuation reduced the annual cost of the copper loop from £ 76.41 to £ 65.62 representing a reduction of £ 10.79 per loop or of 14%. Changing the WACC further reduced the average cost per loop to £ 59.10 or by 10% for the 2005/06 financial year. For the fiscal year 2007/08 Ofcom reports an (unaudited) BT estimate of £ 65 as the LRIC for the ULL.[44] These costs correspond again to a rate ceiling of £ 81.69 which is much above the relevant costs.

In 2009 Ofcom (2009) made new decisions regarding the price ceiling for the ULL services. The new price control kept the system of fixing a price ceiling for 2009/10. This ceiling was then indexed for the service in 2010/11. The new ceiling was fixed such that if an equivalent annual indexation were to apply until 2012/13 it would deliver a price that equals Ofcom's assessment of the projected efficient fully allocated cost of ULL in that particular year.

Table 4-2: New price controls for ULL in the UK

	Previous price (ceiling)	Price in 2009/10	Indexation in 2010/11
ULL annual rental charge	£ 81.69	£ 86.40	RPI + 5.5%

42 See Ofcom (2005a), p. 42.
43 See Ofcom (2005c).
44 See Ofcom (2009), p. 67.

On 22 September 2009, Carphone Warehouse Group PLC brought an appeal against Ofcom's LLU Statement mentioned above to the Competition Appeal Tribunal.[45] British Sky Broadcasting and BT both intervened. On 27 November 2009, the Tribunal referred to the Competition Commission the specified price control matters. On 31 August 2010 the Competition Commission notified the Tribunal of their determination of the price control matters. On 11 October 2010 the Tribunal has remitted the decision under appeal to Ofcom with the following direction: For the ULL service the annual rental charge for the unelapsed period of the price control is £ 89.10. The charge for the first relevant year was even set at £ 90.46 for the period beginning on 1st April 2010 and ending 14 October 2010 and the amount of £ 89.10 for the remainder of the second relevant year.

On 31 March 2011 Ofcom (2011) published a consultation on the revision of the price control for LLU and WLR services. Ofcom proposes new ULL annual rental charges which are expected to come into effect later this year and will run until 31 March 2014. Today's regulated wholesale price of £ 89.10 per year is supposed to decrease in real terms by between RPI -1.2% and RPI -4.2% every year. For its base case calculation Ofcom assumes a real decrease of RPI -2.7% which would result into a nominal price increase to £ 90.70. To calculate the new charges Ofcom basically relied upon its previous approach to calculate costs on a CCA replacement cost basis with an RAV valuation approach for assets deployed before 1997. Ducts as a major component to be used to carry copper lines have been re-evaluated by BT/Openreach in 2010. This re-evaluation is reflected in Ofcom's new charge proposal. As part of this re-evaluation BT updated the cost and national build discount elements of its absolute evaluation calculation for their duct assets. As a result the duct valuation increased to £ 6.5 billion, an increase of £ 1.8 billion compared to the 2008/09 equivalent valuation. The largest single reason for this increase is a much lower national build discount which decreased from 45% to 14.5% based on data by a new single contractor. This increase in the capital cost asset base was partially compensated by a lower WACC. Ofcom's cost model and the new charge proposals are based on a WACC for Openreach of 8.6%.

Ofcom does not give much regulatory guidelines regarding the pricing of fibre unbundling. In its latest decision on wholesale local access (market 4) Ofcom included fibre-based local access in that market besides copper-based and cable-based access. It did, however, effectively not impose an unbundling remedy on BT's GPON network. Instead, Ofcom imposed a wholesale virtual unbundled local access (VULA) obligation.[46] VULA is an active line product with similar characteristics as bitstream access. Ofcom's conclusion is based on the assumption that non-physical products have underlying characteristics consistent with physical products and should therefore be included in the same market. Furthermore, Ofcom defined some functional characteristics for VULA like localness, minimum functions incorporated, service-

45 See Ofcom (2010b).
46 See Ofcom (2010a).

agnostic and dedicated capacity for VULA which should make it functionally similar to physical unbundling.

While copper LLU, sub-loop unbundling and physical infrastructure access (duct and pole access) is in principle subject to LRIC pricing, Ofcom allows BT pricing flexibility for the VULA service. This includes geographic variations, volume discounts and tiered pricing. However, BT is required to provide VULA to communications providers on an equivalence of input basis as to its own downstream divisions.

In its comments to Ofcom's intended decision the Commission[47] accepted VULA to be included in market 4 although it is characterized as an active NGA product. The Commission accepted that VULA has many features which indicate that it is equivalent to local loop unbundling. The Commission did not challenge Ofcom's finding that today fibre unbundling would not be a justified and proportionate remedy in case of GPON. Nevertheless, the Commission assumes Ofcom to re-assess the active line remedy as soon as a technology[48] enabling fibre unbundling (like WDM) is available. The VULA remedy should be replaced by fibre unbundling as soon as it is technically and economically feasible or should possibly continue to be required in addition to full fibre unbundling.

4.3.2 Austria

The Austrian NRA RTR is generally following a FL-LRAIC approach for determining the wholesale LLU prices. Insofar and as long as retail prices are unregulated and are not necessarily cost-based, a cost-based wholesale pricing approach does not necessarily exclude economic distortions of competition. Depending on the retail pricing policy of the incumbent cost-based wholesale prices may lead to inconsistencies of pricing between the integrated and non-integrated competitors. If the incumbent values the copper network differently to a FL current cost approach or if he engages in a price discrimination, the retail prices of the incumbent may not be replicable by competitors on the basis of FL-LRAIC-based wholesale rates. In such a case a margin squeeze occurs. Competitors are then unable to meet the retail price of the incumbent on the basis of FL-LRAIC wholesale prices and efficient downstream costs. Downstream competitors face a situation of price discrimination at the wholesale level. Cost-based wholesale prices therefore are a necessary but not a sufficient condition for price consistency and undistorted competition between integrated and non-integrated operators. If retail prices are set below (full) costs a margin squeeze may occur even if wholesale prices are cost-based.

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47 European Commission, SG-Greffe (2010) D/7658 of 1/06/2010.

48 The Commission mentions the example WDM as fibre unbundling technology, while we understand WDM as a wavelength unbundling enabler only.

To avoid such a competitive distortion and a potential foreclosure of the market, RTR requires that the relevant wholesale price also has to meet a margin squeeze test such that the wholesale rate is not allowed to exceed a level that would generate a margin squeeze for competitors. The level of retail rates decides whether this competitive consistency condition generates a binding condition for wholesale pricing. Effectively, the relevant wholesale price becomes the minimum of a price which is margin squeeze free and a price set at the level of the relevant FL-LRAIC.

RTR applied this pricing method in 2007 for the first time when it identified that the LRIC were significantly above the margin squeeze free price. This situation remained in further rate cases in particular because FL-LRAIC tended to increase over time. In September 2010[49] RTR estimated the relevant FL-LRAIC in a range of 13.22 - 16.72 € per month while the margin squeeze free wholesale price was determined at 5.87 €. Table 4-3 describes prices and costs for ULL in Austria.

Table 4-3: ULL costs and prices in Austria

	2007	15.11.2007	2009	2011
FL-LRAIC	10.44	10.44	11.99	13.22 - 16.72
Wholesale price	10.44	6.35	6.35	5.87

The significant reduction of the ULL wholesale price in 2007 effectively was a decision of the incumbent Telekom Austria (TA). TA intended to reduce a low-priced access bundle product including telephony, internet and mobile access for 19.90 €, originally only for a two month action period. RTR provided TA with the option either to reduce the ULL wholesale price or to increase the intended retail price because the actual wholesale price did not provide a sufficient margin between the retail and wholesale product on the basis of RTR's calculation rules for a margin squeeze.[50] TA decided in favor of reducing the wholesale price and RTR confirmed the level of the ULL charge.

To identify the margin squeeze free wholesale price RTR applies the equally efficient operator (EEO) standard. According to this standard a wholesale price is margin squeeze free if the incumbent can produce retail and other wholesale products in the value chain on the basis of the wholesale price and its own downstream costs without making a loss. RTR does not apply this test for a single retail product, because the unbundled local loop is used to produce a variety of different services and end-user prices are differentiated. Instead, RTR is applying the test for all broadband products provided over the copper line. The relevant revenues are therefore determined as a weighted average of all average revenues per user (ARPU). From the revenues RTR

49 Telekom-Control-Kommission (2010).
50 See Telekom-Control-Kommission (2007).

deducts those downstream costs which a competitor would raise itself. At the retail level these costs include:

- Marketing and sales
- Billing and bad debt
- Accounting
- Product development and management
- Customer service/call center
- Backhaul and international connections
- Costs related to additional services like Web-space, E-Mail
- Other common costs at the retail level.

Furthermore, competitors have to generate certain technical services which are not provided as wholesale services. Those costs include:

- xDSL equipment like modem and DSLAM
- Equipment at the collocation point
- Maintenance of technical equipment
- Work force for network services
- Capital costs of own infrastructure
- Common costs at the infrastructure level.

Avoidable costs which are provided by the access seeker itself can either be one-off or recurring.

The net revenues determined on the basis of gross revenues minus avoidable costs are then compared with all (one-off) and recurring charges for wholesale provision. These costs include the wholesale price for the unbundled loop, all costs related to collocation and those for backhaul connection. If the calculation generates a positive margin, then the corresponding wholesale charges are margin squeeze free.

In addition to this overall margin squeeze test relating to all retail products provided over the access infrastructure, RTR applies in addition a test related to each single product. This test intends to avoid margin squeeze in the sense of predatory pricing. To pass this test and to avoid cross subsidization, each retail product has to cover its individual variable or incremental costs. According to this test each product has to provide a positive contribution over and above the variable or incremental cost/price of the corresponding wholesale product(s). The wholesale price therefore defines the minimum level of each retail price. This test even is applied for temporary pricing policy actions.

The price for the sub-loop from the street cabinet to the network termination point is determined as a fixed percentage point (77.3%) of the fully unbundled loop. There is no price or cost element for inhouse cabling, because it is assumed that these costs have already been covered by the end-user in providing the line.

The Commission commented RTR's pricing approach critically[51] in its letter regarding RTR's last measures regarding market 4. The Commission argued that wholesale prices for the ULL should generally be cost-based. Otherwise negative incentives to invest would occur for the incumbent to upgrade and expand its access infrastructure.

4.3.3 Germany

BNetzA is one of the NRAs which consistently over the last 12 years applied a FL-LRIC approach to determine the regulated ULL rental charge. This cost standard is mandatory under German telecommunications law for all ex ante regulated wholesale services. The BNetzA also consistently applied the same approach to calculate the FL-LRIC over the years. We will describe this approach for the latest ULL decision in the following. The approach led to a slightly decreasing ULL charge as Table 4-4 shows. Related or unrelated to the pricing decisions, ULL is a quite attractive wholesale product in Germany. 9.7 Mio. lines were unbundled in Germany at the end of 2010. About 25% of all copper access lines are provided on that basis.

Table 4-4: Monthly rental for ULL in Germany

		Delta
1999[1)]	12.99 € (25.40 DM)	+2.44 €
2001	12.68 € (24.80 DM)	-0.31 €
2003	11.80 €	-0.88 €
2005	10.65 €	-1.15 €
2007	10.50 €	-0.15 €
2009	10.20 €	-0.30 €

1) New rates were usually fixed at the 1 April for the following two years.

BNetzA applied a FL-LRIC approach also in its latest ULL decision from March 2009.[52] The network assets of the copper access network were valued at current costs. The relevant network asset elements were calculated on the basis of a bottom-up engineering cost model. The model uses a scorched node approach insofar as number and location of MDFs are concerned. For the feeder and the drop segment as well as the number and location of distribution points ("Kabelverzweiger", street cabinets) and related elements the model relies upon a scorched earth optimization approach. This

51 See SG-Greffe (2010) D 8552, Brüssel 17/06/2010.
52 See BNetzA (2009).

means that the model endogenously builds on an optimized efficient network structure instead of the “real” network structure of the existing access network. The optimization starts from a given demand for copper access lines distributed in the country at the point of decision making. The minimal investment values are calculated for each of the 8,000 access areas[53] and then aggregated to a nationwide average value. Investment values per line (as well as the ULL price) is calculated on a nationwide basis of the whole copper access network.

The model parameters on current prices of equipment items are mainly based on information provided by DTAG. This information was completed with information from other market players. BNetzA, however, did not accept requested price increases for deploying cable and ducts of 40%.

OPEX were basically calculated on the basis of cost information provided by DTAG. This information was partially corrected by efficiency considerations or error corrections.

Many of the relevant investment and cost parameters of the BNetzA cost calculation are treated as confidential. The parameters listed in Table 4-5 are published in the latest TAL decision.[54]

Table 4-5: Key cost parameters for ULL in 2009

WACC (real WACC after adjustment for fluctuations, from 5.51% to 7.19 %	7.19%
Asset lifetime of copper cables	20 years
Asset lifetime of ducts and manholes	35 years
Investment savings due to infrastructure sharing with other utilities	
• Feeder cable segment	11.43%
• Drop cable segment	27.24%
• Additional internal investment savings due to VDSL in the feeder segment	4%
Investment value of standard ULL	928.26 €

Basically due to increased current prices of network assets (mainly cable deployment, cable and labor costs) the investment value per ULL increased from the previous decision in 2007 from 868.87 € to 928.26 € (increase of 6.8%). This increase was (more than) compensated by a lower WACC (7.19% instead of 8.07%) and lower allowed OPEX. The combined effect of all parameter changes lead to a cut of the ULL charge from 10.50 € to 10.20 € (a reduction of 2.9%).

53 In the previous decisions the modeling was based on a sample of 600 MDF areas.
54 See BNetzA (2009).

BNetzA also applied a margin squeeze test to check the consistency of the calculated ULL wholesale price with the retail price level of DTAG. For calculation purposes BNetzA used a reasonably efficient competitor test. BNetzA did not apply the test for each individual retail price but only for a combination of retail prices. Competitors shall be able to reproduce a telephony only product as well as a bundle product consisting of telephony and DSL on the basis of unbundling. In the case of a bundle product BNetzA calculated on the basis of the cost items in Table 4-6 that revenues exceeded competitors' cost by about 10% resulting in a no margin squeeze relationship. Similarly in the case of a telephony only service, revenues exceeded competitors' cost by even 30% according to the BNetzA calculation.

Table 4-6: Margin squeeze calculation in case of a bundle product

Monthly cost of TAL access seeker		Monthly revenues of a broadband bundle product
Wholesale price TAL		
Provision	1.95€	
Monthly rental	10.20€	
Cost of DSLAM	4.64€	
Cost of splitter	0.89€	
Transport in concentration network	2.10€	
Collocation	0.93€	
Transport IP backbone network	2.31€	
Usage dependent cost telephony	3.00€	
Customer acquisition, maintenance, common cost, billing, bad debt	6.99€	
Sum	**33.01€**	**36.55€**

Source: BNetzA (2009) p. 68

The debate on the proper level of the ULL rental charge in Germany has received new fuel from a decision of the European Court of Justice (ECJ) in 2008[55] and subsequent decisions built on the ECJ's decision of the German Administrative Court[56]. The ECJ decision was related to the BNetzA decision on the ULL prices in 2001. The Court made critical comments regarding the application of a current cost approach as well as a historic cost approach for ULL. Without developing a clear definition it asked for a stronger consideration of the "actual costs" of the operators for determining the ULL price. From an economic perspective, the European Court decision was confusing insofar, that the Court's costing concept did neither exclude historic or current cost as a

55 European Court of Justice, Decision of 24.4.2008, Rs. (55/06, Arcor AG & Co./Bundesrepublik Deutschland).

56 VG Köln, Decision of 27.11.2008, AZ.: 1K1749/99; VG Köln Decision of 27.8.2009, AZ.: 1K3481/01.

relevant standard nor give a meaningful guideline how eventually to combine both cost standards in a relevant and meaningful way.

In any case, on the basis of the ECJ decision the German Administrative Court declared the TAL decisions of BNetzA from 1999 and 2001 as invalid. This Court case is not yet finalized because BNetzA appealed against the decision.

Besides the open court cases, there is a discussion in Germany whether and to what extent the European Court's decision has any relevance to subsequent decisions on ULL prices and in particular on upcoming decisions. The competitive carriers' association VATM argues that the Court's decision has to be taken into account for all past and upcoming ULL decisions.[57] The BNetzA on the other hand doubts the relevance of the decision because there has been a change in the telecommunications legislation in Germany in the meantime.

The second topic which is highly debated in Germany is whether or not the European Court has set a binding new cost standard to be applied by BNetzA. While the competitive carriers in Germany argue, that the Court requires some kind of combination of historic and current cost as a new guideline for actual costs, the BNetzA does not interpret the Court's decision such that it requires a (new) combined cost standard. BNetzA interprets the European Court's decision such that it still gives the NRA the flexibility to choose between historic and current cost to determine the cost of ULL.[58] BNetzA's understanding is that the Court does not prescribe a combination of historic and current cost as a new (binding) cost standard called "actual costs" to apply.

One of the competitive carrier's association in Germany recently has published a study[59] to make the economically unclear "actual cost" concept of the European Court of Justice more concrete and calculable. The authors of the study define actual costs as historic cost up to the point of regulatory decision making and as current costs for the prospective two year regulatory period. The regulated price should then become a weighted average of these costs. The study calculated the historic cost on the basis of the investment values of BNetzA, deflated these values backwards and assumed significant higher depreciation periods. Without going into calculation details the authors calculated "actual" costs for the ULL rental for 2011 on this basis at 6.94€ (at the maximum) compared to a current regulated price of 10.20€.

On 31 March 2011 BNetzA made a new decision on the monthly ULL charges to be applied from 1 April 2011 to 30 June 2013. Basically the BNetzA used the same approach as before and calculated ULL charges on the basis of a current cost approach by using a cost modeling approach.[60] Monthly charges were reduced (in nominal terms) from € 10.20 to € 10.08. The sup-loop part was reduced slightly less (in relative terms)

57 See for instance the position of its legal advisor, Kühling (2010).
58 See BNetzA (2009), p. 20ff.
59 See Dialog Consult (2011).
60 See press release of BNetzA from 31 March 2011.

from € 7.21 to € 7.17. In its decision the BNetzA points out that the investment value of the copper loop has been increasing due to increased input prices, reduced economies of scope in the deployment of other infrastructure and a decrease in the number of copper loops. This increase of the capital cost base was compensated by an efficiency increase in OPEX cost components.

In January 2011 BNetzA published its draft decision regarding access obligations for market 4 including unbundled access to DTAG's FTTH network.[61] Unbundled access to the fibre loop of FTTH has to be provided regardless whether the network is deployed in a Point-to-Point (P2P) or a Point-to-Multipoint (GPON) architecture. In case of P2P unbundled access has to be provided at the Optical Distribution Frame (MPoP). In case of GPON access has to be provided at the splitter (Distribution Point). In case WDM PON is available in addition to access at the Distribution Point, access to a wavelength has to be provided at the ODF.

The decision only indirectly deals with the pricing of fibre access. BNetzA did not set an ex ante pricing rule for this type of access but decided in favor of ex post regulation of fibre ULL. Ex post price regulation works under German telecommunications law such that intended prices have to be notified to BNetzA in advance. BNetzA then has to check whether they are abusive e.g. are leading to a margin squeeze, are discriminatory or are abusively high. Ex post regulation does not require to apply the FL-LRIC cost standard which is generally required under German telecommunications law in case of ex ante price regulation.

In its comments to the BNetzA notification of market 4 remedies the Commission[62] made critical remarks regarding the access points in fibre networks and the lack of cost-orientation for access based on FTTH. The Commission asked for the imposition of the access obligation in a technology-neutral and not in a architecture-specific way. Otherwise, the dominant operator could be encouraged to make architectural choices with a view of possible regulatory consequences. In that sense access to the fibre loop in case of FTTH should be given at the most appropriate point in the network, which is normally the MPoP. In that regard the Commission asks for clarification of the access obligation. Regarding the ex post price control remedy for fibre access the Commission expresses its doubts that this methodology will not result in cost-oriented prices as required by Recommendation 25 and Annex I of the NGA Recommendation. In the view of the Commission the price control as proposed by BNetzA does not provide the necessary legal and regulatory certainty for access seekers. Therefore the Commission asks BNetzA to impose an ex ante price control based on true cost orientation for fibre access.

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61 See BNetzA (2011).
62 See SG-Greffe (2011) D/2/2850, Brussels 24/02/2011.

4.3.4 Italy

Price determination methods for the unbundled copper loop in Italy changed rather often in the last decade. AGCOM, the Italian NRA, just recently[63] decided to change the cost methodology for determining the appropriate price for the copper access lines from HCA to CCA. This was due to EU harmonization and in order to encourage a shift from copper to fiber by giving a proper "make-or-buy" signal to alternative operators. While the decision was made in 2009, the cost methodology is now for the first time applied in the actual market analysis. Also the accounting method changed now from FDC to Bottom-Up LRIC[64] as part of the same decision.

Table 4-7: LLU trend in Italy (monthly rental)

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
€ 8.30	€ 8.30	€ 8.30	€ 8.05	€ 7.81	€ 7.64	€ 8.49	€ 8.70	€ 9.02	€ 9.28
EU benchmarking (best tariff)			Price Cap (FDC/HCA		Cost orientation (RoR) on FDC/HCA		Price cap on BU-LRIC model (change from HCA to CCA)		

The price control method changed several times over the recent years. While in the years 2003 to 2005 the price was set by using EU-benchmarks, in 2006 and 2007 a price cap was applied on the cost determined by FDC/ HCA. In the two years to follow (2008 and 2009) price control was based on cost orientation (Rate of Return regulation), while in the market analysis under discussion now a price cap was applied once again for the years 2010 to 2012.

Under the BU-LRIC model used by AGCOM asset life times for trenches with ducts are 40 years, for trenches hosting direct buried cables 25 years, for aerial cabling poles 20 years. The asset life times for underground copper cables are assumed to be 25 years (in ducts or directly buried), aerial cables have the same life time as the poles, 20 years.

The WACC decreased over the last decade from 13.5% (before 2006) to 10.20% (2006 - 2009) and to actually 9.36% (2010 onwards). LLU prices had always been calculated as a national average. The BU cost model under use in the actual market analysis did not calculate the LLU cost on a nationwide geodata analysis, but was based on a sample of 50 MDF areas only of approximately 10,500 MDFs in total. According to a WIK analysis the choice of the sample taken by AGCOM systematically overestimate the LLU cost. This result is based on a BU-LRIC model which calculates costs on the basis of all MDF without sampling.

63 AGCOM resolution 731/09/CONS.

64 For Bitstream Access the cost methodology already in the past had been CCA, but the accounting method changed from FDC to BU-LRIC in parallel with LLU.

The determination of the copper LLU price includes two OPEX components, regular maintenance and fault maintenance (Table 4-8). The fault maintenance costs represent a significant share of the total LLU monthly cost and are under discussion in the Italian market. During the notification process of the results of the recent market analysis the Commission stated doubts in the AGCOM approach to assume the cost and case figures for fault maintenance delivered by Telecom Italia to be efficient. Thus the values have been decreased slightly in a not really transparent way.

Table 4-8: OPEX in monthly LLU prices 2008 - 2012

LLU cost components	LLU 2008 (FDC/ HCA) [€]	LLU 2009 (FDC/ HCA) [€]	LLU 2012 (LRIC/ CCA) [€]
Network cost (incl. regular maintenance)	5.11 (67%)	5.61 (66%)	6.83 (74%)
Fault maintenance[1)]	1.84 (24%)	2.28 (27%)	1.80 (19%)
Wholesale commercial cost	0.69 (9%)	0.60 (7%)	0.65 (7%)
Total monthly LLU price [€]	**7.64**	**8.49**	**9.28**

[1)] Cost components based on assumptions provided by Fastweb

There exists an option for a bitstream access product instead of an unbundled local loop in those MPoP areas, where due to technical reasons a LLU service cannot be offered. In MPoPs with lack of collocation space this bitstream is a temporary remedy until sufficient space had been provided by the incumbent. The bitstream price regulation follows that of the copper ULL.

AGCOM published its draft regulation on access services to next generation networks in January 2011 .[65] The public consultation process will end in the middle of March 2011, and the decision process will be finished after EU notification and final decision by AGCOM not before end of May 2011. The draft decision proposes to differ between areas of infrastructure competition or potential infrastructure competition and areas where only the incumbent Telecom Italia owns fibre access infrastructure. Remedies proposed are duct access, access to dark fibre and inhouse cabling, and in monopoly areas fibre LLU access at the MPoP, starting in 2013. If Point-to-Multipoint fibre topologies (with GPON network architecture) are deployed only fibre sub-loop access at a distribution point closer to the end customer is mandated. Bitstream access at the MPoP only is mandatory as long as a LLU (or sub-LLU) access is not available. A virtual ULL or VULA service in case of Point-to-Multipoint fibre topologies is not mandated. Dark fibre and fibre LLU differ in the network segments covered and the price structure. Dark fibre can be rented per network segment only (feeder, distribution,

65 AGCOM resolution 1/11/CONS.

drop/ inhouse), on an IRU base for 15 years, while fibre LLU ends at the CPE and has a short term lease contract paid on a monthly basis.

All prices for wholesale services considered in this proposal are based on cost orientation in a BU-LRIC manner, including a risk premium. But if the ducts already exist a specific risk premium cannot be applied. The difference between the two approaches (existing ducts without risk premium and new ducts with risk premium) is not quantified yet. The bitstream pricing may differ between areas with (potential) infrastructure competition and infrastructure monopoly areas. In the competitive areas it is proposed to only mandate nondiscriminatory pricing, while in the latter cost orientation shall be mandated.

4.3.5 France

Table 4-9 shows the evolution of LLU prices in France. The most prominent change is the one related to the 2002 decision[66] which reduced the number of lines taken into account for determining the cost of unbundling (see below) and reduced the WACC from 12.1% to 10.4%. Since 2005 ARCEP does no longer determine the LLU prices ex ante but verifies ex post that FT complies to its obligation to set “non-excessive” tariffs. France Telecom dropped the price to 9.50€ and to 9.29€ in 2006. France Telecom explained that productivity gains allowed to decrease the wholesale price from 9.29 to 9€ in January 2009.

Table 4-9: Monthly LLU prices in France from 2000 to 2011

<table>
<tr><th>Date</th><th>11-2000</th><th>07-2001</th><th>06-2002</th><th>06-2005</th><th>01-2006</th><th>01-2009</th><th>01-2011</th></tr>
<tr><td>LLU price</td><td>17.10€</td><td>14.48€</td><td>10.50€</td><td>9.50€</td><td>9.29€</td><td>9.00€</td><td>9.00€</td></tr>
<tr><td>Cost base</td><td colspan="4">LRAIC</td><td colspan="3">LRAIC/ FDC (?)</td></tr>
<tr><td>Asset valuation</td><td colspan="4">Successive replacement cost
(les Coûts de Remplacement en Filière (CRF))</td><td colspan="3">Current cost with economic amortisation (~tilted annuity)</td></tr>
<tr><td>Basis of cost calculation</td><td colspan="2">100% of lines</td><td colspan="2">~70% of lines</td><td colspan="3">~95% of lines</td></tr>
<tr><td>WACC</td><td>>12.1%</td><td>12.1%</td><td>10.4%</td><td>?</td><td>?</td><td>10.7%</td><td>?</td></tr>
</table>

Source: Bouygues, WIK

In France copper access line costs are not determined on the basis of all lines which was the case only up to 2002. In 2002 ARCEP took note[67] that alternative operators

66 ARCEP decision 02-0323.
67 ARCEP decision 02-0323, p. 15/16.

tend to unbundle lines primarily in denser populated areas and that the average copper local loop costs depend on the density of the area. ARCEP decided to distinguish two areas, one densely populated area where it is likely that other operators will invest in unbundling within two years and a lower density area where it is highly unlikely that such investment will occur. At that time ARCEP considered about 70% of total lines for determining the LLU cost. Therefore the cost of the French LLU cost was dominantly derived from the average copper cost in denser areas (about 21mn lines of 34mn lines).[68]

In 2005 ARCEP noted[69] that the footprint of unbundling had enlarged significantly (also due to activities of local governments) bringing the average cost of unbundled lines closer to the average cost of all lines. However, ARCEP also noted that the existence of the compensation fund for Universal Services was likely to conflict with a LLU price based on all lines. It was decided to exclude the longest lines from the LLU cost determination. These make up 5% of all lines so that the new regime extended its copper pair average cost base to 95%.

Up to 2005 the cost of unbundled local loops in France was determined as Long-Run Average Incremental Cost.[70] The asset valuation was based on Successive Replacement Cost ("les Coûts de Remplacement en Filière"). This approach was originally proposed by France Telecom and is supposed to emulate a "make or buy" decision of either renewing or maintaining an asset. It determines the asset value as the difference between 1) the cost of renewing the asset immediately at its market value and 2) the cost of maintaining the asset until the end of its lifetime.[71]

In 2005 ARCEP changed the asset valuation to current cost with economic amortization. However, under this approach the asset is not valued at its "economic" value based on future discounted revenues. The approach is effectively a tilted annuity method. While mathematically equivalent to the replacement cost approach applied in previous decisions, it is not applied to a theoretical investment path but to the historical investment path. According to ARCEP this methodology has three main advantages[72]: non-discrimination (in particular between the different offers of France Telecom), creation of an incentive for FT to invest efficiently in the copper local loop, and an incentive for alternative operators to invest efficiently in unbundling.

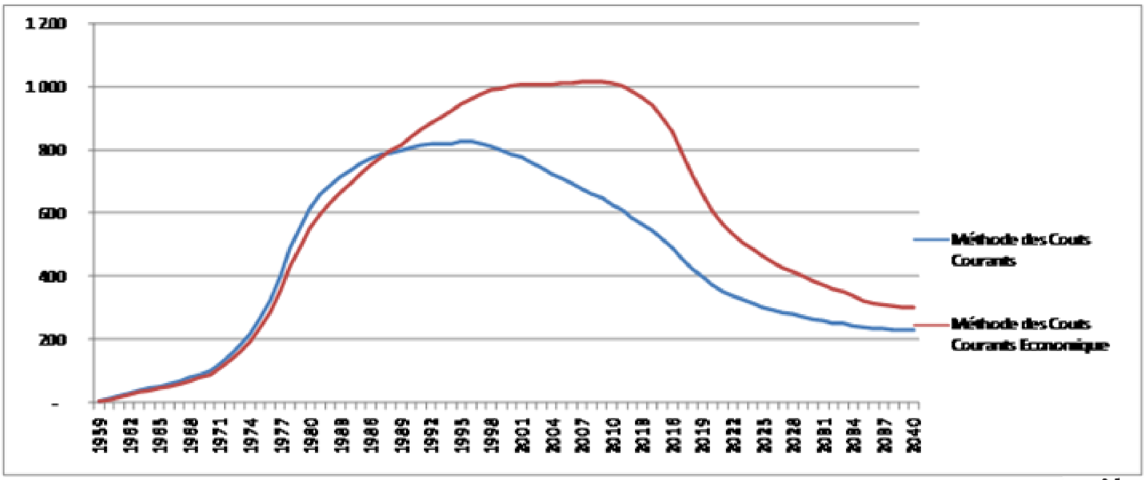
ComReg summarizes this approach in a consultation of cost methodology as follows[73]: "With the economic amortization method, the increase in the depreciation charge over time exactly counterbalances the decrease in the capital charge over time, which implies that the sum of the depreciation charge and the cost of capital are constant over

68 In the 2005 decision 05-834 ARCEP quantified this share still as 70% of all lines.
69 ARCEP decision 05-834, p. 31/32.
70 EU Commission Case FR/2005/0174.
71 ARCEP decision 05-0834, p.8, ComReg 08/56, p. 24/25.
72 EU Commission Case FR/2005/0301.
73 ComReg 08/56, p. 26. The exact method remains unclear to us.

the years if prices are stable. Therefore, LLU prices that are based on these charges are less influenced by the short term investments of the incumbent. Also, the annuity varies with asset price changes, which would give proper signals to investors."

Current cost with economic amortization (e.g. tilted annuity) shifts depreciation to later years compared to current costs with straight line amortization. The impact of this effect is shown in Figure 4-4 which shows the investments in ducts in France given constant investments after 2006. The blue graph represents investments for ducts in current costs (depreciation plus cost of capital based on remaining net book value) and the red graph is current cost with economic amortization. The costs do not include OPEX. Alternative operators complain that this approach is inappropriate when considering assets that will not be renewed like ducts and that it overcompensates the incumbent.

Figure 4-4: France Telecom Investment into ducts (without common cost and OPEX, in mn €, constant investments from 2006)



Source: Bouygues

The cost standard applied by ARCEP after 2005 appears to be a Fully Allocated Cost standard.[74] To our understanding ARCEP has mainly conducted ex post price control with top-down cost models.[75]

In the course of the 2005 consultation historic cost accounting and the previous successive replacement cost method were discarded.[76] The reasons for deciding

74 ComReg 08/56 calls the approach FAC. Also, the present cost determination includes direct and indirect costs with 6% common cost mark-up which may be an indicator for FAC rather than LRAIC. It is however, not entirely clear to us which approach ARCEP is applying.

75 To our knowledge Bottom-Up models have not played an important role in ARCEP's decision making, even though some early LLU prices have been set ex ante. In addition, some of the price changes shown here may have been a result of France Telecom reducing the price in advance of an ARCEP decision.

against historic cost accounting were primarily that it does not take the evolution of prices into account. In addition ARCEP stated that historic cost accounting does not allow to moderate the impact on prices from changes in the investment rate. ARCEP states that successive replacement cost does not encourage efficient investments by France Telecom and would lead to high LLU prices.[77]

In November 2010 ARCEP published a decision regarding the economic conditions that would rule access to ducts in France Telecom's access network.[78] The decision in particular determines how the relevant cost of duct is to be shared by the copper and fibre loops. The relevant cost is determined from the normal regulatory accounts as it relates to the local loop. (It apparently excludes costs that are explicitly incurred to enable roll-out of fibre FTTX that would not have been necessary if one had used a less volume consuming technology.[79]) ARCEP considers four indicators for determining the shares of the costs of the duct network to be allocated to copper and fibre. These are the relative lengths of copper and fibre cables, the relative volumes that copper and fibre cables occupy in the ducts, the relative volumes of cables effectively in use, and the relative number of customers that get access either over copper or fibre. ARCEP decided to use the last of these approaches. The reason is that allocating the cost according to the numbers of customers using either technology would better reflect the needs of long-term transition from copper to fibre. It would allow a progressively increasing share of the relevant costs to be charged to fibre as it would be proportional to the corresponding revenues. It would also not disturb the equilibrium of current services using copper as technology. ARCEP reports that the majority of respondents in the public consultation expressed themselves in favor of this approach. ARCEP's approach does not reflect any cost-based pricing rule but represents value of service pricing. Over time the cost allocation approach brings the allocation of costs closer to the actual capacity used by each technology. In the first years when the penetration of fibre still is low, fibre uses a (much) larger share of duct capacity than costs are allocated. ARCEP's allocation approach lightens fibre from costs it would otherwise have to carry and reduces the risk of fibre investment to a relevant degree. This method of allocation, however, also amounts to a cross-subsidization of fibre by copper, as the share of the actual use of duct space by fibre is presumably larger than the share of customers currently getting access over fibre.

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76 During the consultation process stakeholders also proposed a price-cap approach and the Infrastructure Renewal Accounting method. Both were discarded by ARCEP for being a mechanism for tariff control rather than asset valuation (price-cap) and too theoretic (Infrastructure Renewal Accounting).

77 ARCEP decision 05-0834.

78 See ARCEP decision 2010-1211 of 9 November 2010.

79 See p. 8 of the decision.

4.3.6 Spain

On 23 February 2011 the Spanish NRA CMT published a statement in which the results of a review of the regulated prices of four products are reported. The four products reviewed and the proposed changes to their prices are shown in Table 4-10.

Table 4-10: Products reviewed by CMT and proposed changes to their prices

Product	€/month		Change in %
	Current	Proposed	
Copper ULL monthly rental	7.79	8.32	+6.8
Shared monthly rental	2.06	2.06	0
Naked bitstream monthly rental	9.55	9.11	- 4.6
Wholesale acces to the analogue telephone line	11.28	10.75	- 4.7
Wholesale acces to the ISDN telephone line	18.61	14.86	-20.2

Source: CMT (2011)

The most relevant change shown in Table 4-10 is the one for the copper ULL monthly rental, and we will focus on it in the following. Before we do this, some comments on the proposals regarding the other three products are in order.

- *Shared monthly rental* CMT proposes no change to the rental. The proposal is not based on any cost appraisal. It is claimed that the market for the product is declining and does not share in the dynamism which is characteristic for the unbundled access market in general. Further it is argued that this development reflects the preferences of customers as well as the strategies of the operators who do not put great efforts into promoting this product. It is implied that no further decrease in the price for this product is justified given that it is already at a very low level.

- *Naked bitstream monthly rental* The reduction in the price for this product follows from the finding of CMT that the component "STB activation", heretofore considered part of the product, actually does not belong to it. Correspondingly the cost of this component has been taken out of the total cost for the product. Furthermore, the mark-up to account for costs that cannot directly be accounted for has been reduced from 11.05 % to 5 %. For details regarding the cost reduction, the reader is referred to the confidential annex of the CMT document.

- *Wholesale access to analogue and ISDN telephone lines* The reductions in the prices for these two products follow from the evaluation of Telefónica's cost accounting records for 2008. For details the reader is referred to the confidential annex of the CMT document.

As regards the monthly rental for the copper ULL, Table 4-11 below shows its development since January 2001.

Table 4-11: ULL monthly rentals from 2001 until present

Period	€/month
January – December 2001	13.00
January – December 2002	12.62
January 2003 – March 2004	12.32
March 2004 – September 2006	11.35
September 2006 – November 2008	9.72
Since November 2008	7.79

From Table 4-11 follows that this is the first time that an increase in monthly copper ULL rental is being proposed. The CMT goes to some length explaining the procedure that it used to arrive at this result.

The line of argument can be summarized as follows:

- Telefónica's cost accounting system is criticized on several counts. In particular, it is observed that the costs that would emerge would tend to overstate the relevant costs. Nevertheless it is pointed out that despite the deficiencies in the cost accounting records, there are indications that the cost of the unbundled loop would be substantially higher than the current price for it. The reason is seen in a structural disequilibrium between Telefónica's existing network and the one demanded. The reason for this is seen in that more and more households remain without a fixed connection so that the number of lines are decreasing. This tendency is expected to continue into the future.

- It follows a discussion of the likely market evolution which comes to the conclusion that in the face of the uncertainties inherent in this development, a change in the economic parameters on which regulation is based should be contemplated. It is further argued that, in order to obtain cost estimates that are independent of the cost accounting records of the operator, CMT should have at its disposal an instrument with which to determine the cost of the unbundled copper loop independently. Such an instrument should be a bottom-up cost model. The procurement of such a model is under way.

- It is then argued that in the light of the foregoing discussion one could already undertake a prudent adjustment of the rental which would avoid disruptive changes in the business cases of the operators. The notion of a *climb path* is introduced analogous to the *glide path* used for declining rates for other markets. It is mentioned that Ofcom in the UK and Agcom in Italy have already been applying this concept.

- The new proposed copper ULL rental is then derived on the basis of a benchmark analysis. The starting point consists of the monthly copper ULL rentals of 13 EU countries (including Spain[80]). It is then found that the rate for Spain is below the average of these 13 rates. By an argument, which need not be recapitulated here in detail, the proposed rental of 8.32 € per month is then derived, one of the arguments in its favor being that it is below the average of the rates in the set of benchmarks which equals 8.68 €. The concluding statement is that the increase from 7.79 € to this level would in all likelihood not be inconsistent with the results to be expected from the future cost model as well as with the appropriate regulatory intervention called for at the present time.

In the discussion summarized above there is no mention that the cost of overcapacity in the access network, caused by the decrease in the uptake of lines, should not be rolled into the cost of lines actually in use. It appears that without a trace of a doubt it is accepted that declining numbers of lines will inevitably lead to higher unit costs

4.3.7 Australia

Australia is on its way to set up a nationwide fibre network financed by the state and operated by a state-owned entity called NBN Co. To manage the transition from the current industry and network structure the Australian government has negotiated an agreement with the incumbent operator of the copper network Telstra in 2010.[81] This agreement deals with the decommissioning of the existing copper and HFC networks, the migration of existing Telstra end-users onto the NBN Co fibre platform and the use of Telstra's existing passive infrastructure (e.g. ducts, conduits acquired) for deploying the NGN fibre network. The agreement assumes a progressive disconnection of copper services and decommissioning of Telstra's fixed line copper and HFC networks as the NBN FTTP network is rolled out.

Related or unrelated to this major restructuring of the industry, the Australian Competition and Consumer Commission (ACCC) initiated a major reform of the access pricing principles for fixed line services in December 2009.[82] The new access pricing principles will be applied to all legacy network services delivered over Telstra's copper

80 See Table 4-1.
81 See NGN Co. (2010).
82 The ACCC published a first discussion paper in December 2009, a draft report in September 2010, and made its final decision in March 2011.

network including ULL[83], wholesale line rental, PSTN origination and termination and other services. The new approach relies on a review of the 1997 telecommunications access pricing principles. According to these principles, the ACCC has considered that the long term interests of end-users are best promoted by cost-based access prices based on the total service long-run incremental cost of providing the service, including a mark-up for overhead costs (TSLRIC+). TSLRIC is based on a forward looking incremental cost basis valuing inputs using current prices.

According to the ACCC's assessment, application of TSLRIC had the following (critical) implications:

- The continual revaluation of network assets means that there has been ongoing uncertainty over the level of access prices.
- TSLRIC compensates an access provider as if it is continually upgrading assets even when they continue being used beyond their assumed lifetime, thus generating little incentive to upgrade the copper network to modern access technologies.
- Past depreciation of existing asset values not being taken into account may have resulted in over-recovery by the access provider.
- Considerable uncertainty regarding what constitutes a modern equivalent asset (MEA).
- Less profitability of the copper access network being bypassed by own investment of access seekers given the current technological and market developments. Telstra's copper access network remains an enduring bottleneck instead of a network to be bypassed.

As a consequence of its concerns over the inappropriateness of the access pricing principles as applied so far, the ACCC released a discussion paper in December 2009 considering a different pricing approach for regulated fixed line services. The ACCC decided to move to a building block approach with a locked-in initial regulated asset base (RAB). The so-called building block model (BBM) approach is an established approach to determine the revenues required by regulated businesses which has been widely adopted by Australian utility regulators in other sectors. The new approach determines an initial value for the RAB, locks it in and rolls it forward from one year to the next to reflect net capex.

83 This services is called unconditioned local loop service (ULLS) in Australia.

The BBM approach involves and requires the following steps for calculation:[84]

- Forecasts of operating expenditure for each year
- A return of capital of the regulated firm (i.e. depreciation)
- A return on capital to the regulated firm (i.e. compensating the firm for its efficiently incurred investments)
- Efficiency mechanisms and service quality incentives
- Forecast tax liabilities.

The revenue requirement for each year is determined using the following formula. For example in year one:

$$RR_1 = Expected\ (OPEX_1) + \underbrace{(RAB_0 * WACC)}_{\text{Return of capital}} + \underbrace{Expected\ (DEP_1)}_{\text{Return of capital}} + Expected\ (TAX_1)$$

Where

- RR is the revenue requirement
- OPEX is operating expenditure
- WACC is the weighted average cost of capital
- RAB is the regulatory asset base
- DEP is depreciation
- TAX is tax payable.

The ACCC considered possibilities for the RAB in the range between the scrap value up to the optimized replacement cost. While the scrap value could be justified by the sunk nature of the copper network, it would be inconsistent with the access provider's legitimate commercial interests. The ACCC also decided to take into account past recovery received by the access provider for the regulated assets, thus minimizing the risk of cost over-recovery or cost under-recovery. No further adjustments for any estimated past over- or under-recovery will be made after the initial RAB is set. From the various possibilities to value the initial RAB, the ACCC chose the depreciated actual cost (DAC) approach which adjusts the historic cost of an asset by the proportion that the costs have already been recovered.

The ACCC assumes that the DAC pricing approach provides efficient investment incentives because the access provider can recover its actual capital costs. Sunk assets become recovered, there is no regulatory opportunism. The roll-forward mechanism will permit future efficient investments in sunk assets. The ACCC argues that the initial RAB value has no implications for competitive neutrality because bypass of the existing copper access infrastructure is unlikely. By locking-in a value for the

84 See ACCC (2010), p. 30.

RAB, reliability and certainty for both the access provider and access seekers is improved.

It is interesting to note which changes in the wholesale rates this fundamental change of the accounting and costing approach would cause. The ACCC calculated draft indicative prices as shown in Table 4-12.

Table 4-12: Current indicative prices compared with draft indicative prices from 1 January 2011 to 31 December 2014 (in AUS $)

	Current indicative prices	Draft indicative prices based on initial RAB of $7.5b
ULLS access prices with geographically de-averaged prices		
SIO-weighted national average (per line per month)	$28.50	$28.42
Band 1	$6.60	$6.50
Band 2	$16.00	$16.00
Band 3	$31.30	$31.00
Band 4 (nominal)		$100
WLR (per line per month)	$25.57 (Homeline) $26.93 (Businessline)	$20.00 (nationally averaged)
LSS (per line per month)	$2.50	$2.50
PSTN OTA (per minute)	1c (headline rate)	1.1c
LCS (per call)	17c	7.0c

Source: ACCC (2010), p. 55

The interesting result is that the ULL prices would effectively not being changed; resale product prices would be cut by between 25% and 60% and termination would increase by 10%.

Because the ACCC received a lot of critical comments to its draft report in particular from the incumbent Telstra[85], it could not implement its approach in time (1 January 2011). The ACCC made its final decision on 3 March 2011[86] and released its new interim access determinations at that time. The new rates have been backdated to commence on 1 January 2011 and expire on 31 December 2011 (or on the introduction of a final access determination for that service). The ACCC totally changed the structure of the ULL prices compared to its original proposal as represented in Table 4-12. The ACCC came back to a much more averaged pricing approach with significant price increases for the more dense areas. It decided to set a single copper access price of $ 16 for CBD, metropolitan and regional areas (Bands 1 to 3) – the same price previously

85 See Telstra (2010).
86 See ACCC (2011).

set for metropolitan areas (Band 2). The ACCC has also, for the first time, set a price for Band 4. The Band 4 price is for the most remote areas. In June 2010, there were only about 144 active ULL lines in Band 4 compared to over 690,000 active lines across Band 1 to 3. Table 4-13 compares the previous prices with the prices to apply from 1 January 2011 due to the new costing approach.

Table 4-13: Previous indicative prices compared with IAD prices to apply from 1 January 2011 to 31 December 2011 (in AUS $)

ULLs access prices with averaged prices	Previous indicative prices	New IAD prices
Band 1	$6.60	$16.00
Band 2	$16.00	$16.00
Band 3	$31.30	$16.00
Band 4		$48.00
WLR (per line per month	$25.57 (Homeline) $26.93 (Businessline)	$22.10
LSS (per line per month)	$2.50	$1.80
PSTN OA and TA (per minute)	1 c (headline rate)	1.0c
LCS (per call)	17c	9.1c

Source: ACCC (2011)

Although the ACCC has rejected national averaging of ULL prices in the past, it is mainly justifying its return to averaging with the changing nature of the telecommunications industry and in particular NGN Co's stated intention to charge uniform national wholesale prices for using the NBN. Averaging of Band 1 to 3 ULL prices at this time will ease industry's transition to national wholesale pricing for the NBN. Band 4 access areas are not part of the averaging because they are largely outside the fibre footprint. Averaging, furthermore simplifies the ULL price structure and may reduce administrative costs. The ACCC assumes that for most access seekers the Band 1 price increase will be more than offset by the lower Band 3 ULL prices and lower prices for other regulated fixed line services. The reduction in price charged in Band 3 may even promote further investment in those areas.

4.4 Summary of findings

European NRAs reveal relatively clear preferences regarding price control methods, cost base and accounting methodologies for regulating wholesale charges for local loop unbundling. The preference is for cost orientation, a trend towards using current cost accounting and a fairly even distribution of using LRIC and FDC accounting methods. Despite this high degree of harmonization in principle, costing methodologies in detail however, vary significantly. As a consequence the range of ULL prices is rather large in Europe.

Some NRAs control ULL wholesale prices ex ante, others only ex post or set rate ceilings. The accounting lifetime of assets vary from 15 to 25 years for copper cables and from 30 to 45 years for ducts. The relevant WACCs for the access networks are in a range of 7% to 13%. The ULL charge usually (with a few exceptions) represents a national average of the loop costs despite the fact that costs vary significantly according to access density and competitors' demand for ULL is focused on the denser part of a country. Asset valuation is at current costs, historic cost or a combination of both. Even more important are the differences in the way in which current costs are calculated; here seems to be a lot of discretion for incumbents and/or NRAs. Some NRAs apply the current cost valuation on all network elements as installed in the access network; other NRAs apply efficiency considerations and only take into account those network elements and assets which are needed to run the access network efficiently. Some NRAs inform their cost calculation through bottom-up cost models, others through top-down models, a third group just relies on accounting information provided by the incumbent. Also the depreciation methods vary from straight line to economic depreciation where the latter often is made operational by a tilted annuity approach.

There are more differences in the costing methodology when certain cost parameters are being considered. The differences mentioned above are more related to basic methodological aspects. They should explain that the differences in regulated ULL prices which can reach a factor of three in Europe are not only explained by structural national cost differences but are to a large degree also the result of fundamental differences in detail in applying the same basic costing methodology.

The vast majority of NRAs is not yet addressing the costing and pricing implications of decreasing demand for copper access lines properly as we have argued in Chapter 2 and 3 of this study. Some NRAs increased ULL prices in their latest decisions (like the UK and Spain) even though (and sometimes because) demand is decreasing. In Italy the NRA even switched from HCA pricing to CCA with a major price increase in a moment in time where this switch is most questionable.

Some NRAs are beginning to identify and to address the issue that certain costing methodologies may lead to over-recovery of the relevant cost and therefore may distort competition between the incumbent and its competitors.

Not all NRAs seem to apply systematic margin squeeze tests to check the appropriateness and consistency of wholesale and retail prices. In Austria the systematic application of a margin squeeze test has even led to a retail minus rule as the effective calculation method to determine the adequate level of the wholesale price.

Our analysis and results on costing methodology indicate, that increasing copper access charges is not the appropriate regulatory answer to a shrinking demand for copper access. Also the transition to fibre networks requires other answers to copper wholesale prices than many NRAs have given so far as we will show in the following chapters of our study.

5 Modeling the copper and the fibre access network

5.1 General approach

Our basic modeling relies upon an engineering bottom-up cost modeling approach. This means we model the total cost of the services considered under efficient conditions, taking into account the cost of all network elements needed to produce these services in the specific architecture deployed. This approach is coherent with an LRIC approach as applied in regulatory economics.

We calculate the cost of a Fibre-to-the-Home network following a Greenfield approach. This means that the investor will construct a new, efficient state of the art network from scratch, assuming that currently existing infrastructure, if included in the new network, has to be considered at (full) cost.

However, when considering to deploy fibre networks as next generation of access networks there could be available infrastructure from legacy networks which may be reused for NGA to generate investment savings. This possibly could have an impact on the investment decision. Therefore we have also run a sensitivity with reduced investments for FTTH, which we call Brownfield scenario (Section 5.4.4).

The model and the assumptions are basically the same as in a recently published study which we have conducted for Vodafone on fibre architectures and competition.[87] The primary differences are an improved optimization algorithm for cable sizes and increased asset lifetimes of passive infrastructure. In addition, we do not model the in-house fibre cabling and have also adjusted the ARPU accordingly. The fibre network is modeled on the basis of Point-to-Point architecture as that is considered to represent the most future-proof technology and also enables efficient unbundling. GPON would result in slightly lower build costs – around 10% reduction. However, as discussed in the study for Vodafone, reduced costs would be more than counteracted by the more limited capacities of this network design and poorer competitive and retail dynamics.

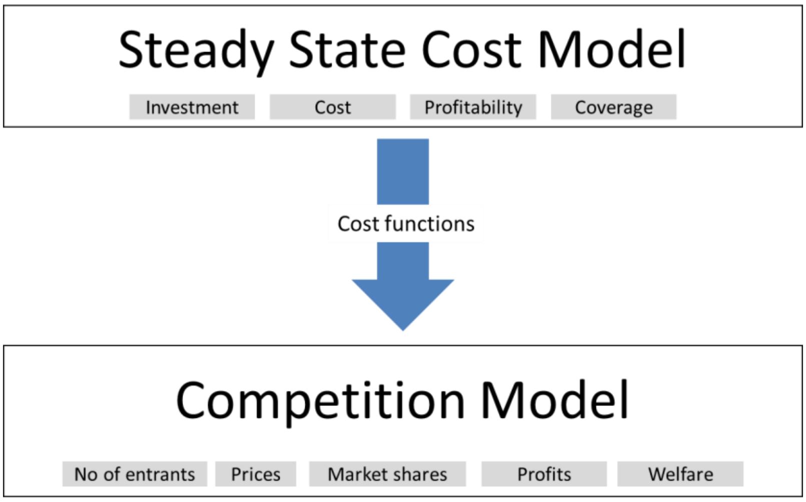
The costs of the copper network are not modeled explicitly. We started here from the European average ULL charge as a representative of the LRIC of the copper network. Using the same modeling structure we then derived the cost of the copper network in the various clusters from that starting point. We also modified the LRIC as relevant cost platform for the copper network and also considered SRIC as a decision relevant cost platform for the incumbent operator.

We have developed two partly interlinked modeling approaches to analyze the impact of different architectures and wholesale scenarios on investment, cost, profitability, reach, competition, market shares, prices and welfare. The first model is a steady state cost

87 See Hoernig et al. (2010).

model. This model feeds cost functions into the second model environment which is a strategic competition model. Figure 5-1 shows the relations between the two models and their primary outputs (grey). This section explains the cost model and shows our results primarily related to determining the investment and cost of FTTH and copper networks. Chapter 6 is dedicated to the competition model.

Figure 5-1: Overview of modeling framework



5.2 Euroland

The viability of access networks strongly depends on the subscriber density (subscribers per km²) and on settlement structures. The denser the subscribers, the sooner the access network will become viable. Thus the modeling depends on concrete settlement structures of a given country and the results derived depend on that country.

For purpose of this study we decided not to choose a dedicated European country but chose a settlement structure which is typical for European countries. We designed a hypothetical country for approximately 22 million households or a population of around 40mn inhabitants. This country is referred to as “Euroland”. We have defined 8 clusters, each having typical structural access network parameters derived from detailed geo-modeling of access networks in several European countries on a nationwide basis. The geotypes characteristics rely on exact data from several countries. In that sense, Euroland is a generically representative country.

Each of the 8 clusters is characterized by specific subscriber densities. The viability of a specific business model is calculated for each cluster separately, like for a separate profit center, i.e. the viability of a business model in Cluster 1 is independent from the viability in Cluster 2. In each of the clusters we assume the access network to be rolled out to 100% homes connected. For each of the clusters, the point where the NGA business may become viable is calculated individually and independently from the results of other clusters. The operators (incumbent and entrants) invest in all clusters which are viable.

The clusters are composed in a way that they address similar numbers of potential subscribers. Table 5-1 provides an overview of the resulting cluster classification.

Table 5-1: Structural parameters of Euroland

Geotype	Cluster ID	Potential customers per km²	Total potential customers per cluster	Share of total customers	Potential customers (cumulated)	Number of MDF	Potential customers per MDF	Average trench length per potential customer (m)
Dense urban	1	4,000	1,763,916	8%	1,763,916	69	25,564	2.4
Urban	2	1,600	2,163,672	10%	3,927,588	168	12,879	5.4
Less Urban	3	800	2,646,000	12%	6,573,588	252	10,500	7.8
Dense Suburban	4	470	2,062,480	9%	8,636,068	280	7,366	10.2
Suburban	5	280	2,460,360	11%	11,096,428	303	8,120	13.1
Less Suburban	6	150	2,989,056	14%	14,085,484	417	7,168	17.4
Dense Rural	7	60	4,331,208	20%	18,416,692	1,421	3,048	28.6
Rural	8	< 60	3,448,368	16%	21,865,060	2,488	1,386	55.1
			21,865,060	**100%**		**5,398**		

The steady state model runs for all 8 clusters described in Table 5-1. Typically in the dense clusters there are larger MDF locations concentrating significantly higher numbers of potential subscribers than in the rural areas, thus with 28% of the MDF one can already cover 64% of the potential subscribers (Cluster 1–6). Our assumption is that the number of MDF for copper equals the number of MPoPs for a FTTH roll-out, i.e. we have modeled a steady state in which no MDF locations are dismantled.

The clusters are mainly used to consider the cost differences due to the different geographic and settlement information. We use cluster-specific individual input data for access network structure input data, for construction cost and for deployment methods (e.g. underground ducted, buried or aerial cabling). The main cluster-specific values are the construction cost of ducts/cables, manholes, sleeves and aerial cables and the inhouse cabling. Construction costs are highest in the densely populated areas, while aerial cabling is used to a larger degree in the rural areas.

Table 5-2: Aerial deployment share per cluster

Cluster ID	Aerial share
1	0%
2	0%
3	10%
4	20%
5	30%
6	40%
7	60%
8	60%

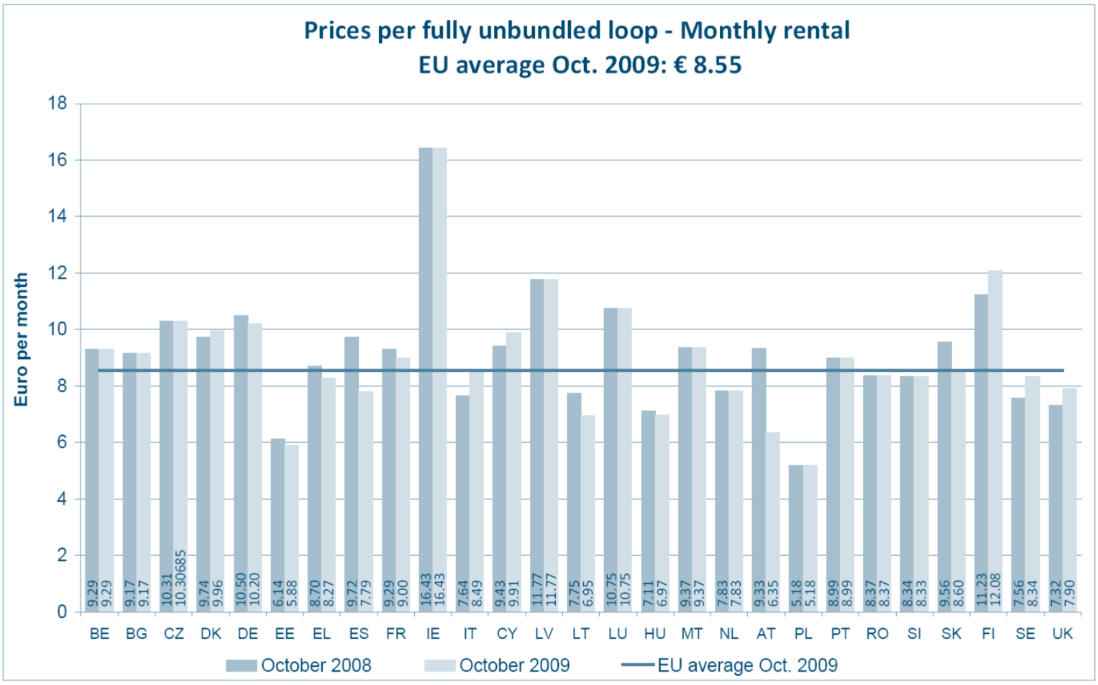
The values for MPoP components like Ethernet switches/ ports, OLTs, ODF ports and patch cables and fibre splices and also the prices of fibre cables and CPE are identical for all clusters.

Our clustering approach also enables us to determine the viability of each of the clusters independently from other clusters. We have approached the modeling of the passive copper and fibre access network in slightly different bottom-up calculations. They are described in the two following sections.

5.3 The copper access network

The copper access network connects every customer of Euroland in every cluster. We have opted for an approximation of copper network costs by basing them on the European average of monthly LLU cost (8.55€, see Figure 5-2). That means we take the LLU charge as a proxy for the incumbent's LRIC in Euroland. Therefore, the monthly fixed cost of operating the passive copper network that connects all of Euroland's 22mn customers to MDF locations is (in principle) 22mn times 8.55€[88]. Since the competition model only considers the first four clusters we have derived cluster-specific LLU charges by weighting the average national charge with loop lengths, investment per meter and number of lines per cluster. We derived the following cluster-specific monthly copper network costs per line (see Table 5-3). These costs represent the passive network from the Network Termination Point at the customer site (without inhouse cabling[89]) to the MDF in the central office.

Figure 5-2 European unbundling prices



Source: 14th EU Implementation Report

88 We assume that in addition to network cost the wholesale price also includes sales cost (including inter-carrier billing) of the incumbent's wholesale division. We assume that this cost is 0.90€ per month, which is a value more at the high end of the relevant cost estimates. This is part of the variable cost per subscriber in Table 5-4 and Table 5-9.

89 The costs of the inhouse cabling are not part of the LLU charge in many countries.

Table 5-3: Deriving cluster-specific copper network costs from the national average

Cluster	Averaged LLU charge	Deducted LLU-cost per cluster (production cost of the incumbent)	Number of customers	Adjusted monthly fixed cost of incumbent
1	8.55€	2.06 €	1,763,916	2,046,143 €
2		4.16 €	2,163,672	7,053,571 €
3		5.64 €	2,646,000	12,542,040 €
4		5.49 €	2,062,480	9,466,783 €
5		6.48 €	2,460,360	13,728,809 €
6		7.81 €	2,989,056	20,654,377 €
7		9.86 €	4,331,208	38,807,624 €
8		19.17 €	3,448,368	63,001,683 €

Not surprisingly, in denser areas the incumbent produces at a monthly cost lower than the (nationally averaged) access charge that competitors have to pay for unbundling. This is important to note because it implies wholesale profits for the incumbent in the competition model which only considers Clusters 1 to 4 under certain assumptions on the wholesale price. The incumbent's monthly fixed cost of operating the passive copper access infrastructure in Euroland is therefore the sum of the first four clusters' homes multiplied with the respective deducted cluster-specific LLU cost. To remain comparable with our FTTH cost calculation we need to track sales cost aspects (see footnote 88) separately from network cost and as subscriber-driven (rather than homes passed-driven) cost. We have therefore reduced the cluster-specific LRIC by 0.90€ (last column in Table 5-3; also see Section 5.4.2). The only variable cost elements of the access network are therefore these "sales cost" and the network sided ODF port that is driven by subscribers rather than by homes passed (0.02€ per month). All other passive access network costs are fixed.

For feeding inputs into the competition model properly we have divided the incumbent's operation into a NetCo and an OpCo unit. The NetCo provides the passive access network to entrants (and to its own downstream organization) and the OpCo runs the active components of the network and markets it to customers. The OpCo bears the cost for active equipment in the exchange (DSLAMs, Ethernet Switches) and their energy consumption, concentration and core network, central office floorspace, CPE and retail cost (customer acquisition, sales and marketing, customer care, churn and billing). These cost items are dominantly variable costs except for the fixed cost components of the core and concentration network and the floorspace itself. The wholesale access seeker also bears the OpCo's downstream cost elements which are largely similar to those of the incumbent but not identical. The difference is that we have accounted for a separate small MDF that the access seeker will install in addition to the incumbent. Furthermore we assume that in terms of the sales costs discussed earlier the incumbent self provides access at a lower cost than to entrants.[90] This explains the difference in variable downstream cost components between OpCo and entrant. The access seeker only faces variable costs for the NetCo components because he buys unbundled access which is assumed to be priced solely as variable access charge.

The cost of inhouse cabling was not considered. The aggregate cost functions for incumbent and entrant for the first four clusters are shown in Table 5-4. This is the input for the competition model. Variable cost is cost per subscriber per month.

Table 5-4: Total monthly cost for the copper network (Clusters 1-4)

	Copper incumbent	Copper LLU entrant
NetCo fixed cost	31mn €	0 €
NetCo var. cost	0.92€	8.55€ (LLU charge)
OpCo fixed cost	7mn €	7.6mn €
OpCo var. cost	9 €	9.68 €

As we have shown in Section 2.2 the incumbent's decision to switch from a copper to a fibre network does not depend on the LRIC replacement cost of the copper network but on the cost of operating and maintaining the copper network. These costs are called short run incremental costs (SRIC). The SRIC are basically OPEX of the copper access network. To calculate the relevant amount of these costs, we have analyzed three different cost models with a view towards the share of monthly OPEX as part of total LRIC and found the results as shown in Table 5-5. Based on the range of these findings we chose to base the SRIC in this model on 20% of the total LRIC cost.

90 This is reflected in a discount of variable cost for the OpCo. It was modelled this way in order to have a NetCo incumbent wholesale unit that sells at a uniform price to both access seekers and incumbent OpCo.

Table 5-5: Comparison of OPEX and CAPEX of average monthly cost for LLU

	CAPEX	OPEX	Total	OPEX as a % of total cost
WIK model for Italy	6.01	0.85	6.86	12%
Swedish model of PTS	6.05	2.09	8.14	26%
Danish model of NITA	6.44	1.18	7.62	15%

Source: WIK-Consult

5.4 The FTTH network

There are several FTTH network architectures one can deploy. Since this study is not intended to compare these architectures but to model fibre/copper migration in a competitive market environment, we concentrate on one fibre architecture which is most future proof. For a comparison of advanced FTTH architectures we refer to our recently published study that used the same modeling structure and compares the performance of several FTTH architectures.[91].

Thus we assume the FTTH network to be rolled-out in a Point-to-Point architecture. FTTH P2P deploys fibre access lines from the MPoP to each of the customers' homes (apartments, dwellings). The complete fibre capacity is available for each customer in the subscriber access network since every customer has a dedicated fibre from his home to the MPoP, thus one fibre per home in both the feeder and the drop cable segment is required. Because of the uncertainties of the future bandwidth need of residential and business customers this Point-to-Point fibre plant appears to be the most future-proof solution, because the use of the full optical spectrum per fibre is not restricted by any intermediate technology. Not only the CAPEX of the investor are calculated in a bottom-up approach, it is also the wholesale costs and prices that are derived from this architecture.

Another discussion covers the manageability of larger fibre network starpoints, so that an upper limit regarding the fibre count at the MPoP might exist. Today large copper MDFs serve more than 35,000 copper pairs. An end-customer connection in Point-to-Point fibre plants needs only a single fibre instead of a copper pair and each fibre requires less space (has a much smaller diameter) than a copper wire, while the fibre connectors are more space consuming and additional space to organize the larger bending radius of fibre cables has to be considered. The Optical Distribution Frame may therefore be larger than the copper equivalent, so the ODF may still be a little bit larger

91 See Hoernig et al. (2010).

per fibre, but due to technical innovations we expect this to change over time[92]. Overall, a fibre MPoP will be able to serve more fibre links than the largest copper MDFs today. Therefore, we are convinced that with our model approach of assuming the existing copper MDF locations to be the proper scorched nodes of the new NGA network, where all existing spare ducts may be used, we are conservative and are not facing fibre management problems.

In the P2P architecture the incumbent terminates the access fibres on an Optical Distribution Frame located in each of the MPoPs. Thus an ODF has as many customer sided ports as potential customers are in the field and as many homes have been passed by the fibre plant. The ODF is used to connect the single access fibres to the ports of the traffic concentrating Ethernet equipment by patching only those subscriber access fibres to the network sided ports of the ODF, which then are connected to the ports of the Ethernet switches. Thus patchcables, network sided ODF ports and Ethernet ports are demand driven.

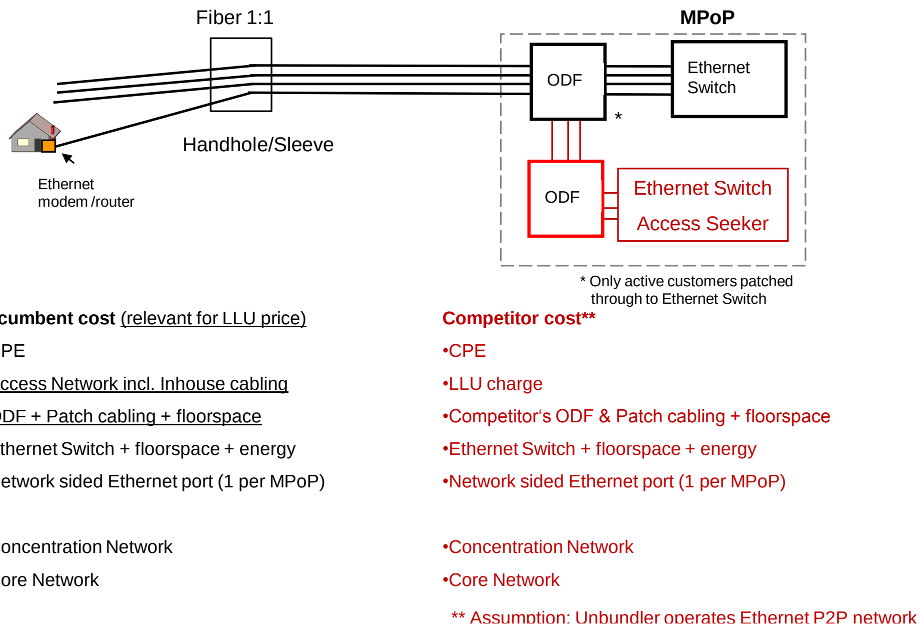
This arrangement also allows to connect each end-customer individually to ports of a different speed (0.1 to 10 Gbps) or to separate dedicated equipment, thus enabling full end customer service flexibility.

5.4.1 Network cost

Using our bottom-up cost model we determine cluster-specific investments and monthly cost for deploying and operating a FTTH network that connects all customers in Euroland. Figure 5-3 describes the P2P topology in general and it defines the cost elements which are considered in the incumbent's total cost. It also details which cost items become part of the fibre LLU price (underscored cost positions) and it defines which elements and costs of the access network the competitor has to bear directly (red). The wholesale entrant's business model is described in more detail in Section 5.4.2.

92 At the FTTH Council Europe conference in February 2011 Dättwyler demonstrated an ODF with more than 6700 fibres on a footprint of 120 x 80 cm.

Figure 5-3: FTTH/P2P architecture with fibre LLU



As indicated above the cost functions we feed into the competition model separately show cost functions for the NetCo who provides the passive access infrastructure and the OpCo who activates the network and markets services to customers. The scope of the NetCo activities is equivalent to the scope of the local loop unbundling wholesale product. The NetCo has a large fixed cost component (derived from our bottom-up cost model) that represents the cost of the access network from the customer to the ODF in the MPoP. The only variable components are a) the network-sided ODF port that we only price for actual subscribers (driven by penetration rather than homes-passed) and b) a "wholesale sales cost" that reflects wholesale marketing, inter-carrier billing etc. The "downstream costs" of the OpCo consist of the elements defined in Table 5-6.

Table 5-6: OpCo downstream cost

	Fixed cost	Var. cost per subscriber
CPE		x
Customer Ethernet Ports at the MPoP		X
Aggregating Ethernet Ports at the MPoP	x	
Floorspace	x	
Energy for active equipment at the MPoP		x
Concentration network cost	X	x
Core network cost	x	X
Retail cost (customer care, billing, sales & marketing, churn, customer acquisition)		x

The values of the most relevant input parameters in addition to the structural data for Euroland are presented here in the following two tables.

Table 5-7: Investment assumptions

Element	Invest per unit	Lifetime (years)
Ethernet CPE	100€	5
ODF port / patch cabling	23€ / 11€	35
OLT	1000€	7
Ethernet Port 1Gbps / 10Gbps	120€ / 2000€	7
Civil works for trenches, ducts	100€-60€ depending on cluster	35

Table 5-8: Cost and other assumptions

Element	Assumption
National concentration network cost per month	6mn € + 0.092€ per subscriber
National core network cost per month	7mn € + 1.32€ per subscriber
Retail cost (customer care, billing, sales & marketing, churn, customer acquisition)[93]	5€ per subscriber per month
WACC	10%
OPEX mark-up on Invest	0.5% passive, 8% active equipment
Common cost mark-up on CAPEX / OPEX	10%

The cost of inhouse cabling was not considered. This is a debatable assumption[94] which we fixed for having a symmetrical approach to the copper network. The aggregate cost functions for incumbent and entrant for the first four clusters are shown in Table 5-9. This is the input for the competition model.

Table 5-9: Total monthly cost for the fibre network (Clusters 1-4)

	Fibre investor	Fibre LLU entrant
NetCo fixed cost	76mn €	0 €
NetCo var. cost	1.38 €	13.92€* (fibre LLU charge)
OpCo fixed cost	6.9mn €	7.6mn €
OpCo var. cost	13.22 €	14.96 €

* 13.92€ = 76mn € (NetCo fixed cost) / 70% of lines + 1.38€ (var. cost per subscriber)

5.4.2 The unbundling business model

For competitors using wholesale access we have considered a fibre unbundling scenario for the P2P architecture in which a competitor rents the unbundled fibre loop, places an additional Optical Distribution Frame of his own at rented collocation space in

93 From our experience this value is a very conservative assumption at the low end of the conceivable cost range..

94 Who bears the cost of inhouse cabling is not uniform in Europe. There are countries where the cost of inhouse cabling is paid by the house owner (e.g. Germany) and countries were they are paid by the network operator (e.g. France).

the MPoP where he operates his own Ethernet Switch. The competitor's ODF is connected via a dedicated connection cable to dedicated customer sided ports of the incumbent's main ODF. The costs of all these elements are part of the competitor's total cost. In addition, the competitor has to bear the cost of the concentration and core network himself. The differences in OpCo variable downstream cost equivalents between fibre investor and LLU entrant (see Table 5-9) are due to a) the competitor's additional ODF and b) our assumption that selfprovisioning inside the integrated incumbent is less expensive. As explained above we have applied a discount on the incumbent retail cost rather than discounted the wholesale price of self-supply. The difference in fixed cost is due to the fact that part of the MPoP floorspace cost of the investor is accounted for in the NetCo unit and that the competitor practically pays for the floorspace of two ODF.

Wholesale prices for the competitor's business case have been determined as LRIC of the network elements of the incumbent which are used for wholesale access, i.e. they are directly based on the cost determined for the incumbent. Since a significant part of costs is fix, the total costs per customer strongly depend on the number of customers on the incumbent's network. Wholesale prices have been determined under the assumption that the incumbent's network operates at a 70% take-up. This rate corresponds to the market share of the FTTH network against the competition of mobile and cable networks.[95] This also means that these are the lowest possible wholesale prices under the LRIC assumptions.

Initially, our cost and profitability analysis is cluster-specific, so the wholesale price in Cluster 1 is independent from the wholesale price in other clusters. Before providing inputs to the competition model we create an average wholesale price for the first four clusters as an aggregate. This price is 13.92€ per month and includes the passive network from the Network Termination Point at the customer side (excluding the inhouse cabling) to the Optical Distribution Frame in the MPoP.

Wholesale prices used in this cost model for calculating the business model of a competitor are always a fixed monthly access charge per user per month (linear access charge). On top of the LRIC network cost per customer a wholesale sales cost of the incumbent's wholesale division (wholesale inter-carrier billing, sales and marketing,) is applied to determine the access charge for wholesale access seekers. This wholesale division cost was assumed to be 0.90€ per user per month (less than 20% of the assumed retail cost that incumbent and competitors both spend for each subscriber). This value presumably is at the upper end of the relevant costs if assessed against efficiency criteria.

95 The corresponding share in Germany of the fixed network today amounts to about 80% of potential subscribers.

5.4.3 Profitable coverage and critical market shares

The cost model's primary result is total cost per subscriber per month which basically is fixed cost divided by number of subscribers plus variable cost per subscriber. Naturally, these total costs decrease with increasing penetration. By comparing this total cost per subscriber and month with the Average Revenue Per User (ARPU) we can determine the point where, if at all, revenue equals the cost. This is the "critical market share" necessary to make the NGA business profitable and hence it determines the viability range of a network operator. We have used an ARPU of 42.05€ for the fibre investor and 39.95€ for a fibre LLU access seeker. The difference reflects an incumbency advantage, e.g. a first mover or brand advantage. The results presented in Table 5-10 are cluster-specific. Where critical market shares exceed 70% we consider the business model not to be viable because other technologies remain relevant players in the access market.

Table 5-10: Critical market shares for FTTH (cluster by cluster)

Cluster	Total potential customers	Fibre investor	Fibre LLU operator
1	1,763,916	20%	7%
2	2,163,672	32%	7%
3	2,646,000	43%	10%
4	2,062,480	42%	11%
5	2,460,360	52%	20%
6	2,989,056	63%	Not viable
7	4,331,208	Not viable	Not viable
8	3,448,368	Not viable	Not viable

Under our assumptions on costs and revenues the incumbent can profitably roll-out its fibre network up to Cluster 6 or for 64% of the population (Table 5-1). The competitors can follow the incumbent only up to Cluster 5. Here the competitor already needs a 20% market share to run a profitable business model.

5.4.4 Brownfield sensitivity

In bottom up LRIC modeling we consider the situation that an investor constructs a new, state of the art forward looking fibre network, taking into account future demand (Greenfield scenario).

In the real world the investors often face the situation that locations and infrastructure already exist which may be reused by a new network generation in order to save investment. This will be considered in our modeling approach by taking the existing

MDF locations as scorched nodes of the new network (maybe some of the MDF will be dismantled), not looking for new locations, thus the remaining are a subset of the existing ones. Regardless of any dismantling scenarios, the cost of the locations that are in use are fully considered.

The investor's decision nevertheless is driven by the level of (additional) investments he has to make, considering that there are existing ducts with spare capacity which could satisfy part of the demand of the new network, thus resulting in lower investment expenditures. We face that situation by defining a scenario which we call Brownfield in contrast to the above mentioned Greenfield scenario, where we reduce the investment for the passive network components ducts, trenches and manholes[96] by dedicated percentages due to the NGA architecture and their fibre demand and due to the part (segment) of the access network, where this spare capacity is located.

Proceeding like this requires that duct infrastructure exists which still has spare capacity to host all of the new required fibre cables. If only part of the cables could be hosted, a new trench would have to be dug so no significant savings could be achieved.

Our basic assumption is that on average the spare components have existed for half of the total equipment life time, thus we assume that the new FTTH network can use the duct infrastructure of an older network for an average remaining lifetime. In the cases where the existing infrastructure has been reinvested in the shorter term future (e.g. due to poor constitution of the ducts) an investor may decide to reinvest now before the new fibre cables will be plugged in. Otherwise reinvestment can hardly be managed without broadband customer interruption (relatively soon after they have taken up the service). In consequence for the components being reused we only consider half of the investment one would need in a Greenfield environment. Thus we have to assume, how many of the components (ducts) per network segment may be reused.

We assume that in the feeder network segment (between MPoP and Distribution Point) only in 20% of the cases the existing duct network may also host the new fibre cables for FTTH/P2P, resulting in an investment reduction of 10% of the feeder duct infrastructure[97]. We believe these assumptions to be optimistic, since we assume here that in Euroland all feeder cables are already constructed in a ducted manner, which is not the case in each European country.

In the drop network segment (between the Distribution Point and the customer) sharing of existing ducts only can take place where ducts are deployed. For our Brownfield scenario we assume optimistically that ducts exist in half of the areas where there is no

96 For ease of expression in this section we call these components „duct infrastructure" only, since the ducts determine their ability to be reused. Direct buried lines cannot be reused.

97 This assumption takes into account, that with a FTTH/ P2P fibre topology each end-customer home passed has its dedicated fibre in the feeder segement. Thus fibre Point-to-Multipoint topologies may have a higher share of duct reuse due to a lower fibre count, see: Hoernig et al. (2010).

aerial construction[98] and that all of these ducts can be shared with the new fibre cables. For the ducts to be installed these assumptions reduce the required investment for duct infrastructure by 25% in the drop cable segment.

Table 5-11: Assumption on effective reduction of investments through duct-reuse

Drop	25% in non-aerial deployments
Feeder	10%

The results and implications of this calculation are shown in Table 5-12 where we have also shown what the impact would be if the savings from reusing ducts by the investor are passed onto the fibre LLU competitor through reduced access charges. The viable range of the fibre investor does not change but costs and therefore critical market shares are reduced noticeable. The unbundling business case becomes more attractive as the first five cluster now only require a market share of below 10% and entry in the 6th cluster could become profitable now.

Table 5-12: Critical market shares and fibre LLU price for Greenfield and Brownfield deployment

	critical market share fibre investor		critical market share fibre LLU		Monthly fibre LLU price	
Cluster	Greenfield	Brownfield	Greenfield	Brownfield	Greenfield	Brownfield
1	20%	16%	7%	6%	7.47 €	6.41 €
2	32%	25%	7%	5%	12.77 €	10.64 €
3	43%	33%	10%	7%	17.12 €	14.24 €
4	42%	33%	11%	7%	16.56 €	13.87 €
5	52%	41%	20%	9%	20.50 €	17.29 €
6	63%	49%	n.v.	15%	24.78 €	20.87 €
7	91%	73%	n.v.	n.v.	35.46 €	30.48 €
8	n.v.	n.v.	n.v.	n.v.	66.63 €	57.12 €

98 For aerial deployment shares see Table 5-2.

5.4.5 WACC sensitivity on fibre LLU price

The German NRA BNetzA has recently published a study on the calculation of the appropriate WACC for broadband access.[99] This study had to quantify in particular the specific risk related to FTTH/B networks. The study determined the relevant risk for the (copper-based) fixed network as well as for a fibre network. The study calculates a risk premium for fibre networks in the amount of 2.59% over and above the baseline of a WACC of 7.11% for the fixed network in 2010. The relevant (real) WACC for calculating a fibre network therefore amounts to 9.7%

This high level delta between the two interest rates is driven by the following building blocks:

(1) Increased fibre beta (1.3 vs. 0.78)
(2) Higher market risk premium for fibre (5.69% vs. 4.73%)
(3) Higher risk for fibre debt (6.81% vs. 5.98%)

Other factors determining the WACC like risk-free interest rate, taxes, debt/equity ratio are assumed to be the same.

The capital cost is a significant leverage for cost determination. In our base case the WACC is assumed to be 10%. We calculated sensitivities on the WACC from 7% to 12% and show the impact on critical market shares and the fibre LLU charge. As in the base case calculations the fibre LLU charge is presented as a cluster-specific LLU charge which is based on the investor's cost at 70% penetration.

Deviating from the base case the WACC variations change the minimum profitability level in less dense clusters significantly. In the first cluster changes are minor and hardly noticeable[100]. As expected the fibre LLU competitor's critical market shares change only moderately until the shape of the cost curve leads to dramatic increases in critical market share and – depending on WACC - deny profitability in Clusters 5 to 8.

99 See Stehle (2010).
100 Moving from the 10% WACC base case to a WACC of 7% reduces the fibre LLU player's critical market share from 7% to 6% in the first cluster (14% change).

Table 5-13: Critical market shares for different WACC values

	Critical market share Incumbent			Critical market share Fibre LLU		
Cluster	WACC 7%	WACC 10%	WACC 12%	WACC 7%	WACC 10%	WACC 12%
1	16%	20%	22%	6%	7%	7%
2	26%	32%	37%	5%	7%	8%
3	35%	43%	49%	7%	10%	16%
4	34%	42%	48%	8%	11%	16%
5	43%	52%	59%	10%	20%	57%
6	52%	63%	71%	18%	n.v.	n.v.
7	77%	91%	n.v.	n.v.	n.v.	n.v.
8	n.v.	n.v.	n.v.	n.v.	n.v.	n.v.

Table 5-14: Fibre LLU price for different WACC values

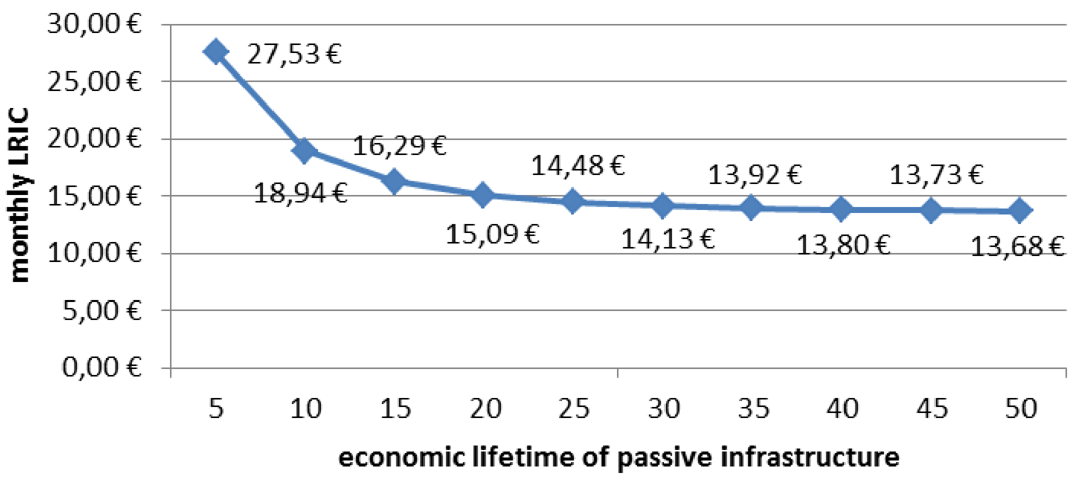
Cluster	WACC 7%	WACC 10%	WACC 12%
1	6.19 €	7.47 €	8.37 €
2	10.44 €	12.77 €	14.40 €
3	14.04 €	17.12 €	19.29 €
4	13.69 €	16.56 €	18.57 €
5	17.00 €	20.50 €	22.96 €
6	20.78 €	24.78 €	27.59 €
7	30.40 €	35.46 €	39.02 €
8	56.97 €	66.63 €	73.43 €

Generally, a 1%-point deviation from the base case WACC of 10% induces a 5 to 6% change in the fibre LLU charge.

5.4.6 Economic lifetime sensitivity

We have varied the economic lifetime of passive infrastructure (sleeves, manholes, trenches including ducts and cables) for fibre deployment in Euroland to show how it impacts cost. In this sensitivity we chose to report the fibre LLU price as the LRIC incurred by the investor. Figure 5-4 clearly shows that moving beyond 30/35 years asset lifetime has a very small effect on the cost.

Figure 5-4: Impact of asset lifetime on fibre P2P LRIC (Euroland Cluster 1-4 average)



5.5 Sensitivities on copper network cost

To show the impact of key parameters on the cost of the local loop of the copper access network we have undertaken sensitivity calculations with a BU-LRIC model that we developed for Italy. This is a completely separate bottom-up model whose results do not feed into the competition model. The difference between the model for Euroland and the model for Italy is that Euroland was modelled on the basis of 8 clusters in which all structural data (trench length, MDF size etc.) for millions of users is the same. The average values were derived from geo-data but they remain averages for each cluster. For Italy the real coordinates of all streets and households have been taken into account. There is no averaging until the final step of dividing the cost for all lines by the number of lines.

In December 2009 Fastweb mandated WIK-Consult to develop a state of the art Bottom-Up LRIC model to calculate the cost of an efficient operator to produce the copper local access loops in Italy for connecting the customers to a PSTN/ DSL based telecommunication network. Assets valuation is based on the current cost standard. The bottom-up model was fed with geo-coordinates of all Italian households, buildings, streets and all ~10.000 MDF locations to determine an efficient network not on the basis of a representative sample but all of Italy. We have applied a scorched node approach by taking existing MDF locations for granted. Since neither the borders of the MDF service areas (access areas) nor the assignment of buildings to MDF locations are publicly available, we have derived access areas by allocating the access lines per home to the closest MDF location, thereby already conducting a first network optimization.

Four different sensitivities were conducted regarding:

1. WACC,
2. Economic lifetime of passive access network,
3. A 10% reduction of the number of access lines,
4. A 20% reduction of the investment in trenches and poles.

5.5.1 WACC

We have run the cost model for all of Italy with three different WACC (8%, 9.38% and 11%). The results are shown in Table 5-15. Each variation induces a 10-11% change in monthly loop cost.

Table 5-15: Copper LLU cost: WACC sensitivity

WACC	8%	9.36%	11%
Total cost per month	**6.55**	**7.34**	**8.15**

5.5.2 Economic lifetime of ducts and trenches

As described in Section 5.4.1 an economic lifetime of 35 years for ducts and trenches was applied for Euroland. In light of the ongoing discussion about the “real” and appropriate duct lifetime we have extended the asset lifetime to 50 years as sensitivity for Italy. Moving from 35 to 50 years only has a very minor impact (1%) on the monthly LLU cost as shown in Table 5-16.

Table 5-16: Copper LLU cost: economic lifetime sensitivity

	35 years	50 years
Total cost per month	**7.41**	**7.34**

5.5.3 Decreasing volumes in the fixed network

The demand for copper access networks can be expected to decrease through the migration of customers to fibre and cable.[101] Customers focusing mainly on voice with only limited broadband requirements may also decide to abandon copper in favour of mobile-only. We have approximated the impact of a 10% demand reduction by removing 10% of access lines. This was done after trenches for connecting all customers were defined because it can be assumed that a major share of removed lines will be in (multi-dwelling) buildings that still have demand for copper and need to be connected. This 10% reduction has been applied undifferentiated to all lines (no differentiation between loop lengths or customer density). After reducing the number of lines cable sizes were optimized again to reflect an efficient network.

The impact of this sensitivity is a rather minor reduction of investment (1%) but an increase in investment per line by 6%. This is directly reflected in a local loop price increase of 6% (see Table 5-17).

Table 5-17: Copper LLU cost and investment: reduction of number of lines

	Base case	10% less lines
Total cost per month	**7.34**	**7.79**
Total investment (in mio. €)	21,558	21,391
Total investment per line (in €)	661.77	702.89

5.5.4 Reducing the cost of infrastructure

We have shown arguments for a different valuation of ducts (see Section 3.5) that should lead to lower costs. Our sensitivity goal was to model a 20% decrease of the investment into ducts to reflect such a lower asset valuation while keeping all other assumptions. However, in Italy ducted deployment is practically non-existent because almost all copper cables are directly buried in the ground. We have opted to approximate the impact of a duct cost decrease by reducing the investment into infrastructure (trenches and poles for aerial deployment) in Italy (manhole and sleeve invest remain unchanged). Accordingly, the sensitivity is using trenches and poles as proxy for the impact of a duct cost decrease. Table 5-18 shows that the total investment, the investment per line and the total cost per month decrease by roughly 10%. This also highlights the importance of trenches and poles which account for about half of total investment.

101 In fact cable operators are irrelevant in Italy.

Table 5-18: Copper LLU cost and investment reduction of investment into trenches and poles

	Base case	20% invest reduction
Total cost per month	**7.34**	**6.58**
Total investment (in mio. €)	21,558	19,294
Total investment per line (in €)	661.77	592.25

6 Impact of wholesale prices on competition, investment and consumer welfare

6.1 Objective

The task is to develop a model of competition between copper and FTTH with multiple competitors (“entrants“) in order to show aspects of the transition from copper to FTTH, in particular how the transition depends on

- the regulated copper access charges for copper unbundling
- the regulated FTTH access charges for fibre unbundling
- whether there is a single integrated incumbent potentially offering both copper and FTTH or two separate network operators for the respective technology

The objective is to generate and compare the (potential) coexistence and relative shares of copper and FTTH and to find in a market equilibrium end-user prices, consumer surplus and producer surplus (for both incumbent(s) and other firms), leading to welfare results.

6.2 Modeling approach[102]

6.2.1 The theoretical model

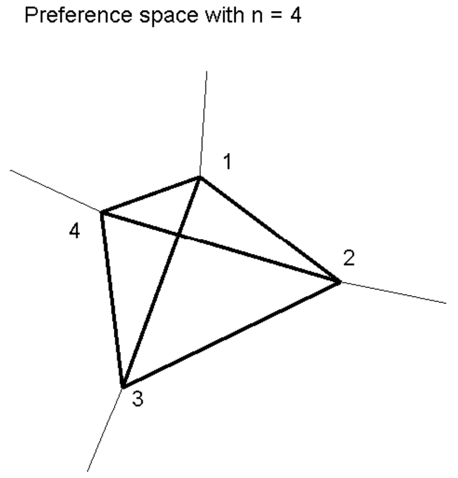
The challenge for building a competition model that captures the interaction of firms offering different types of services and differentiating brands within service groups is to characterize user preferences for services and firms and to derive demand. The main approach to this has been the Hotelling model, which assumes that the consumers and two competing firms are located along a line with fixed length. However, this model is restricted to competition between two firms and therefore cannot be used for any larger number of firms or services.

Our modeling approach is therefore based on the pyramid model, which is closely related to the spokes model and is a generalization of the Hotelling model:[103] For each pair of services, there is a set of consumers who choose between these two products and these consumers are (uniformly) distributed in their willingness to pay for one service rather than the other. Graphically this leads to a pyramid, as illustrated in Figure 6-1, with each service located at one of the tips of the pyramid. In addition, there may

102 The descriptions in this section are based on Hoernig et al. (2010).
103 The pyramid model was first developed by von Ungern-Sternberg (1991), while the spokes model originates from Chen and Riordan (2007).

be “Hinterland” consumers who consider only one of the services, represented as the thin lines emanating from the tips. We do not consider the “Hinterland” case in this study in detail.

Figure 6-1: Preference space



An alternative would be the Salop model, which is widely used in the industrial organization literature.[104] A major disadvantage of the Salop model is that it imposes a very particular substitution pattern across products: A service is a substitute only to its two neighboring services implying that cross price elasticities to other services are equal to zero. Our modeling approach allows for positive cross price elasticities between any pair of services.

Another frequently used model is the logit model.[105] Our approach and the logit model have in common that all cross price elasticities are strictly positive. While our approach is in general very flexible, our chosen implementation and the logit model have in common that a given number of available services are affected symmetrically by the introduction of an additional service. In terms of implementation, an advantage of the present framework is that it leads to linear demand functions and, thus, explicit solutions. This is not the case for the logit model unless all market participants are symmetric, which is not true in the context of this study.

Infrastructure. Our approach captures essential aspects of competition in FTTH or copper-based markets, both on the wholesale and retail side. In our main model one firm, the “incumbent”, owns and invests in a copper and/or FTTH access network, to

104 See Salop (1979).
105 For an extensive treatment, see Anderson, de Palma and Thisse (1992).

which other firms ("entrants") must obtain access in order to provide copper-based or NGA-based services. Entrants are assumed to be specialized on one of the services and are otherwise symmetric. They need to make own investments in order to use copper-based or NGA access. In a second model the incumbent is restricted to a copper access network, while an independent fibre investor (which could be an alternative telecommunications operator or an energy company) may or may not invest in fibre, thereby potentially driving out the copper incumbent. We consider both models with and without a third vertically integrated broadband infrastructure ("cable"), to which no other firms have access.

Demand. The services that firms offer are both "horizontally" and "vertically" differentiated. The former means that consumers do not react strongly to small price differences because individual preferences for firms' brands differ. In particular, assuming a uniform distribution of individual tastes in this horizontal dimension leads to linear demand functions over the relevant range of prices. As a result of horizontal differentiation, the market is imperfectly competitive and firms will enjoy positive mark-ups. Vertical differentiation expresses differences in service quality and goodwill or brand recognition as perceived by consumers, i.e., at equal prices a firm with higher service quality would attract more consumers. Service quality is assumed to affect all consumers similarly, i.e. we abstract from market segmentation in the service quality dimension.

We call potential subscribers "competitive" when they are actively in the market. In the model each competitive subscriber makes a first choice between two of the firms, and unless their offers are very unfavorable, he will choose one of the two. It is assumed that all pairs of preferred firms (before quality differences) are equally likely in the population, so that effectively each firm will compete with any other firm for consumers. Formally speaking, cross price elasticities are different from zero for all product pairs. Due to the assumption of uniform distributions of consumer tastes, the resulting demand function of each firm is linear in its own price and linear in the price of all other firms. This makes the analysis tractable and allows for explicit solutions. In spite of advances in empirical demand estimation that allow for more flexible demand specifications, the linear demand system remains popular in empirical research. Our underlying micro foundation permits us to compare markets with different numbers of firms in a meaningful way.

If the firms in the market include the cable firm, our model has the feature that the sum of copper and/or FTTH subscription demands is variable. However, total demand for subscription (including cable) is fixed and assumed to be 95% of potential subscribers in the clusters considered. In the absence of cable as a non-copper and non-FTTH-based competitor, the sum of copper-based and FTTH subscriptions is fixed at 70% of all potential subscribers in the clusters considered. In the presence of cable 5% of the population are assumed not to sign up for any fixed network but rather to stay without a connection or resort to mobile only. In the absence of cable the remaining 30% are deemed to subscribe to cable or stay without a connection or resort to mobile only.

All subscribers then either buy one subscription or none, where competitive subscribers will always buy one subscription. Not buying leads to a surplus normalized to zero, while the choice between the two preferred options is based on the comparison between prices, quality of service and the relative preference for the two brands.

Cost structure. We consider market outcomes on a monthly basis, so investment cost for providing or using copper or fibre NGA have been translated into a monthly value over the lifetime of the infrastructure. Each firm also bears downstream costs which consist of a fixed part and a variable part as a function of the number of subscribers. For the latter, the model allows for either increasing or decreasing marginal cost. In the actual model runs we have only used constant marginal costs, though.

The wholesale access tariff paid by the entrants to the incumbent consists of a price per subscription and potentially also of a fixed fee. In this study we are considering only linear wholesale access tariffs – i.e. those tariffs that would be set for operators not entering into a long-term volume commitment.

We treat the incumbent as if he were under vertical accounting separation into a NetCo that supplies copper-based or FTTH infrastructure access and an OpCo that sells copper-based or FTTH end-user services. The incumbent's NetCo sells access to other firms ("entrants") and to the OpCo. This accounting separation does not affect pricing behavior and overall profits but it provides for an automatic price-squeeze test.[106]

All cost components consist of fixed costs and constant variable costs, but we could also include a quadratic term to model non-constant variable cost.

- Incumbent(s):
  - Costs of wholesale products for the whole output
  - Price of wholesale products for own end-user sales
  - Downstream network and retail costs for own end-user sales. In case of an integrated incumbent the downstream network costs (core and concentration) are
    - Fully allocated to that service if only one is offered
    - Split 50:50 if services over both networks are offered

- Competitors:
  - Price of wholesale products purchased
  - Downstream network and retail costs for end-user sales. Entrants/competitors are modelled on a scorched node basis, where nodes are determined by the

106 In our model runs price squeeze generally has not been an issue.

incumbent's network architecture. Entrants fully penetrate each modelled cluster.

- Cable TV/DOCSIS3
  - Total costs of own end-user sales

While the costs of copper and fibre for both incumbents and entrants come from the results of the WIK cost model for clusters 1 through 4 , we have made the following cost assumptions for cable. The fixed costs of cable for clusters 1-4 for both the access network and the core/concentration network are set at 20 million € per month. This compares to about 13 million € SRIC for the copper incumbent or about 38 million € LRIC for the copper incumbent for the same set of clusters. It also compares to about 70 million € Brownfield LRIC for the fibre incumbent or about 83 million € Greenfield LRIC for the fibre incumbent. Since we primarily rely on the SRIC/Brownfield costs for the decision about switching from copper to fibre or leaving the market altogether, the fixed costs for cable appear reasonable. Since we assume the presence of cable all the time, any change in the cable fixed costs would only affect the cable profit, but not prices. We further assume 10 € variable cost per cable subscriber for network and retail operation, which compare to 9.92 € for the copper incumbent and 14.60€ for the fibre incumbent.

We generally treat the price of the wholesale product ("access charge") as a variable in order to determine the effects of changes in its level on the relevant outcome variables. However, two types of access charges are most relevant for each type of access provider.

First, for both copper and FTTH the access charge can be based on the traditional Greenfield long-run incremental costs (LRIC) of the access service, which in turn contain the fixed and variable costs incurred by the incumbent for the FTTH access product. Here the variable costs of the NetCo include wholesale sales costs. These wholesale sales costs are saved when the incumbent provides the access product internally to himself. A linear wholesale charge is then the total LRIC divided by the FTTH access quantity (including access used internally by the incumbent).

Second, under the assumption that copper networks are no longer expanding the copper access charge can be based on those costs necessary to keep a copper access network going. They are the short-run incremental costs (SRIC). These are basically the operating costs to run the copper network. They can be substantially lower than LRIC. For FTTH access networks SRIC are not relevant, because these networks can safely be assumed as expanding. However, when building such networks the incumbent can use existing infrastructure from the copper access network. This leads to Brownfield (LRIC) costs as a relevant alternative to Greenfield LRIC for the case of FTTH access. SRIC and Brownfield LRIC are relevant because these costs are the crucial base for the incumbent's decisions whether to shut down the copper access network and switch to an FTTH access network or not.

Equilibrium. We can think of our competitive game as consisting of five stages, which determine the order in which participants make their moves.

- Stage 0: There exists a copper incumbent in an equilibrium with entrants under a given copper wholesale access charge. There can also exist an additional network with a different technology (cable). This is a natural starting point that largely eliminates multiple equilibria.
- Stage 1: A planner decides on the scenario, consisting of the horizontal integration/separation of incumbents and the access prices for copper and fibre access.
- Stage 2: The incumbent firm or an independent fibre investor decide on investments in copper and/or FTTH access and in concentration/core network infrastructures, based on the restrictions and incentives provided by stages 0 and 1.
- Stage 3: Potential entrants in copper or fibre decide whether to enter or not. If they decide to enter they also decide on their level and type of investment. Their choices and incentives are based on the decisions made in earlier stages.
- Stage 4: Entrants and the incumbent(s) compete for end-users in differentiated copper/FTTH markets using prices as strategic variables.

The choice at stage 1 will be based on the ranking that results from the competition analysis. The choice would be made based on the criteria social surplus, consumer surplus, incumbent's profits, entrants' profits, end-user prices and market shares. Having the planner decide about wholesale access charges at stage 1 before the market players decide about their investments at stages 2 and 3 is natural in order to assess the long-term effects of the absolute and relative levels of wholesale access charges on network investments. At the same time the sequencing means that the planner is committed to the access charges.

The specifics of stage 2 consist of the following: Depending on the scenario considered, the integrated incumbent and/or an independent fibre investor make certain investments in networks and access, which determine their service quality levels and operating cost. We assume that there can only be at most one operator investing in each type of access infrastructure. In the case of an integrated incumbent there will be only one concentration/core network, whose fixed costs we split if both copper and fibre are offered. The independent operator would make a Greenfield investment in the fibre network and has to run its own concentration and core network.

In order to cover the full range of costing options we alternatively consider LRIC/Greenfield and SRIC/Brownfield as the cost basis for the incumbent's decision making. The incumbent chooses either to stay only in copper, add fibre or switch fully to fibre. The incumbent will only invest in fibre if the new equilibrium with fibre yields more profit than the original situation of copper only. In a further model an alternative fibre investor can decide whether to invest in fibre, while the copper incumbent remains in copper or exits. Each model generates the switching point between fibre and copper, based on the most profitable choices for the incumbent (and the independent fibre investor).

Regulated wholesale access pricing follows from stage 1. Our consumption unit is the number of subscriptions. Although the incumbent's costs depend on the level of output, by setting them exogenously at stage 1 we do not make the access charges depend on wholesale output quantities.

At stage 3 the level of investments by competitors is derived from the cost model, assuming full penetration of each active entrant. Competitors enter either using copper or with fibre access technology.

The numbers m1 and m2 of fibre and copper competitors is adjusted through repeated runs of the model in such a way that a free entry equilibrium results, under which the current number of entrants generates a profit and any additional entrant generates a loss. We do this for all possibly relevant combinations of copper and fibre investments, starting from the original copper equilibrium (with entrants) of stage 0.

At stage 4 all active firms compete in subscription fees at the retail level. The resulting market outcome is modelled as the Nash equilibrium outcome of the resulting pricing game, from which subscriber numbers, profits, market shares, consumer surplus and total welfare are derived.[107] This is repeated for each of the cases developed in stages 0-3. In the model with entry and exit, we first allow for a non-specified process of entry and exit with the feature that all active entrants make profits and that the entry of an additional entrant would lead to losses of all active entrants of an active access mode. Here we postulate that entrants correctly foresee the effect of entry (and the associated investment decisions) on the pricing decisions and, thus, on market outcome. Formally, and in line with the literature on industrial organization, the stronger notion of subgame perfect Nash equilibrium is used. This means that we consider subgame perfect Nash equilibria

- of the two-stage game in which entrants first make their participation decision and then all active firms make pricing decisions and

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107 The Nash equilibrium is the standard solution concept used in the literature. It assures that firm decisions are mutually consistent.

- of the three-stage game in which access network investors (incumbent and independent fibre investor) first make their investment and participation decisions in view of the entrants' participation decisions in the next stage and then all active firms make pricing decisions.

The competition at stage 4 will be in prices for differentiated products as described above. We model horizontally and vertically differentiated single-product and two-product incumbents. We cannot distinguish between different consumer types, such as households and business consumers. Consumers only buy subscriptions with unlimited usage.

Under the pyramid model without hinterlands total output is kept constant. So, competition is only for market shares. In the model without cable copper and fibre together serve an assumed 70% of the population as customers with the other 30% either going to other broadband modes, mobile only or stay out of telecommunications. This fully corresponds to the equivalent assumption of the cost model. In the model with cable 95% of the population are assumed to be customers of one of the three modeled types of networks. This approximates a 70% market take-up for copper and/or fibre, but may deviate from the 70% mark, depending on market conditions.

6.2.2 The quantitative model

A formal description of the competitive model is provided in the Appendix. In the market for broadband, n firms (the incumbent or alternative fibre investor, fibre and/or copper entrants and potentially a cable company) compete for N "competitive" consumers. Each firm provides a quality level S_i. The intensity of preferences of consumers between services supplied by firms i and j are measured by t_{ij}.

After investments have been made, firms compete in subscription prices. Market outcomes are given by the Nash equilibrium of this pricing game between firms.

Providing FTTH and copper access involves a marginal cost of c_{01} and c_{02} as well as a fixed cost of K_{01} and K_{02}. Firm i's downstream costs of providing retail services consist of a marginal cost c_i and a fixed cost K_i. Downstream firms pay an access tariff consisting of a per-subscriber price aF for fibre and aC for copper plus (potentially) a fixed fee A. Only the incumbent or the independent fibre investor receives wholesale payments ($\gamma_1 = 1$ and $\gamma_i = 0$ for the other firms), but all firms apart from the cable company use the incumbent's FTTH access ($\delta_i = 0$ for cable, and $\delta_i = 1$ for all other firms).

Model output variables. The following variables are determined at the equilibrium outcome:

- p = final output subscription price

- n = the equilibrium number of firms. While the number of firms is actually an input into the quantitative model, we determine the free-entry equilibrium number by running the model with an increasing number of entrants, until under n firms entrants are profitable while under (n+1) firms entrants expect to make losses.
- prof = profits per month per firm. The allowed return on capital (WACC) is part of the costs and not part of the profits.
- WhProf = wholesale profits of incumbent. These include profits from the sale of the incumbent's Netco to the incumbent's Opco.
- s = market share per firm
- sum(q) = market output
- CS = consumer surplus. It has to be noted that in our model total output (including cable) does not vary.
- W = welfare = CS + sum(prof). The main welfare effects stem from cost and "willingness to pay" (WtP) differences of the various technologies and suppliers. Among others, welfare is affected by changes in the market shares of the different technologies and by changes in the market shares of the different providers using the same technology. With endogenous entry, also the duplication of fixed costs affects the welfare analysis. Not covered in the welfare analysis are spillover effects on industries that would benefit from the presence of fibre in developing new products or new business models.

In addition to these variable we use the following abbreviations:

aC = Copper access charge

aF = Fibre access charge

IncF = Incumbent fibre

IncC = Incumbent copper

EntrF = Entrant fibre

EntrC = Entrant copper.

6.2.3 QoS and willingness to pay in the basic model

While costs are given by the WIK cost model, the demand data are generated by assumptions on certain parameter values. The most important demand-related parameters are:

The gross surplus Si generated for consumers with the highest willingness to pay (WtP) for service i or firm i. This parameter expresses quality (QoS) and goodwill. The Si therefore capture vertical product differentiation. They are derived proportionally from assumed ARPUs.

The „transport costs“ tij for consumers located between firms i and j. These reflect the decline in willingness to pay by consumers away from i and j. They express both the heterogeneity among consumers and the substitutability between the suppliers‘ services. The tij therefore capture horizontal product differentiation. The tij can in principle differ from each other and tij can differ from tji. We have used this feature to make product differentiation within the same technology less pronounced than product differentiation between different technologies.

The vertical product differentiation parameters for Willingness to Pay – here expressed as ARPUs - are provided in Table 6-1.

Table 6-1: ARPU assumptions for quantitative model

Incumbent FTTH	Entrant FTTH	Incumbent Copper	Entrant Copper	Cable
38.07 € - 42.05 €	36.92 € - 40.79 €	30.10 € - 34.08 €	29.20 € - 33.06 €	36.30 €

These ARPU figures translate into maximum Willingness to Pay (the Si in the model) in Table 6-2. This represents the highest price any single customer would be willing to pay and perhaps reflects specific benefits that a few customers may experience from fibre that cannot be achieved through other means such as home security through video surveillance.

Table 6-2: Maximum WtP assumptions for quantitative model

Incumbent FTTH	Entrant FTTH	Incumbent Copper	Entrant Copper	Cable
86.00€ -95.00€	83.42€ -92.15€	68.00€ -77.00€	65.96€ -74.69€	82.00€

The ranges in Table 6-1 and Table 6-2 reflect sensitivity analyses around assumed values. In the following 'high', 'low' and 'intermediate' refer to endpoints and midpoints of the ranges. This is shown in Table 6-3.

Table 6-3: ARPU constellations of relative valuation of copper against fibre

Low valuation of copper			Intermediate valuation of copper			High valuation of copper		
	copper	**fibre**		**copper**	**fibre**		**copper**	**fibre**
incumbent	30.10 €	42.05 €	incumbent	32.09 €	40.06 €	incumbent	34.08 €	38.07 €
entrant	29.20 €	40.79 €	entrant	31.13 €	38.86 €	entrant	33.06 €	36.92 €

The value of the QoS differences between copper, cable and fibre that is expressed in the full range of ARPUS in the tables above may appear large and incumbency premia may appear small from today's perspective. However, it has to be kept in mind that we are considering situations with potentially full FTTH penetration, which could only happen several years from now. It can be expected that the share of customers with high-bandwidth demands and the prevalence of corresponding applications will then be much higher than now. Thus, the premium for ultra-high bandwidth will also be much higher than now. Also, we restrict most of the numbers presented in this study to middle points of the ARPU range. In contrast, the incumbency premium, which includes both QoS differences and goodwill advantages of the incumbent, will likely become smaller, as time goes by. This justifies the small incumbency premium of 3% over entrants that we have chosen.

If, in practice, consumers are not willing to pay for some additional cost of fibre because they do not see utility in the services that it makes possible, then there is neither an economic nor a welfare-maximizing case for fibre to be installed.

Model runs. The competition model runs over aggregate WIK cost functions of clusters 1 through 4 and therefore all of this remaining chapter relates to this set of clusters. As shown in Chapter 5 above the investor as well as competitors can run a profitable business model in all these clusters. The restriction to Clusters 1 through 4 means, in particular, that many suburban and all rural areas are excluded from consideration.

We have run the model for both the integrated copper/fibre incumbent and the case of two separated network providers for fibre and copper. Because of the market disadvantages of independent fibre investment we will here mostly display results for the integrated incumbent.

The discretionary data inputs were calibrated to be compatible with assumed ARPUs, with plausible quality differences and with plausible market shares.

The investment hurdles for FTTH against the preexisting copper access network are substantial. Based on a Greenfield approach to fibre and LRIC for both fibre and copper, copper over all stages of production is 12.08€ cheaper to produce per subscriber than fibre. The difference increases to 13.92€ if one uses a Brownfield approach to fibre and short-run average incremental costs (SRIC) for copper.

On top of having to pay the access charge entrants have a downstream variable cost disadvantage against incumbents of 1.74 € under fibre and 0.68 € under copper (due to ODF/MDF equipment duplication and sales cost). They also have about an 8-10% fixed cost disadvantage downstream due to the missing opportunity of economies of scope of an integrated business model.

Given the above cost considerations fibre investment faces a high hurdle. Thus, the market advantage of fibre in terms of consumer appreciation has to be large in order to succeed. Also, because of larger downstream cost differences relative to incumbents, fibre entrants face higher hurdles than copper entrants.[108]

Realistically, both an integrated incumbent and an independent fibre investor will make use of already existing facilities when investing in fibre. Hence, the Brownfield approach is most appropriate for their decision making. Also, the copper incumbent will only consider the costs of maintaining a copper network (SRIC), when deciding on giving up copper.

6.3 Model runs on the variation of access charges

6.3.1 Varying the copper access charge (aC)

6.3.1.1 Main assumptions

In this section we provide the results of a number of model runs. They are a subset of a much larger number of runs we performed. We chose the ones provided as examples and because we believe them to be the most realistic and the most relevant ones for policy assessments. In the current section we consider variations of the copper access charge aC for given levels of the fibre access charge aF. In the following section variations of aF for given levels of aC are taken up. Finally, we present results of parallel variations of both aC and aF.

108 Because of the higher overall level of marginal costs for fibre compared to copper it may be that these disadvantages do not play out fully in practice.

First, the copper access charge is varied in eight stages from 1.71€ to 11.97€ (reference charge: 8.55 €).[109] All other modeling parameters remain constant.

We mostly concentrate on the incumbent's profits under various scenarios, because they determine, which technology he chooses. In contrast, we provide prices, entrants' profits, market shares and consumer surplus/welfare only for selected cases.

We currently only consider an integrated incumbent as the fibre investor. Since it almost never pays for an integrated incumbent to operate copper and fibre side-by-side, in this section the incumbent is assumed only to operate the more profitable of the two networks. Joint supply of copper and fibre is addressed below in Section 6.3.2.4.

Unless stated differently SRIC and Brownfield costs are applied to determining the decision, whether to invest in fibre or not. The SRIC/Brownfield cost assumption is referred to as the "low-low" case as opposed to the "high-high" case for LRIC/Greenfield costs.

We use intermediate valuation of copper relative to fibre as our reference case.

6.3.1.2 Results on performance variables and the switch from copper to fibre

The integrated incumbent always invests in the type of network that is most profitable for him, given the regulated access charges. Thus, a switch from copper to fibre occurs, when fibre profits exceed copper profits for the same combination of access charges (aC, aF). Obviously, the incumbent's profits are influenced by many factors (e.g. costs, market share, retail prices), wholesale access charges being only one of them. Our results, however, suggest that their influence can be substantial.

The switching points from copper to fibre are marked by a circle in the following figures 6-2 and 6-3. They show a strong increase in the incumbent's copper profits from an increase in aC. As a result, copper is preferred by the incumbent if aC is sufficiently high. To the left of the vertical line marking the switching point in Figure 6-2 fibre profits are higher than copper profits, while to the right of the line copper profits are higher than fibre profits.[110] In contrast, aC does not influence profits from fibre. Instead, fibre profits depend on aF. An increase in aF increases the range, where fibre is preferred.

Consequently, under aF = 11.65€ = Brownfield LRIC the switch from copper to fibre occurs below aC = 3.42€ (> SRIC = 1.95€), while under aF = 19.49€ the switch from

109 The stages are generally defined by 20% increments or decrements starting from the 8.55€ level. Similarly, we mostly used 20% increments or decrements for fibre access charges starting from fibre LRIC of 13.92€. Thus, the second decimals are not shown for higher precision but only because they reflect 20% changes. The only exceptions from the 20% changes are made to include copper LRIC (6.06€), copper SRIC (1.95€) and fibre Brownfield (11.65€), each for Clusters 1 through 4.

110 This is strictly true only if at the switching point both profits are equal. Because we have changed aC in discrete steps this is generally not assured, but it holds almost precisely in this particular case.

copper to fibre occurs below aC = 8.55€. The latter scenario generates substantially lower consumer surplus than the former scenario, with CS = 405 million € under aC = 3.42€ and CS = 334 million € under aC = 8.55€. This also means that at today's copper access charges in Europe it would take fibre access charges above 19€ in order to induce incumbents to build fibre access networks. The resulting end-user prices for fibre would be above 42€ per month.

In contrast, the increase in profits (for the incumbent) from a 10€ increase in aC is about 50 million € per month. This is spread over about 6 million subscribers (counting the subscribers of entrants, who are relevant for the wholesale profits), which corresponds to an over 80 cents profit increase for every one € access charge increase. The profit increase shown in Figure 6-3 for fibre indicates a similar order of magnitude of profit increase for fibre from a one € access charge increase.

Figure 6-2: Incumbent's total profit under variation of aC for aF = Brownfield LRIC

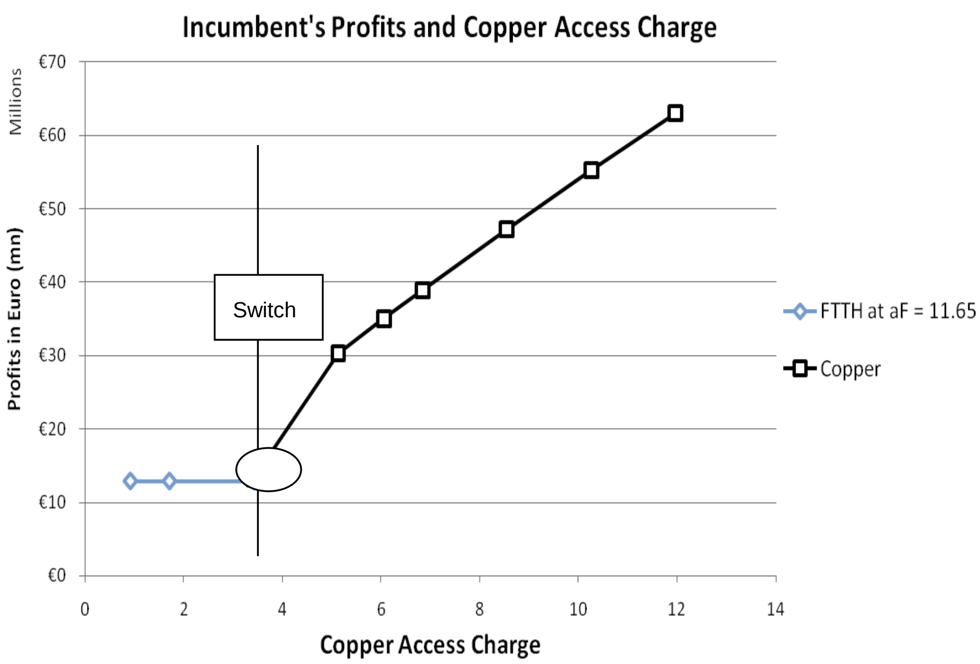
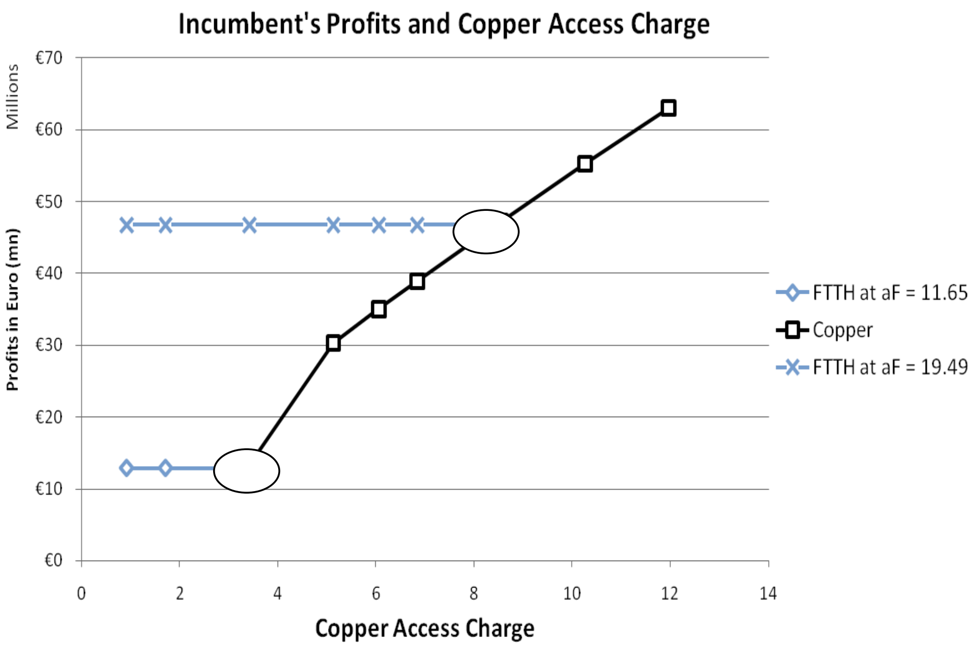


Figure 6-3: Incumbent's total profit under variation of aC for two levels of aF



In the following Table 6-4 and Table 6-5 we provide the outcome variables of the model for two of the runs described so far. They concern the behavior of these variables at the switching point from copper to fibre at the low fibre access charge of aF = 11.65€. Table 6-4 gives the outcomes for fibre alone, while Table 6-5 gives the outcomes for copper alone at aC = 3.42€.

A comparison of the two tables shows how close the incumbent's total profits for copper and fibre are at this switching point. Although aF is set equal to Brownfield LRIC costs, fibre is making a wholesale loss because total fibre output is less than 70% of the market (it is 72% of 95%!). In contrast, copper is making a handsome wholesale profit at aC = 3.42€, which is distinctly above SRIC, even at less than 70% share of the market. Due to the smaller number of entrants for fibre (m1 = 3) than copper (m2 = 4) entrants under fibre make a handsome profit, while entrants under copper barely make any profit. This indicates that at any further increase in aC copper entrants will exit. Total welfare and consumer surplus do not differ much between both scenarios.

Table 6-4: Output variables of the model for fibre at aF = 11.65€

	General	Incumbent-Fibre	Incumbent-Copper	Cable	Each Fibre Entrant	Each Copper Entrant
subscribers		1,871,141		2,308,392	1,341,576	
retail price		36.24		26.03	36.77	
RtProf		14,434,240		17,004,698	6,047,840	
WhProf		-1,517,709				
market share		0.23		0.28	0.16	
aggregate market share		0.72		0.28		
fibre entrants	3					
copper entrants	0					
W	453,891,468					
CS	405,826,718					

Table 6-5: Output variables of the model for copper at aC = 3.42€

	General	Incumbent-Fibre	Incumbent-Copper	Cable	Each Fibre Entrant	Each Copper Entrant
subscribers			1,401,007	2,339,927		1,115,832
retail price			20.90	26.25		20.22
RtProf			4,881,215	18,022,652		312,645
WhProf			8,440,193			
market share			0.17	0.29		0.14
aggregate market share			0.71	0.29		
fibre entrants	0					
copper entrants	4					
W	442,074,235					
CS	409,479,595					

Figure 6-4 shows the effects of increases in aC on end-user prices of all types of firms and technologies. aF is given at Brownfield LRIC = 11.65€. This is the same case as the one depicted in Figure 6-2. So, the switch between fibre and copper occurs at aC =

3.42€. This case is, among others, characterized by the fact that fibre attracts three entrants, while copper attracts four entrants at aC below 5.13€. Only at aC ≥ 5.13€ does the number of copper entrants drop to three.

The most striking observation is that at the switch point from copper to fibre the retail price for fibre is about 15€ higher than the retail price for copper. How can this gap be sustainable? In our model we do not assume that customers simply switch and pay 15€ more for fibre. Rather, we compare equilibrium situations before and after a fibre buildout. The different customer valuations therefore reflect differences after consumers have been getting used to the value fibre provides. It also includes a change in the composition of services demanded, in particular away from single play towards triple play. In Section 6.3.3 we will address some of the adjustment issues and the implications of providing a virtual copper product on the fibre network at an equivalent cost to copper.

The copper retail prices increase in aC. The increase is steeper if, as at aC = 5.13€, the number of entrants decreases. In that case the price increase is actually larger than the increase in aC. The fibre price is not affected by aC and is always higher than the copper price. Entrants always set price close to that of the incumbent. Because of higher costs the price of fibre entrants can, in spite of lower valuation, be higher than that of the incumbent. The end-user price of cable increases in aC and is always below fibre prices and above copper prices. However, as aC increases the gap between copper and cable prices narrows.

Figure 6-4: End-user prices under variation of aC for aF = Brownfield LRIC = 11.65€

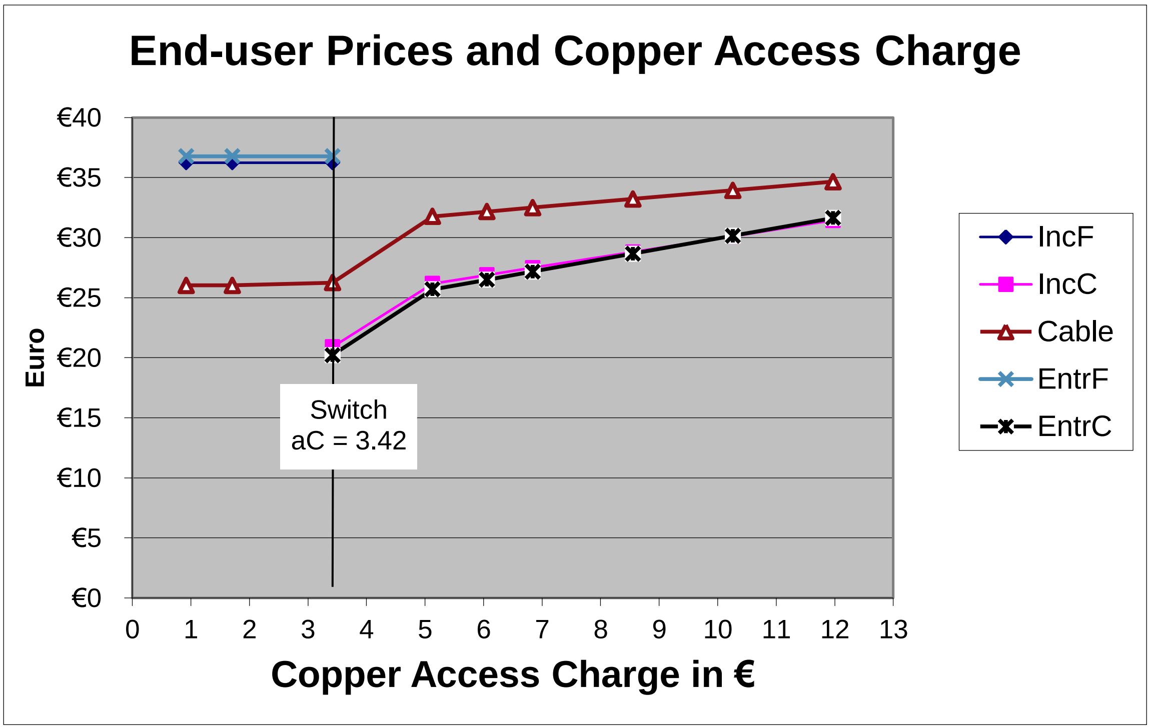


Figure 6-5 shows the effects of increases in aC on consumer surplus (CS) and welfare (W) for the same scenario as before. What sticks out is that an increase in the copper access charge reduces CS but leaves W almost unchanged. The loss in consumer surplus is almost compensated by an increase in profits.

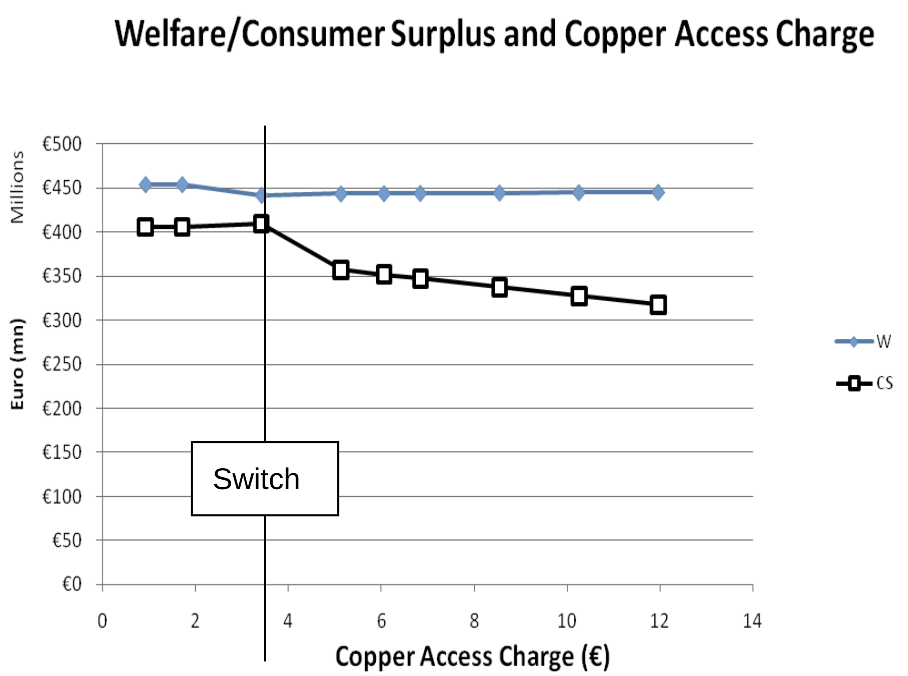
CS decreases because of the price increases for both copper and cable. Welfare changes little because almost all of the price increases lead to higher profits (given that total output of copper plus cable is constant).

At the current aC = 8.55€ in Europe consumer benefits appear as fairly low. A reduction in aC from 8.55€ to 5.13€ would increase CS by almost 20%. Because of further copper entry at aC = 3.42€ the further reduction from 5.13€ to 3.42€ would increase CS by a similar amount. All this is in line with Figure 6-4 on the corresponding price developments. However, that assessment does not hold for the switch to fibre, which leads to no reduction in CS in spite of a more than 15€ price increase. The reason is that over the long run in a scenario in which fibre speeds fibre is valued more highly than copper, even at a substantially higher price – as would have replaced copper speeds, be the case today comparing broadband and IPTV capabilities and the capabilities of narrowband dial-up Internet connections. W and CS are higher under fibre, except at aC = 3.42€, where there is fierce entry competition in copper and therefore CS increases, while W decreases.

As mentioned above the increase in welfare and consumer surplus arising from the switch to fibre probably underestimates the total effect of the switch because households and firms will benefit in ways not captured in their demand for fibre services in this model. Estimating this extra effect is difficult because the end-user demand for fibre access is a derived demand from the demand for the services that can be accessed via the fibre connection. Thus, the increased Willingness to Pay for fibre over copper is a real welfare effect that includes the consumer valuation of new services developed for fibre. However, it does not capture the profit opportunities realized by the sellers of such services, for example, for exports.

Our model also shows welfare increases from a switch from an LRIC/Greenfield approach to an SRIC/Brownfield approach. This, however, is generally not a real welfare effect if it only relates to the way one counts the costs. In other words, the "real" costs do not change if one switches from an LRIC to an SRIC approach. The switch from LRIC to SRIC only represents a real effect if, for example, we use SRIC if copper does not require expansion investments, while we use LRIC if it does; or, if in one case an incumbent can use copper ducts for investing in fibre, while in the other he cannot. Further real changes can occur if regulators use different access charges corresponding to different cost concepts or if incumbents make their investment decisions depend on the cost concept used.

Figure 6-5: Welfare and consumer surplus under variation of aC for aF = Brownfield LRIC = 11.65€



As Figure 6-6 shows for the same scenario as before, an increase in the copper access charge generally reduces the market share of copper entrants and increases the market share of cable, but changes the market share of the copper incumbent very little.[111]

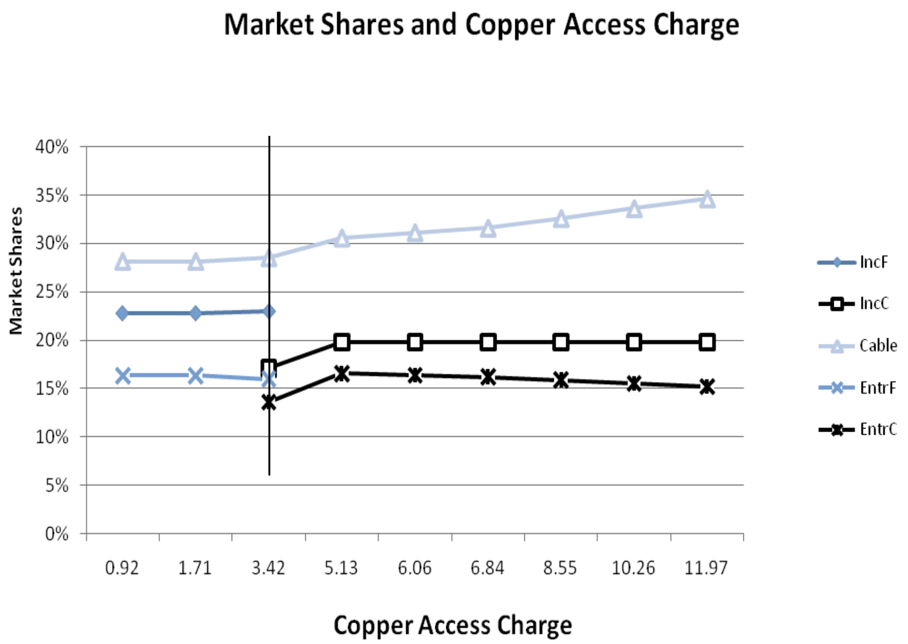
The market share of (individual) copper entrants falls in aC, while the market share of the copper incumbent remains almost constant.

Where fibre is optimal it has a higher market share relative to cable than copper where it is optimal.

Not surprisingly, the market share of cable increases in aC. Cable benefits from the higher costs imposed on its competitors. The market share of cable is higher than that of any other firm but less than half of that of all firms of another technology.

111 It is worth noting that the market share of the incumbent is substantially lower and the market share of entrants substantially higher than the critical market shares provided by the cost model. The reason for the incumbent is that here it is the wholesale market share that counts and that is close to 70% of the population. The reason for the higher market shares of entrants is that competition drives down prices well below the ARPU values assumed in the cost model. Under those prices fewer entrants can survive.

Figure 6-6: Market shares under variation of aC for aF = Brownfield LRIC = 11.65€



As Figure 6-7 demonstrates, an increase in the copper access charge can have ambivalent effects on retail profits. The effects are ambivalent because of the effect of aC on the number of copper entrants.

At aC = 5.13€ the number of copper entrants is reduced from 4 to 3, leading to much increased entrants' profits as well as incumbent's retail profits. Otherwise, without further exit, entrants' profits and incumbent's retail profits decrease sharply in aC.[112] Since we have seen in Figure 6-2 that the copper incumbent's overall profits increase sharply in aC, the wholesale profits must have increased by substantially more in order to make up for the reduction in retail profits. The incumbent's retail profit must decrease in aC since under accounting separation and non-discrimination the accounting upstream cost to the incumbent's retail division is aC. But at the same time the wholesale profits increase correspondingly.

Profits of fibre entrants are unaffected by aC. They only depend on aF (as long as copper and fibre do not exist side by side) and at aF = Brownfield LRIC = 11.65€ fibre retail profits exceed copper retail profits.

112 This effect is absent in the model without cable, which is one of the reasons for developing the model with cable in the first place.

Incumbents always make much larger retail profits than entrants. This occurs because of their QoS and goodwill advantages on the one hand and their lower downstream costs on the other.

In our model retail profits can be very high. This high level is explained mostly by the free-entry feature, which means that there is no entry unless a further entrant can at least earn the WACC. There are two factors that can prevent entry. First, an entrant has large fixed costs that have to be covered in addition to the fixed costs of all other firms. Thus, if entry had no effect on prices and on total output the extra fixed costs would have to be covered from the profits of the already established firms. Second and no less important, entry leads to lower prices and somewhat increased overall outputs, where each established firm will produce less than before entry. Because of overall inelastic demands in the model, total revenues after entry will be less, further reducing overall profits available for covering the entrant's fixed costs.

Figure 6-7: Retail profits under variation of aC for aF = Brownfield LRIC = 11.65€

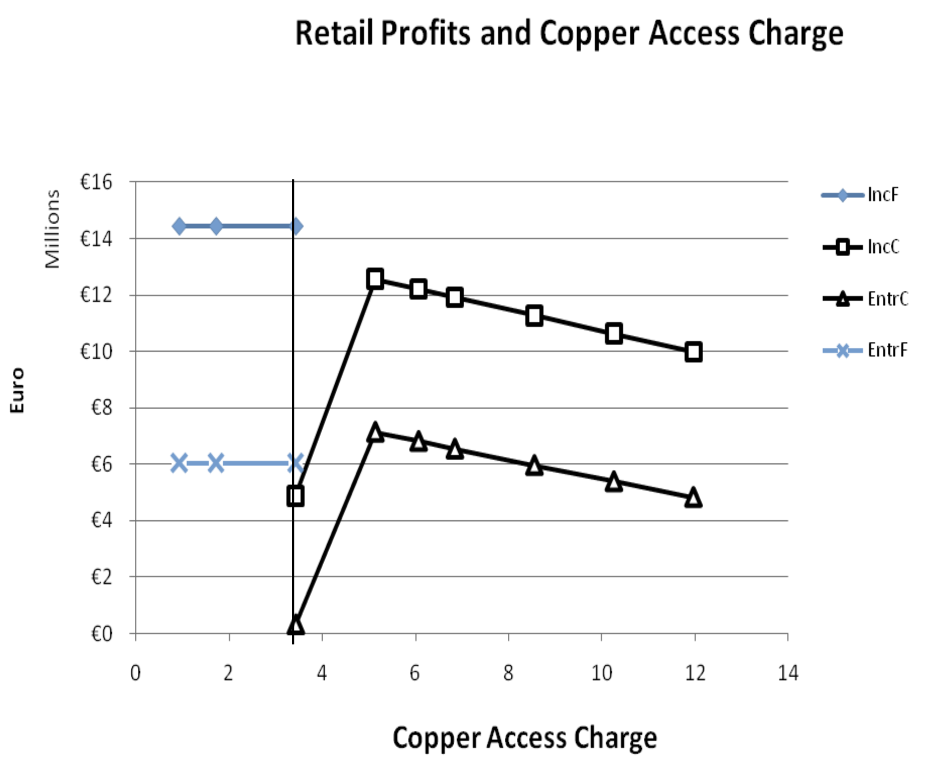
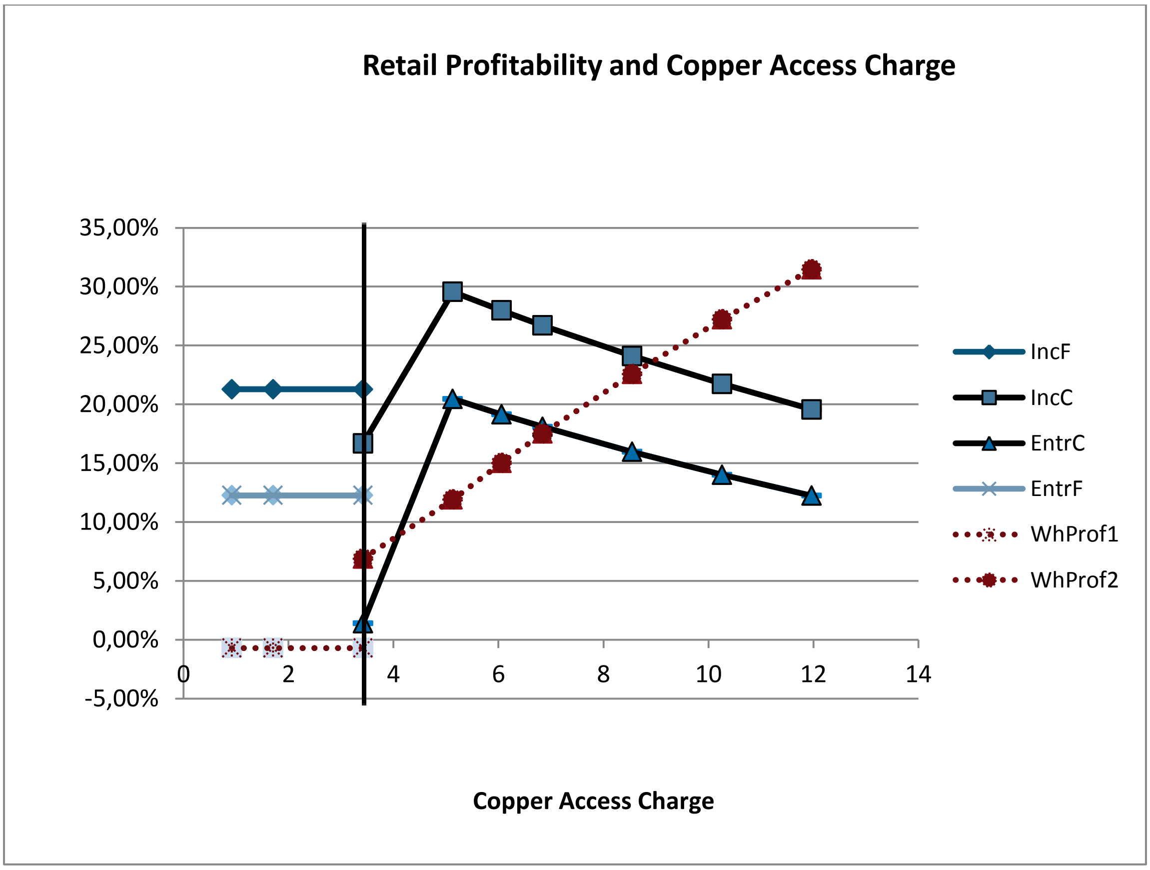


Figure 6-8 provides the same information as Figure 6-7, this time only expressed as retail profits (based on low-low costs) as a percentage of retail revenues and with the addition of wholesale profitability. The main change here is that, due to the higher retail prices for fibre, the retail profitability of fibre is lower relative to the absolute profit levels. Also, part of the higher absolute level of retail profits of incumbents is explained by their larger market share. The wholesale profitability of fibre is negative at aF = Brownfield LRIC[113], while wholesale profitability of copper increases steadily in aC, reaching 30% at aC = 11.92€.

Figure 6-8: Retail profitability under variation of aC for aF = Brownfield LRIC = 11.65€



Summing up, what triggers the incumbent's decision to switch from copper to fibre is that fibre becomes more profitable for the incumbent than copper. Since higher copper access charges increase profits from copper but leave fibre profits unaffected (as long as the two services are not offered side by side), an increase in aC reduces the incentives for a switch. In particular, at today's nationally averaged aC of 8.55€ there

113 It has to be stated here that profits are defined as receiving a return on capital over and above the assumed WACC. Furthermore, the resulting negative profits are within the margin of error of estimating Brownfield access charges, because quantity predictions by the regulator will never be precise.

would be little incentive for the incumbent to invest in fibre. Within the range analyzed wholesale profits strongly increase in aC, while retail profits and entrants' profits suffer, unless an increase in aC forces the exit of entrants. An increase in aC also leads to a reduction in the aggregate market share of copper relative to cable. Furthermore, it clearly leads to a reduction in consumer surplus, while the welfare level is affected quite little. However, since the switch to fibre most likely increases both consumer surplus and welfare, an increase in aC that prevents the switch would have negative effects on both.

Under a Brownfield LRIC scenario in which fibre access charges are €11.65 and copper prices are set at or below the switching point of €3.42, the market supports one cable operator with 28% market share, the fibre incumbent with 23% and 3 unbundling-based entrants with 16% market share each. With copper charges at today's average rate of €8.55, no fibre investment would occur, and the market would support one cable operator with a market share of 33%, and the copper incumbent with 20% and 3 entrants with just over 15% market share each. This market structure does not exist in many markets today. Rather, incumbents in Europe maintain an average of 45% of retail market.

6.3.1.3 Effects of changes of consumer valuations on the incumbent's profits

The higher consumer valuation of fibre is the most important reason for the incumbent to switch from copper to fibre. So, how do variations in consumer valuations affect the incentives for such a switch?

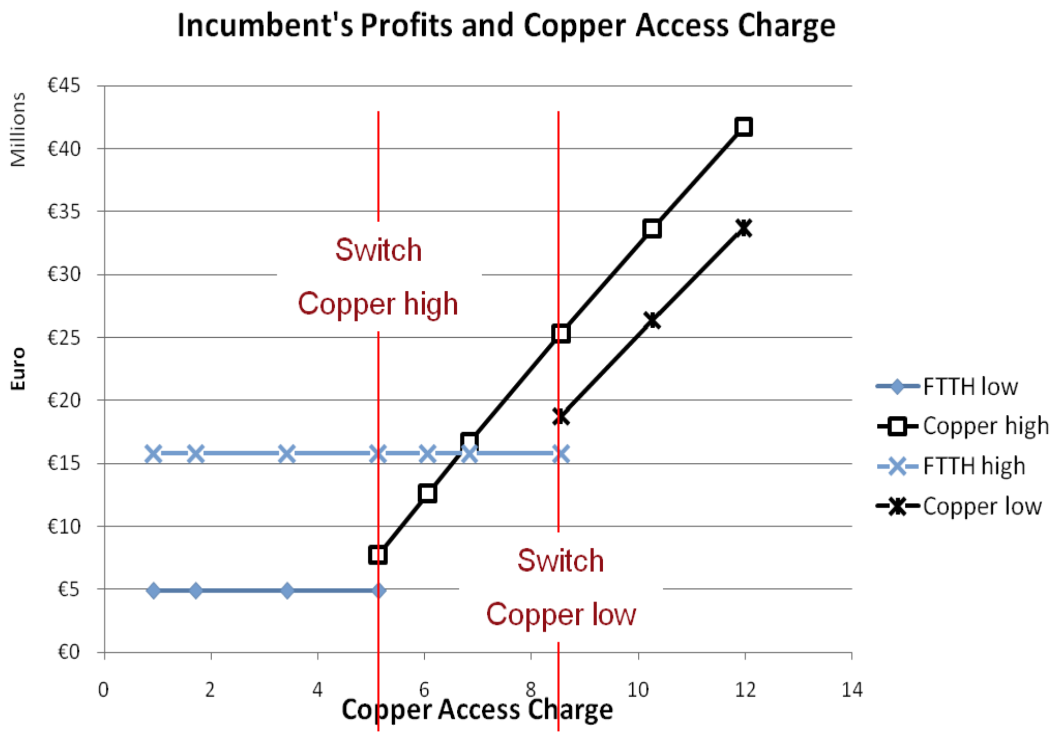
Figure 6-9 shows that a change in the consumer valuation of copper relative to fibre changes the range for which fibre is more profitable than copper. This figure differs from the previous ones in that it shows a variation of aC for a given level of aF = 13.92€ = Greenfield LRIC. While the higher dark line and lower light line represent high valuation of copper relative to fibre, the lower dark line and higher light line represent low valuation of copper relative to fibre.

The switch from copper to fibre occurs at aC = 8.55€ at low copper valuation compared to aC = 6.06€ for intermediate valuation and aC = 5.13€ at high valuation. Thus, by inference, at intermediate valuation the switch occurs, where both aC and aF are set at LRIC, while at high copper valuation copper is preferred at a lower aC and at low copper valuation it is preferred at a higher aC.

At high valuation of copper fibre has little chance at the currently prevailing aC = 8.55€ in Europe even if aF is set at Greenfield LRIC.

The higher the valuation of fibre over copper the lower the necessary difference between aC and aF in order to trigger a switch from copper to fibre, because at high valuation by customers fibre generates more profits for a given level of aF.

Figure 6-9: Sensitivity of switching points and incumbent's profits to consumer valuations of copper and fibre (aF = 13.92€)



We have further linked the consumer valuations of fibre relative to copper to the incumbent's profits from copper and fibre, each considered in isolation. This is done for two sets of access charges. Note that, contrary to the sections above, we here measure valuation in the other direction.

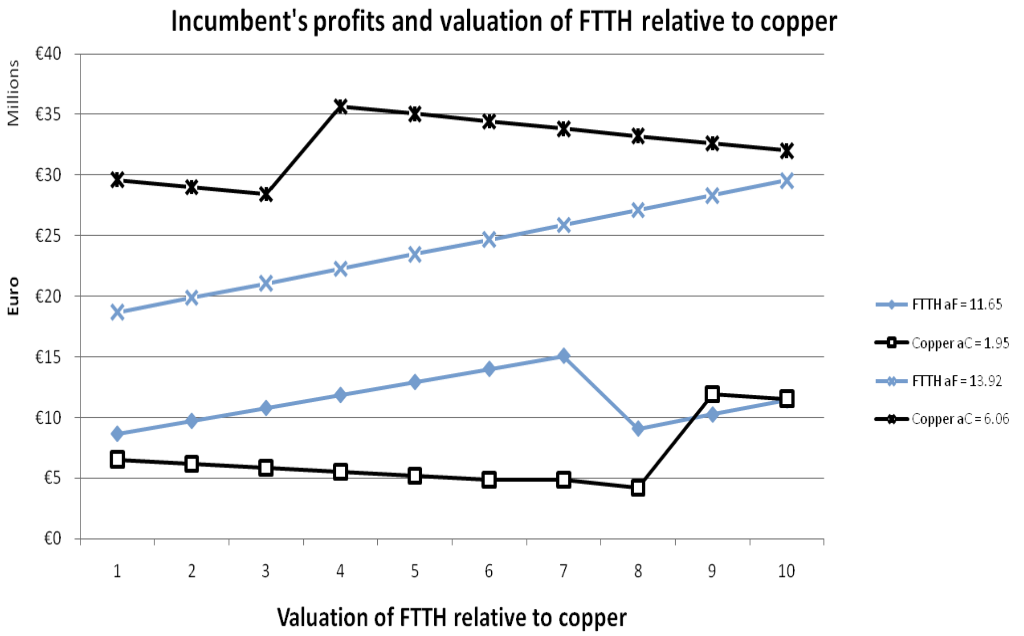
Figure 6-10 shows the effect of the valuation of fibre relative to copper on the development of the incumbent's copper or fibre profits under two levels of access charges but only for SRIC/Brownfield costs. Fibre is valued on the scale with 1 = lowest fibre valuation and 10 = highest fibre valuation, where 1 corresponds to the previous "high valuation of copper" and 10 corresponds to the previous "low valuation of copper".

The upper two lines of Figure 6-9 present the case of traditional LRIC charges (aC = 6.06 and aF = 13.92) and the lower two lines the case for copper SRIC and fibre Brownfield charges (aC = 1.95 and aF = 11.65). For all considered sets of wholesale access charges in Figure 6-10 we assume that the incumbent produces at copper SRIC and fibre Brownfield cost (cost basis: low-low).

The level of access charges has a large effect on the level of profits, as shown by the distance between the two sets of curves.

At LRIC access charges copper profits are always higher than fibre profits but the gap generally narrows with higher valuation of fibre. At SRIC/Brownfield charges fibre profits are mostly higher than copper profits and the gap generally widens. Exceptions to these trends occur only because of entry and exit of entrants, the effects of which can be substantial. In particular, lower valuation of copper leads to the exit of a copper entrant in the upper part of the graph at 4 on the scale and in the lower part of the graph at 9 on the scale, while increased valuation of fibre leads to a new fibre entrant at 8 on the scale.

Figure 6-10: Effects of a change in consumer valuation on incumbent’s profits and switch to fibre for two levels of access charges – Brownfield/SRIC costs



Summing up, as expected, at high valuation copper is more profitable than fibre for a larger range of aC than at low valuation of copper. What may, however, be surprising is that entry and exit of entrants can have such a large effect on the incumbent’s profits that they compensate the effect of even quite large differences in consumer valuations. Thus, within the range of valuations analyzed the effect of consumer valuation changes on the incumbent’s profits and his incentives to switch from copper to fibre is distinct but not overwhelming. This justifies our focus on intermediate valuations.

6.3.2 Varying the fibre access charge (aF)

6.3.2.1 Modeling assumptions

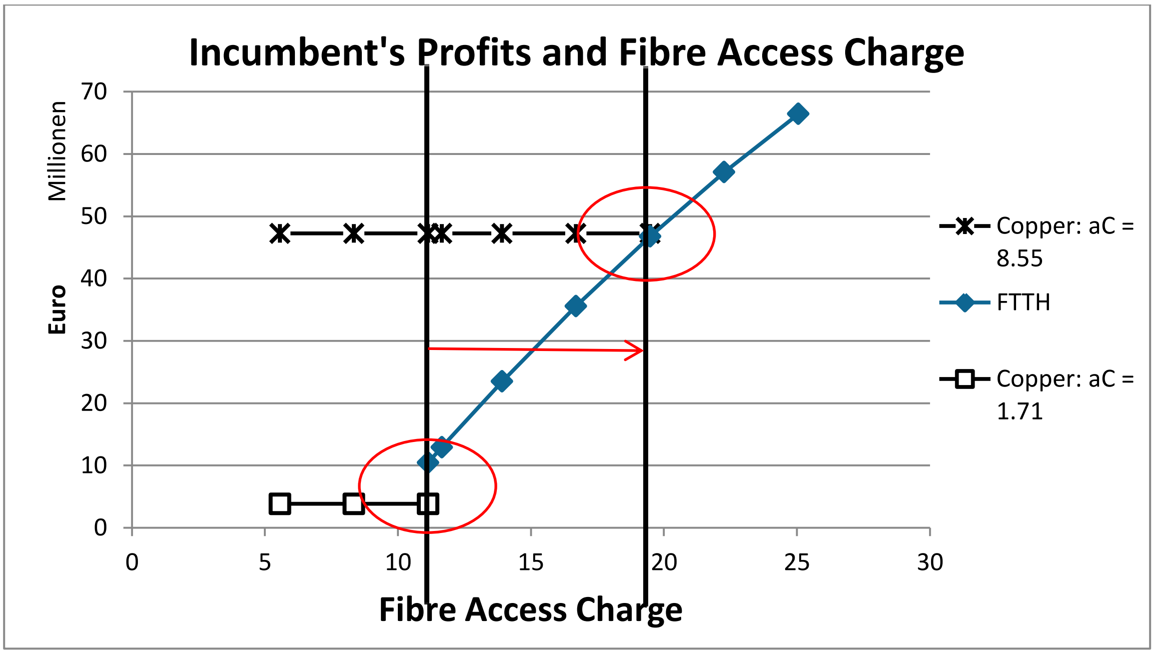
This section addresses the question, what the effects of a change in aF would be for given levels of aC. To answer it the fibre access charge is varied in nine steps from 5.57€ to 25.06€. All other modeling parameters remain constant. As before, if not stated otherwise we assume SRIC/Brownfield costs (low-low), an integrated incumbent and intermediate valuation of copper relative to fibre. We consider two cases. First, the integrated incumbent offers only the profitable service(s). Second, in Section 6.3.2.4 the integrated incumbent for any copper access charge always offers both services.

6.3.2.2 Results for the integrated incumbent offering the most profitable service(s)

As Figure 6-11 shows, an increase in aF substantially increases the incumbent's fibre profits. At higher aC the switch to fibre occurs at a higher level of aF. In particular, with aC = 1.71€ the switch from copper to fibre occurs at aF = 11.14€ (< Brownfield LRIC), where fibre profits substantially exceed those of copper.[114] In contrast, with aC = 8.55€ (= average EU copper access charge) the switch only occurs at aF = 19.49€, or at aF = 22.27€ if we only consider discrete steps of variation.

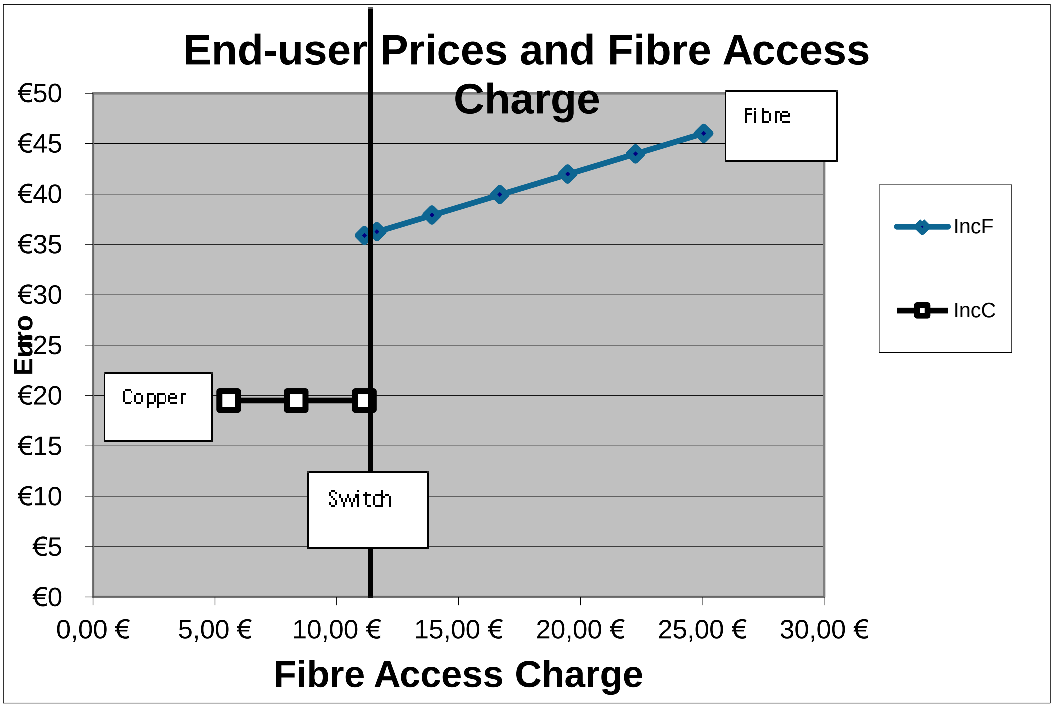
114 The figure shows that the match for the switch is imperfect, due to discrete model runs. Under continuous variation the switch would occur at about aF = 9.80 €.

Figure 6-11: Effects of a variation of aF on incumbent's profits and switch to fibre for two levels of aC



In Figure 6-12 to Figure 6-14 we turn to the effects on end-user prices of variations in aF for given aC levels. Figure 6-12 shows the effects of variations in aF on the incumbent's prices for aC = 1.71€. Because of very low aC the end-user prices for copper are also very low. Since the switch to fibre occurs at a low level of aF, the prices of fibre start low and then increase sharply in aF.

Figure 6-12: Effects of a variation of aF on incumbent's end-user prices and switch to fibre for aC = 1.71€



As Figure 6-13 shows, an increase of aC from aC = 1.71€ to aC = 8.55€ increases the end-user prices for copper sharply (from about 20€ to 29€), in fact by substantially more than the 6.84€ increase in access charge. This is the result of a reduction in the number of copper entrants that is associated with this increase in aC. This large increase is also what moves the switch from copper to fibre from aF = 11.14€ to aF = 19.49€, where the end-user price for fibre is already at close to 45€. After that an increase in aF further increases this price.

Figure 6-13: Effects of a variation of aF on incumbent's end-user prices and switch to fibre for two levels of aC

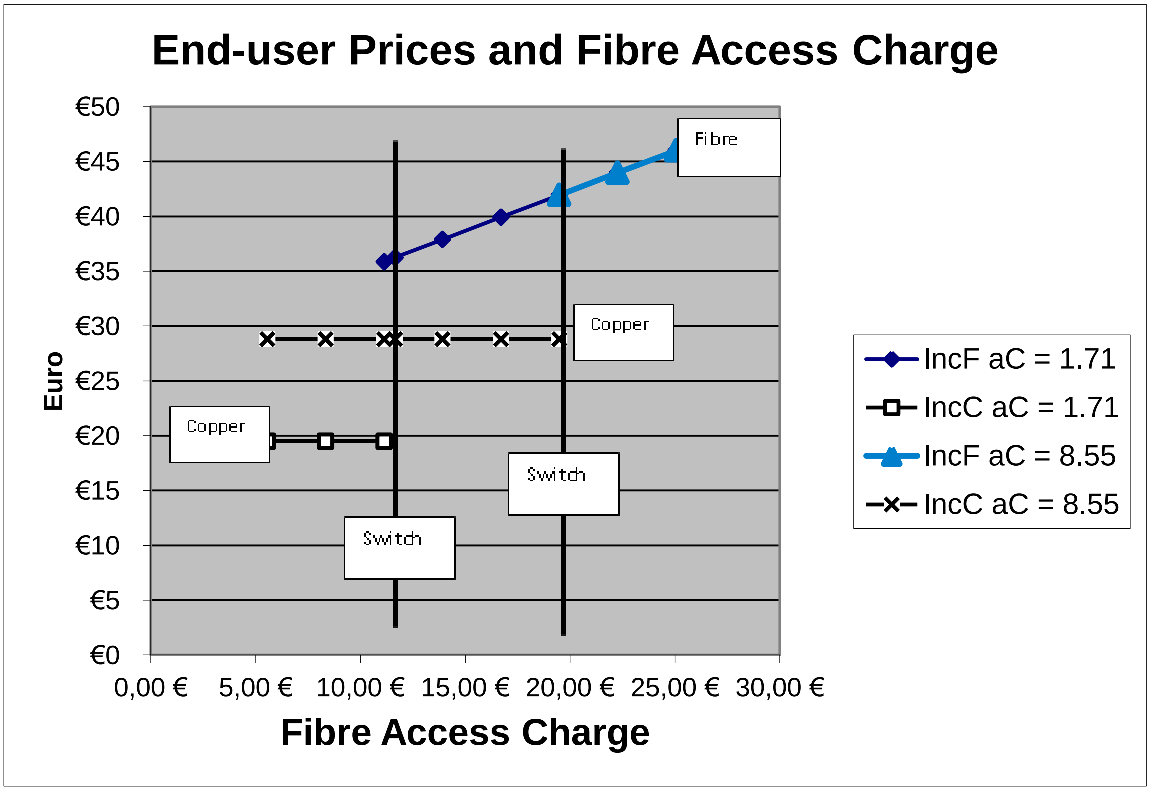
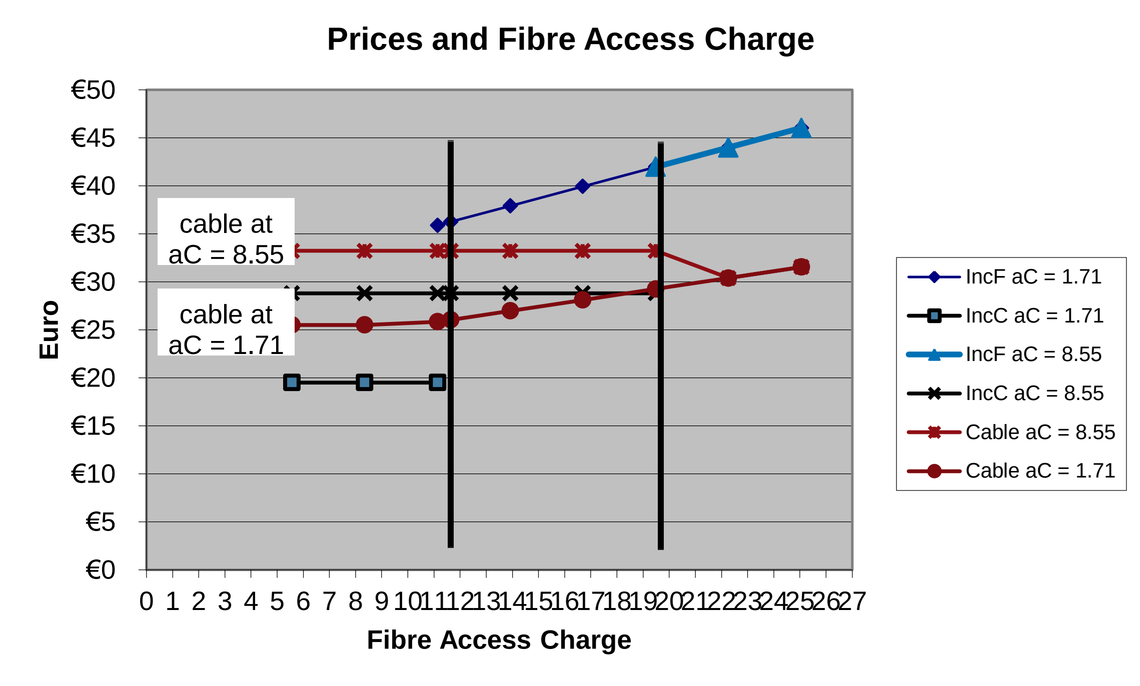


Figure 6-14 provides the same information as Figure 6-13 but adds the end-user prices for cable for the two levels of aC. In both cases the price for cable is clearly above the end-user price for copper and below the end-user price for fibre. As expected it increases in aF, but with a slightly lower slope than the end-user price for fibre. The only surprise is that through the switch from copper to fibre at aF = 22.06€ the end-user price for cable is reduced. This is likely the combined effect of the higher valuation of cable relative to copper and the lower valuation of cable relative to fibre.

Figure 6-14: Effects of a variation of aF on incumbent's and cable's end-user prices and switch to fibre for two levels of aC



Summing up, the effects of a change in the fibre access charge on the switch from copper to fibre are a mirror image of the effects of changes of the copper access charge. Thus, an increase in aF relative to the fixed aC incentivizes the switch from copper to fibre in the same way as a decrease in aC relative to a fixed aF had in the previous assessment. Increases in aF have similar negative performance effects as increases in aC on consumer surplus and welfare.

6.3.2.3 Model with vs. without cable

We have introduced cable in the model, because in the model without cable the choice of the incumbent for either fibre or copper eliminates any intermodal competition and makes the total demand for that service completely inelastic. As a result, retail profits and market shares are unaffected by access charge increases. Thus, there needs to be another communication mode to bring elasticity into the demand and at the same time provide a credible competitor. Given that we restrict the analysis to clusters 1 through 4 with their fairly high population density, cable is best suited to fulfill this function. What then is the importance of the introduction of cable for the modeling results? We only answer this question with two examples that are restricted to the effects on the incumbent's profits. The answers have to be interpreted with caution, because they are derived from two different models with somewhat different parameters.

In Figure 6-15 we show that the introduction of cable can have quite asymmetric effects on copper and fibre profits. In this example the profits for copper at an assumed aC = 8.55€ are virtually identical with and without cable. In contrast, profits for fibre are distinctly lower in the presence of cable and increase less sharply in aF. However, the switch from copper to fibre both with and without cable occurs at aF = 16.70€.

Interestingly, cable profits at aF = 19.49 equal fibre profits. They are reduced by the switch to fibre but at higher aF fibre profits increase by more than cable profits. Nevertheless, cable benefits from higher fibre access charges, although not as much as fibre.

Fibre profits are reduced by the presence of cable and the increase in fibre profits from increases in aF is mitigated by the presence of cable. Thus, in this example cable only seems to discipline fibre. The reason is that at aC = 8.55€ copper's market share in the model with cable is almost exactly equal to the 70% penetration assumed in the model without cable. As a result wholesale profits have to be identical. The model with cable shows three entrants, while the model without cable has four. Thus, with five market participants in each case the level of competition is quite similar, leading to similar retail profits as well.

Figure 6-15: Effects of a variation of aF on incumbent's profits and switch from copper to fibre for model with and without cable – cost basis: high-high

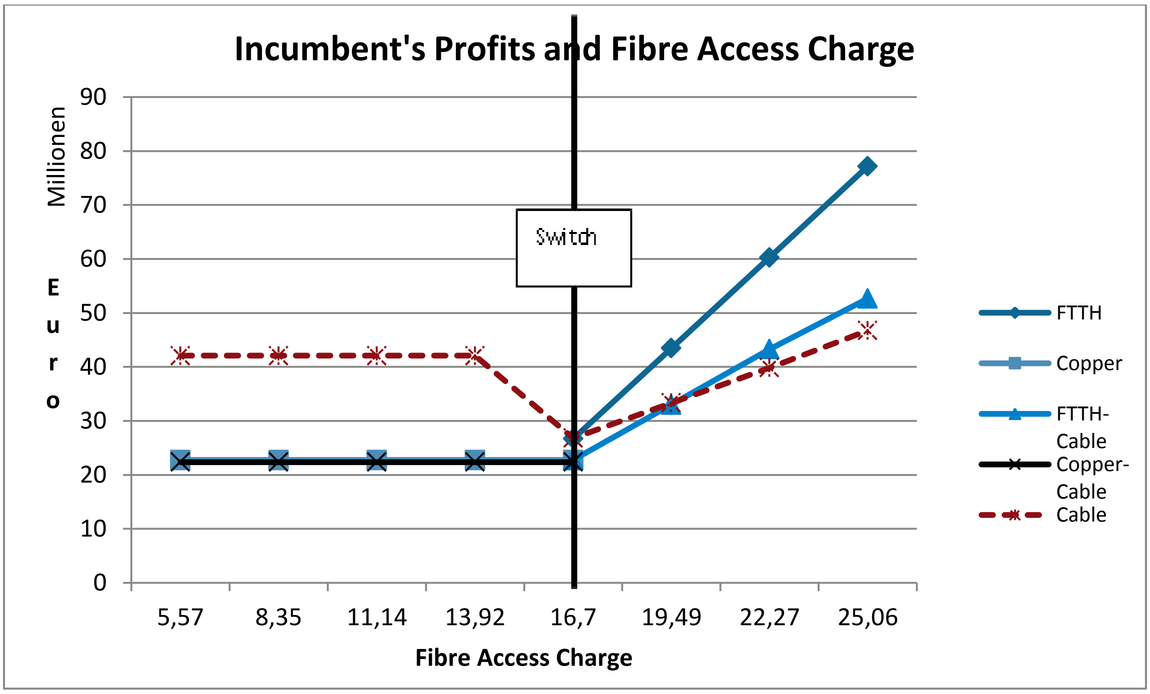
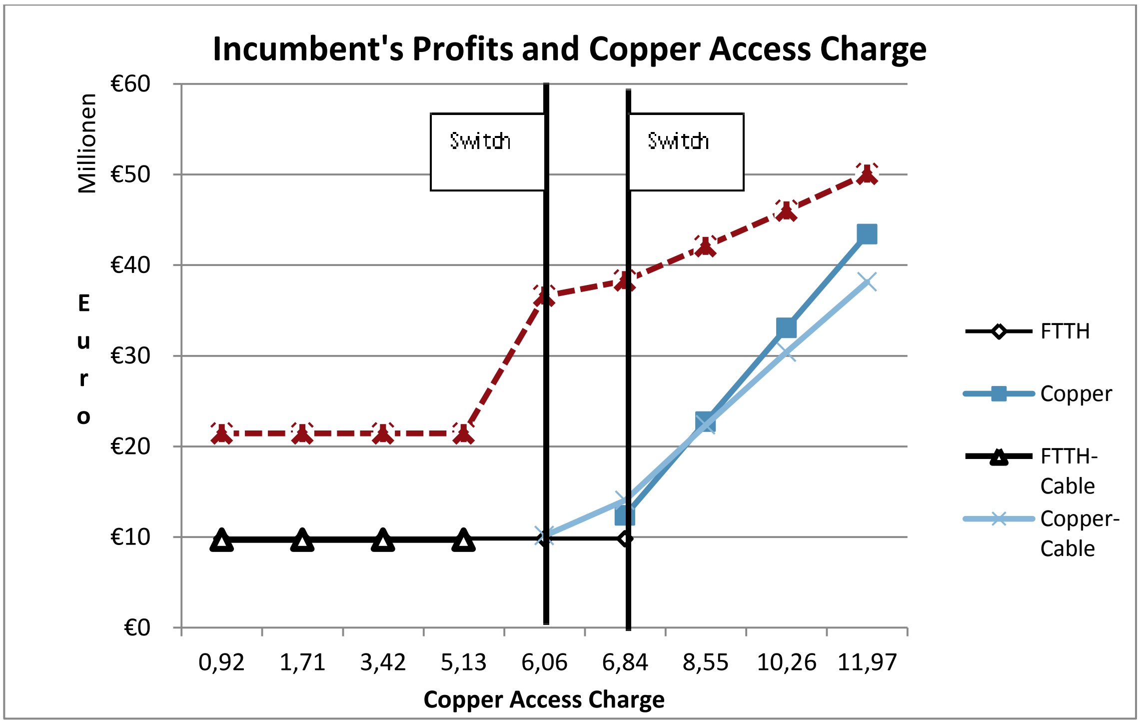


Figure 6-16 shows the symmetrical case of a variation in aC for fixed aF = 13.92€. Here fibre profits are equal both with and without cable for the same reason as copper profits were similar in the previous case. Copper profits in Figure 6-16 also diverge little from each other but it is clear that, as with the case of fibre in Figure 6-15, cable reduces the rate of increase in copper profits as a result of access charge increases. This dampening of the increase in profits through the presence of cable is the general result from this exercise.

Because fibre profits without cable start lower than fibre profits with cable the switch to fibre occurs at a lower aC level with cable than without cable.

Figure 6-16: Effects of a variation of aC on incumbent's profits and switch from copper to fibre for model with and without cable –



6.3.2.4 Results for an integrated incumbent offering both service(s)

Our assumption in the last few sections has been that the incumbent only offers either copper or abandons copper and fully switches to fibre. In the course of our model runs this has actually been a result of optimal choice rather than an assumption, because for all the relevant runs keeping both the copper and fibre networks turned out not to be the most profitable solution for the incumbent. This result, however, is not trivial, since a combination of both copper and fibre would generate substantial downstream savings by avoiding duplication of the core and distribution network. These savings correspond to the full fixed costs of a rival entrant. Thus, an integrated incumbent, who only needs to incur SRIC for the copper access network could actually offer copper very cheaply alongside providing fibre access. It may therefore be surprising that the restriction to a single access network appears to dominate two parallel networks. We exemplify the resulting issues first for a parallel increase or decrease of both aC and aF from their SRIC/Brownfield levels and then for high and low consumer valuation of copper relative to fibre and for a variation of the fibre access charge.

Figure 6-17 is based on intermediate valuation of copper relative to fibre and on low-low costs. It shows that under a parallel variation of both aC and aF the profits for fibre and copper alone clearly exceed the profits for copper and fibre offered jointly. Joint offering of copper and fibre also reduces the number of entrants. There are no fibre entrants and only 2-3 copper entrants. The only point, at which the profit level of the joint offering moves closer to the profit levels of copper and fibre alone, is where copper loses one of three entrants due to the increase in access charges. Because of the resulting overall reduction in competition this kink affects both copper and fibre profits. Otherwise, an extrapolation of the numbers suggests that the profit series do not approach each other at realistic access charge levels. The result is particularly negative for the fibre portion of joint profits, because under joint offering the fibre market share is too small to recover the high fixed costs. It would take very high access charges for joint profits of copper and fibre offered together to reach the profits of the most profitable one offered separately. Such high access charges would probably exclude all entrants.

Figure 6-17: Incumbent's profits under joint vs. separate offerings of copper and fibre

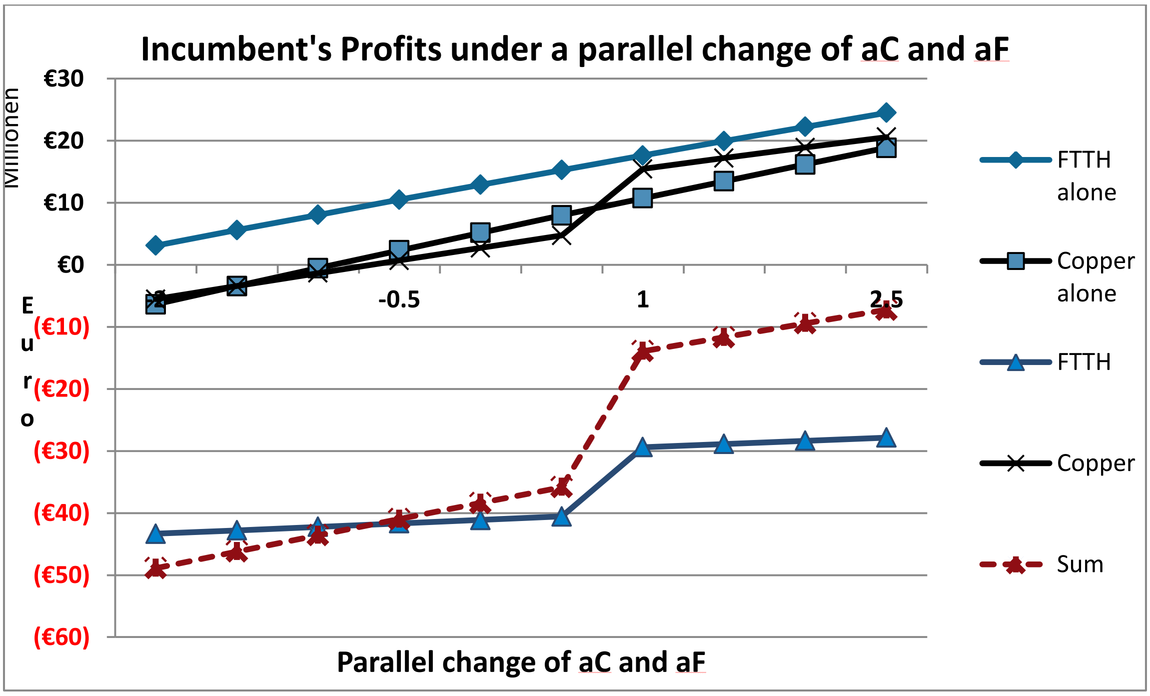


Figure 6-18 and Figure 6-19 illustrate the effects of a variation of aF on incumbent's profits and on the switch to fibre for the case of an integrated incumbent offering both services. Both figures are based on aC = 8.55€ = current aC average in EU, but they differ on the valuation of copper relative to fibre. Figure 6-18 assumes high valuation of copper relative to fibre. In this scenario, because of copper's high market share fibre entrants are never profitable. Thus, for lack of fibre entrants, an increase in the fibre access charge has almost no effect.[115] Fibre is the big loser, while copper turns out to be very profitable. However, the incumbent's total profits are significantly negative.

Figure 6-18: Effects of a variation of aF on incumbent's profits for the case of an integrated incumbent offering both services – high valuation of copper (aC = 8.55€)

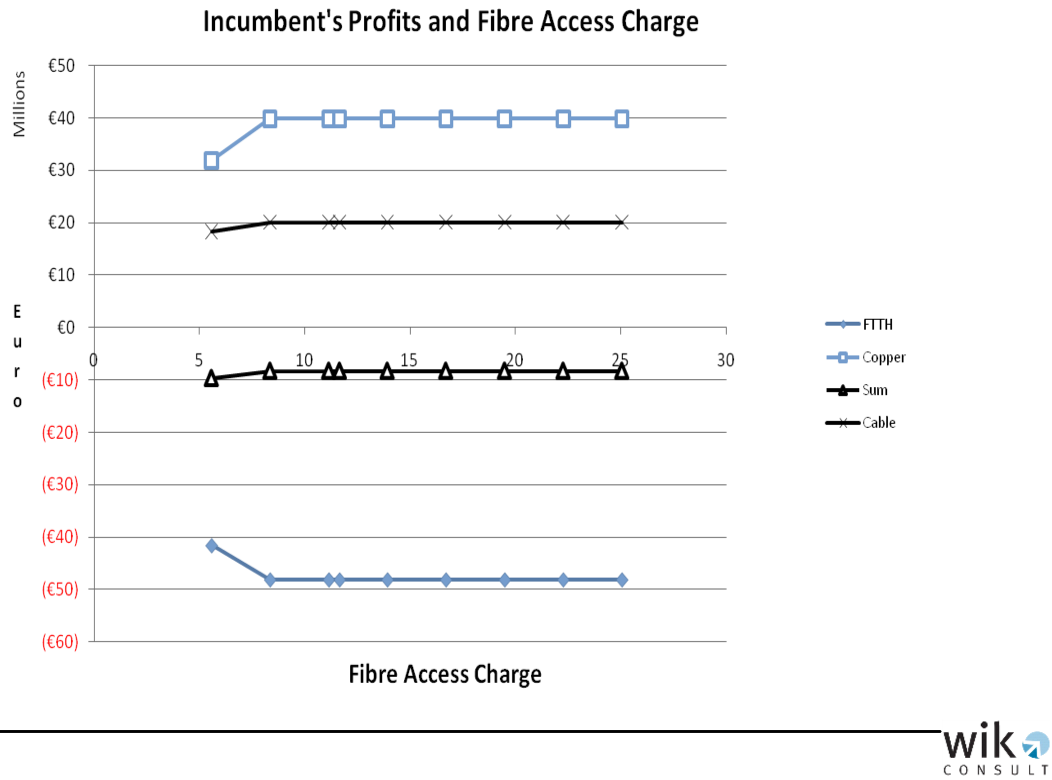
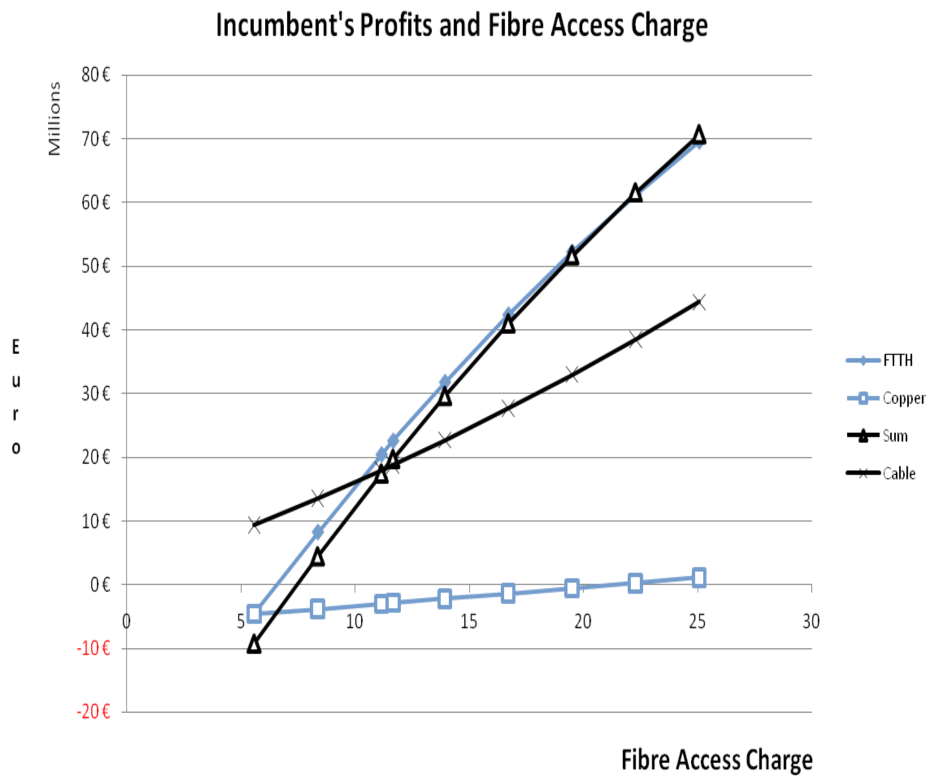


Figure 6-19 with low valuation of copper provides an entirely different picture. In this case copper is scrambling to make any profit and only turns out a positive profit at aF = 25.06€. In contrast, fibre, while making a loss at aF = 5.57€, turns out to be very profitable at high fibre access charges. As before, cable profits increase steadily in aF. This case turns out to be the most favorable for a parallel offering of copper and fibre simultaneously. The main question here is if the sum of the large fibre profit and a small copper profit is smaller or larger than the highest of copper or fibre profits alone. Our model runs show that, because of the relatively high aC of 8.55€, at low levels of aF copper alone easily beats the sum of copper and fibre together. At higher levels of aF and after the switch to fibre this difference shrinks, but fibre alone keeps an advantage of close to 5 million € per month. Therefore, within the range of aF analyzed it is never preferable for the incumbent to operate both networks simultaneously.

115 In fact, because in this case the incumbent prices the end-user service of fibre independently of the level of aF a price squeeze issue may arise at high levels of aF. It would be a purely academic issue because no entrants would appear even at low levels of aF.

Figure 6-19: Effects of a variation of aF on incumbent's profits for the case of an integrated incumbent offering both services – low valuation of copper (aC = 8.55€)



Summing up, it takes very special circumstances and very high access charges to make joint offerings more profitable than the most profitable single network.

6.3.2.5 Results for a parallel variation of both copper and fibre access charges

The results on individual variations of either aC or aF for given access charge levels of the other mode suggested certain patterns of developments. In particular, while incumbent's profits always increase in the relevant access charge, the switch to fibre depends as much on the level of the other access charge. This has lead us to enquire the effects of simultaneous changes of both access charges. We first tried proportional increases of both, but those did not lead to interesting patterns. This changed, however, when we tried increasing or decreasing both access charges by the same absolute amounts. The natural starting points were access charges at LRIC copper/Greenfield fibre LRIC and at SRIC copper /Brownfield fibre LRIC levels.

Figure 6-20 shows the effect of variations in access charge levels on each type of network viewed in isolation. The level increases or decreases starting at access charge levels of LRIC (scale = 0), which are aC = 6.06€ and aF = 13.92€ (Greenfield). We have, in this case, also used Greenfield LRIC as the cost base for fibre and LRIC as the cost base for copper (high-high). Within a large range profits for copper and fibre are the same. In the low range of access charge levels, copper has more entrants than fibre and therefore delivers less profits. Both profits increase sharply in the level of access charges. It is quite striking how a parallel variation of copper and fibre access charges leads to quite similar developments of copper and fibre profits. The increase in copper profits is slightly steeper than in fibre profits, though.

Figure 6-20: Effects of a parallel variation of aC and aF on the incumbent's profits and switch to fibre – Greenfield/LRIC

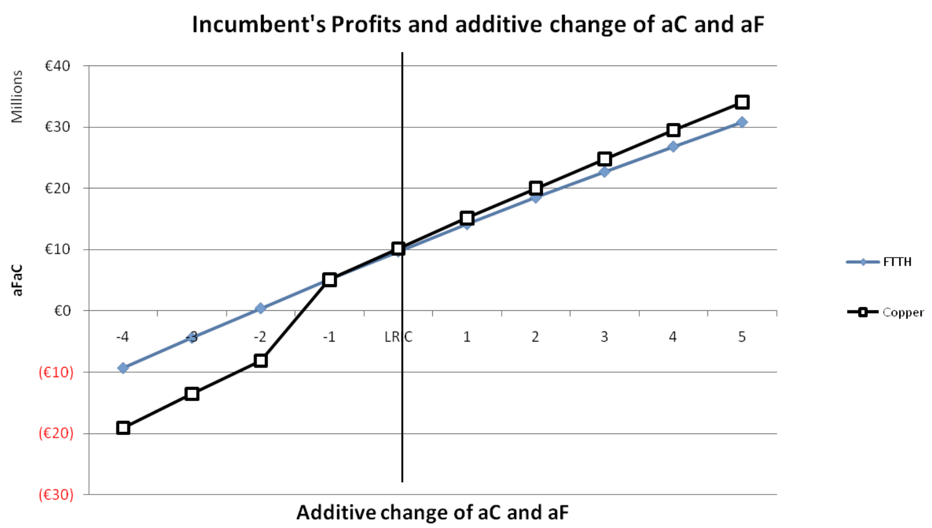
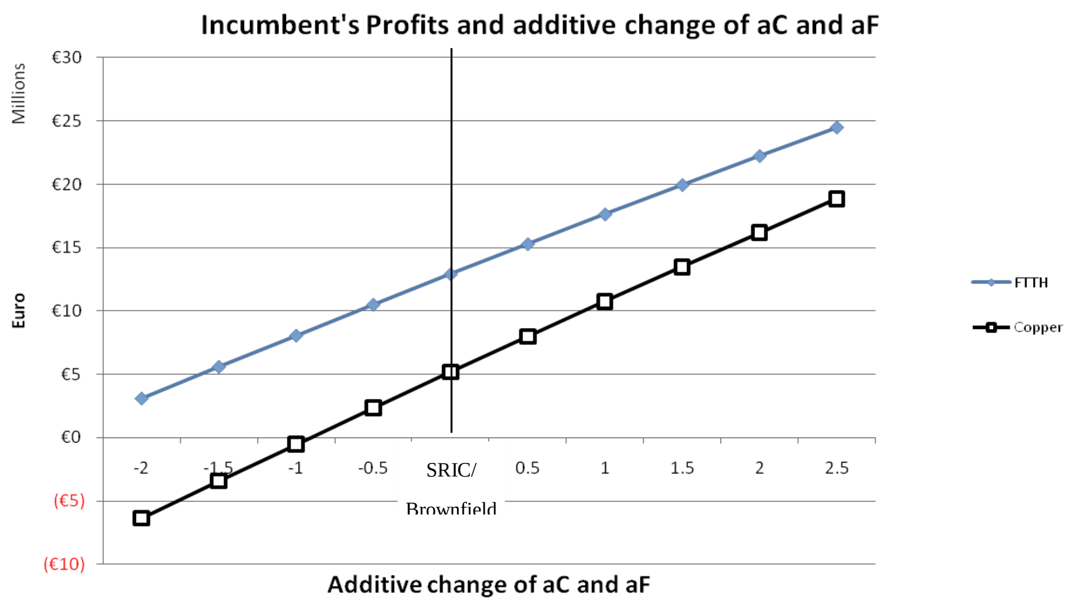


Figure 6-21 repeats the model runs done for Figure 6-17, but in this case for SRIC/Brownfield costs (low-low) and starting levels of access charges at SRIC for copper and Brownfield LRIC for fibre (scale = 0) or at aC = 1.95€ and at aF = 11.65€.

There is a significant difference to the previous result. Now, profit levels for copper and fibre differ significantly, because at the generally low copper access charge levels depicted here copper always has one more entrant than fibre. Otherwise, there is a fairly parallel movement of copper and fibre profits. Again, the slope for copper profits is slightly steeper than the slope for fibre profits. If one forces an equal number of entrants for fibre and copper the profits of both modes are again almost equal.

Figure 6-21: Effects of a parallel variation of aC and aF on the incumbent's profits and switch to fibre – Brownfield/SRIC



The question now is if the above observations are a general phenomenon or just happen to occur for those specific values. Since Figure 6-20 and Figure 6-21 suggest a parallel development of profits under parallel changes in both access charges, the switching points between copper and fiber should also follow a regular pattern. We therefore made runs to establish the relationship between switching points and pairs of access charges. The other model runs displayed so far were based on discrete variations in aC and aF, meaning that switch points were not necessarily exact. In contrast we now have adjusted aC and aF in such a way that profits at the switch points are for all practical purposes equal for copper and fibre. Figure 6-22 presents the results as the solid upward-sloping curve representing (aF, aC) combinations, for which a switch from copper to fibre has occurred. For this figure SRIC/Brownfield costs (low-low) are assumed along with an intermediate valuation of copper relative to fibre.

To the right of the solid upward-sloping curve fibre clearly dominates and in the horizontal direction fibre profits are increasing. To the left of the solid upward-sloping curve copper clearly dominates and in the vertical direction copper profits are increasing.

The lower oval in Figure 6-22 represents SRIC/Brownfield access charges and the upper oval LRIC/Greenfield access charges.[116] While the lower oval lies below the next switch point, the upper oval lies above the next switch point, due to the higher copper profits than fibre profits at those latter access charges (as can be seen in Figure 6-10 above).

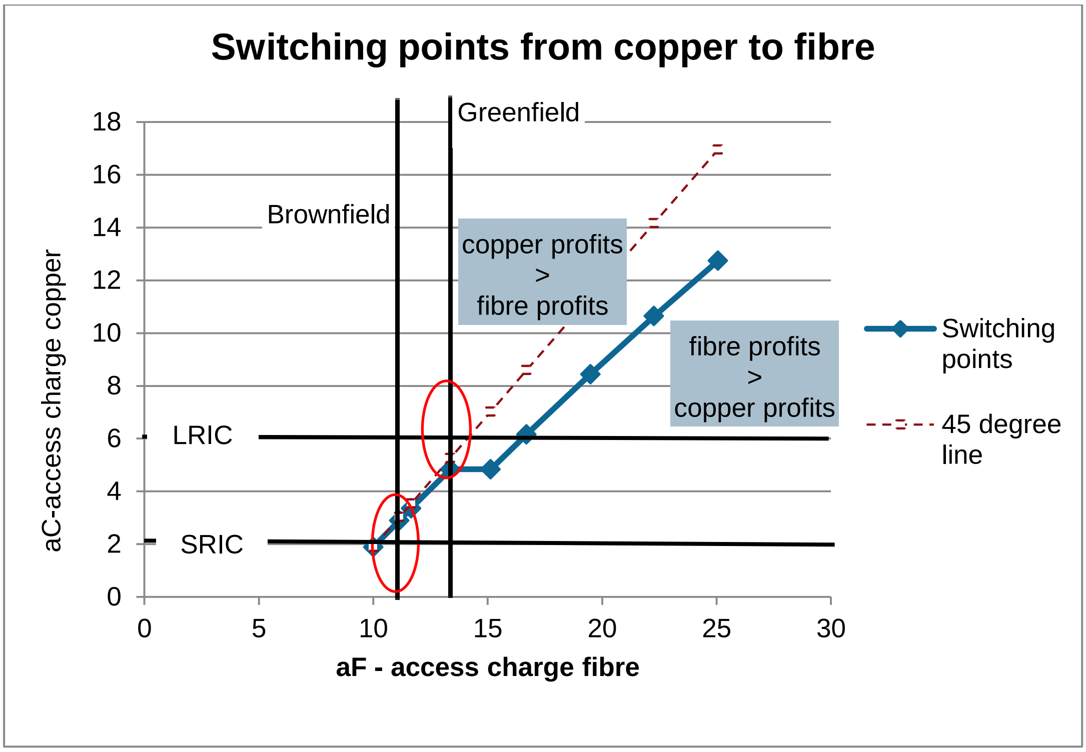
The shape of the curve suggests that with a constant number of entrants the curve would be close to a straight line. The two kinks in the lower part of the curve are the result of the market exit of a copper entrant due to higher aC. With the same units of measurement on both axes the slope of the curve is a little less than 45 degrees. This happens, because fibre profits increase slightly less in aF than copper profits increase in aC. This can be seen from the slightly diverging slopes of fibre and copper profits in Figure 6-20 and Figure 6-21. The effect is enhanced by the exit of the copper entrant, which leads to a discontinuity of the curve, meaning that between aF = 13.37€ and aF = 15.13€ a copper access charge of aC = 4.84€ triggers no switch to fibre, while aC = 4.83€ does.

The shape of Figure 6-22 means that the incentives for a switch from copper to fibre are largely preserved by an equal absolute reduction of both copper and fibre access charges and they are increased if the copper access charge is reduced by more than the fibre access charge. The fact that the curve runs below the 45 degree line means that the gap between aC and aF necessary to trigger a switch from copper to fibre increases in the copper access charge.

As can be derived from Figure 6-9 and Figure 6-10 above the curve in Figure 6-22 would be shifted to the right (down) under a higher consumer valuation of copper and would be shifted to the left (up) under a lower consumer valuation of copper. Thus, under a higher valuation of copper a lower aC level is required for every given aF level in order to trigger a switch from copper to fibre. Vice versa, under a lower valuation of copper a higher aC level is required for every given aF level in order to trigger a switch from copper to fibre.

116 The smaller distance between the two vertical lines relative to the larger distance between the two horizontal lines also reveals that the difference between LRIC and SRIC for copper is much larger than the difference between Greenfield and Brownfield for fibre.

Figure 6-22: Access charge combinations, for which a switch from copper to fibre has occurred



6.3.2.6 An integrated incumbent vs. an independent fibre investor

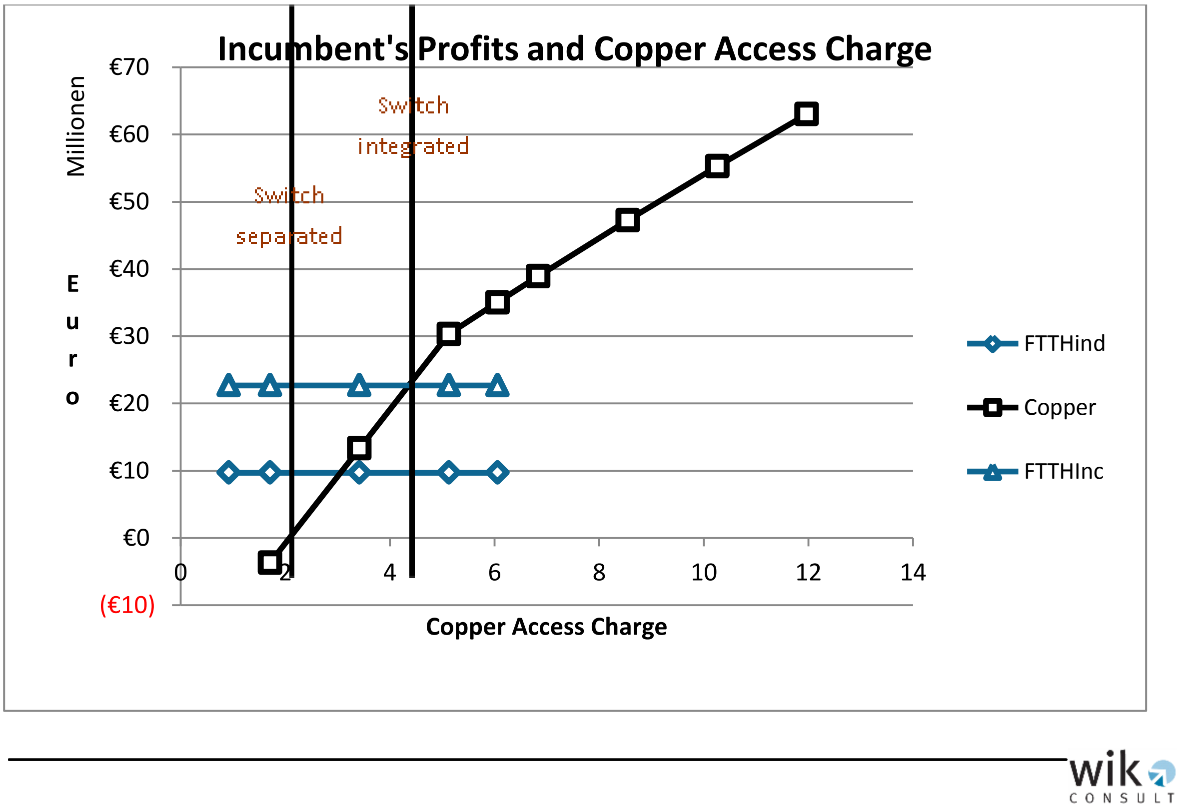
In our model an independent fibre operator can in principle replace a copper incumbent or can build a fibre network along with continued operation of the incumbent's copper network. However, we model neither the possibility that the copper incumbent preempts the independent fibre network nor the possibility that two parallel fibre networks emerge. The latter case would in general not be compatible with our cost results and with our assumptions on ARPUs. The former case would be interesting, because the threat of an independent fibre investor could induce a copper incumbent to invest in fibre before fibre becomes more profitable than copper, just in order not to lose out against the independent fibre investor. This situation can be described as a competition for the market. Our results, however, show that such a threat by an independent fibre investor may only be credible under special circumstances.

Our model runs show that an independent fibre investor can only succeed under two combinations of access charges. The first one is almost trivial. It is that aC (or the valuation of copper) is so low that the copper incumbent leaves the market to the independent fibre entrant. This case is shown in Figure 6-23 ,[117] which provides a comparison of the switch to fibre under an integrated incumbent compared to an independent fibre investor, both in the presence of competition from cable.

In Figure 6-23 aC varies, while aF is given at aF = 13.92€ = LRIC. The upward-sloped line shows the copper profits (based on SRIC) as a function of aC. Fibre profit is constant across different aC levels and is shown by the two horizontal lines. The upper horizontal line shows profits for an integrated incumbent based on Brownfield LRIC, while the lower horizontal line shows profits for an independent fibre investor based on Greenfield LRIC.

An integrated incumbent will switch from copper to fibre, where copper profit is below fibre profit, which holds for all aC at or below about 4.50€ (or, in the discrete case, at aC = 3.42€). In contrast, because the copper incumbent is there first, an independent fibre investor will enter when the copper incumbent exits. This occurs at aC < 2.20€ (or, in the discrete case, at aC = 1.71€). Thus, there is less room for an independent than for an integrated fibre investor.

Figure 6-23: The switch to fibre under an integrated incumbent vs. an independent fibre investor in the case of a variation of aC (aF = 13.92 = LRIC)



117 The results are from the model with cable.

The second possibility for the independent fibre operator is that access charges are so high that both the copper incumbent and the independent fibre investor can operate side by side. This case could be more favorable than the case of duplicate investment by an integrated incumbent. The reason is that the independent fibre investor only needs to make a positive profit, not a higher profit than under operation of only one of the two networks. It turns out, however, that within the range of parameters we looked at this did not happen. One reason is that even at high aC copper keeps a significant market share and that cable's market share is increasing in aC. Consequently, the independent fibre investor cannot achieve enough market share for profitability.

Another reason is that the nature of Nash equilibria does not allow for the independent fibre investor to speculate that the copper incumbent will exit, when he enters. That is not possible because (in the model) the incumbent and the independent fibre investor act simultaneously (at stage 2 of the game). The independent fibre investor, could, however, speculate that entrants will abandon the copper incumbent and switch to fibre if they view this as more profitable. That is possible, because entrants move (at stage 3) after network investors have acted already.

Aside from these strategic issues the relative position of the independent fibre investor will be influenced by cost considerations and a competitive disadvantage. In the integrated case the fixed costs for concentration and core networks are incurred only once rather than for both technologies. Also, an independent fibre investor will ordinarily have no Brownfield advantages when building a fibre access network. Furthermore, the integrated incumbent maximizes profits over both access networks, while in the separate case the two investors compete with each other and each one only maximizes with respect to one of the technologies.

Summing up, an independent fibre investor can succeed only if either aC (or the valuation of copper) is so low that copper exits or if both access charges (aC and aF) are high enough to generate monopoly profits for both and to keep entrants virtually out. The highest level of aF = 25.06€ is not sufficient for that. The same holds for high aC levels, under which copper keeps some market share and cable benefits. Thus, inducing independent fibre investment via access charge levels, even if possible, is likely to cost dearly in terms of lost consumer surplus due to high end-user prices. Even if the conditions for independent fibre entry exist the independent fibre investor would need specific cost or other advantages to overcome the advantages of the incumbent.

6.3.3 Potential conflicts between the incumbent and customers on the decision to switch to fibre

We have assumed so far that (in the absence of an independent fibre investor) the decision to switch from copper to fibre is made solely by the incumbent and is based solely on the criterion of maximum expected profits under given wholesale access charges for copper and fibre. This led to the quite general result that copper is only preferred to fibre under high levels of aC relative to those of aF, because of the effect of access charges on wholesale profits and on the level of downstream competition. The flip side is that relatively low levels of aC vs. aF provide incentives for switching from copper to fibre. Such a switch, however, can lead to conflicts with consumers, who would like to stay with the copper network under the low end-user prices resulting from low levels of aC. This conflict is not directly addressed by our competition model.

The subscriptions that access network providers and entrants sell in the model are only differentiated by type of network and status as access network provider or entrant. A further differentiation by type or speed of service would vastly increase the complexity of the model. Thus, the subscription services in our model have to be viewed as aggregates or composites of all the services offered by a supplier. This has been done explicitly for the derivation of ARPUs in Table 6-1 above. In deriving the ARPUS we assumed certain percentages of users in each of the single-play, double-play, triple-play and business categories. It can therefore be expected that the suppliers offer specific price schedules for these different types of services in such a way that the average prices of the model outcomes result. In that sense, the model is fully compatible with an offer of POTS or "virtual" copper services to end-users over the fibre network. However, if the difference between aC and aF is large enough the continuing users of POTS or "virtual" copper services would nevertheless experience some price increase. If the incumbent decides to buffer this price increase in order to avoid a loss in goodwill the switch to fibre will become less profitable. On the margin between switching and not switching to fibre maintaining the incentive to switch would require an increase in aF to compensate. A lower bound for the increase in aF required would be the amount of subsidy per POTS or "virtual" copper customer multiplied by the number of such customers and divided by the total number of other fibre customers. For example, a subsidy of 10€ per customer for 500,000 virtual copper customers in the presence of 5 million other fibre customers would lead to a minimum increase in aF of 1€. This is a lower bound because it assumes that there is no reduction in the number of fibre customers from the increase in aF and the associated increase in the end-user price for fibre services. As argued in Section 6.3.1.2 above, an access charge increase of 1€ per customer is likely to generate in the neighborhood of 80 cents increase in profits for the incumbent. This would suggest that the increase in aF should be around 1.25€ to compensate for the 10€ subsidy. Any transitional timescale before mandating "switch-off" of copper or copper-equivalent products would have to depend on (a) the attrition rate of subsidized customers and (b) the willingness to burden high-bandwidth services with the cost of the required subsidy.

Such an increase in aF, however, would put fibre entrants at a disadvantage, because they could compete only for those "other" fibre customers and not offer the full range of services (including the subsidized POTS or "virtual" copper services) as competitively as the incumbent. A compromise could be asking the incumbent to offer two wholesale access services, one for general use at the wholesale charge aF and one subsidized and restricted to providing POTS or "virtual" copper services to end users. This may or may not be associated with a further increase in aF because more customers may make use of the subsidy if "virtual" copper services are offered by both the incumbent and entrants.

An alternative to be suggested based on our modeling results is that the regulator leaves the wholesale copper access charges at their current level provided the incumbent commits to a fibre build-out over a pre-specified period. Any delays in this build-out would then trigger a pre-specified reduction in the copper access charge. Thus, there would be a glide-path of declining copper access charges that the incumbent could prevent only by investing in fibre.

Summing up, our results show that a switch from copper to fibre may be accompanied by a retail price increase in the range of 11 - 16 € per month. This gap could be bridged by

- a differentiation of retail prices by product, allowing for "virtual copper" products to be delivered at much lower prices than the fibre average. This could be consistent with profit maximization and feasible for the incumbent However, unless equivalent wholesale options are available, it could be difficult for entrants. Such wholesale options could include
    - two-part access tariffs that would facilitate differentiation by entrants. However, such tariffs may reduce the number of entrants and favor the competitive position of the incumbent.
    - an offer of a low-price "virtual copper" access product on bitstream basis in addition to ULL. This requires an increase of the ULL charge aF to compensate the incumbent and may lead to a delay of the switch to fibre. This option could be limited to a transitional period.
- Our study directly supports the following option: Signalling the regulators' intention to set significantly lower copper-based rates (to remove any super-normal profits), e.g., through a glide-path whilst committing to the swift phase-out of copper if fibre is installed on terms that permit effective competition.

6.4 Conclusions

- Our model analysis is restricted to clusters 1 through 4 and therefore does not include most suburban and all rural areas. Changing the areas covered will affect costs and thereby the quantitative results, although we believe the qualitative results to be robust.

- In the case of an integrated incumbent the decision to switch to fibre is driven primarily by the access charge differences between copper and fibre relative to their respective costs. Obviously, the incumbent's profits are influenced by many factors (e.g. costs, market share, retail prices), wholesale access charges being only one of them. Our results, however, suggest that their influence can be substantial. The relative wholesale charges determine the profitability of one technology compared with another.

- The absolute level of aF plays a role in the investment decision only in so far as profits from fibre investment have to be non-negative in order to enable investment financing. However, absolute pricing levels for copper and fibre access have significant implications for the levels of retail prices, number and profitability of competitors, and consumer welfare.

- An equilibrium with both copper and fibre is possible, but unlikely. It can occur because duplication of downstream costs can be avoided and because the overall number of entrants can be lower. A speedy migration strategy is therefore essential in stimulating fibre roll-out.

- We can distinguish three scenarios of wholesale access charge combinations:

    - At the current European national average copper access charge of aC = 8.55€ a fibre access charge of €19.49 (significantly above the cost-based rate) would be needed to induce investment in fibre. At these wholesale rates, fibre ARPUs would be approx €42 compared with copper rates of €29. Consumer welfare under copper would be 18% lower than in the CS maximising case. This scenario is unlikely to reach the Commission's Digital Agenda ultra-speed broadband targets.

    - If fibre unbundling charges are set on a Brownfield LRIC basis of €11.65 per month as calculated through the Euroland model, the corresponding copper charge at which fibre would be more profitable than copper would be €3.42. In this scenario fibre ARPUs would be €36 compared with copper ARPUs of €21. Consumer welfare would be maximised.

    - If Brownfield adjustments do not apply (for example if existing ducts cannot be re-used for fibre), then Greenfield LRIC for fibre would be €13.92 per month and copper prices would need to be set at €6.06 in order to stimulate fibre investment. In this scenario copper ARPUs would be €27 and fibre ARPUs €38.

- Although efficiently low levels of aC would help better capacity utilization of copper while it is in use (i.e., stimulate take-up of broadband) and would increase incentives for a switch to fibre, such low levels of aC may lead to a rate shock when the switch to fibre occurs. Other investment triggering scenarios involving higher aC would also generate rate shocks of €11 per month or more.

- The avoidance of a rate shock associated with a switch to fibre could be achieved in a number of ways. One way could be to facilitate retail price differentiation on fibre (e.g., charging “copper” prices for lower speeds over fibre). However, this approach raises competitive challenges and necessitates equivalently higher charges for “fibre” speeds.

- Our modelling favours an approach under which regulators **signal** that they plan to decrease copper prices to the relevant levels (e.g., through a glide-path), but would allow rapid switch-off of copper if fibre is installed on fair terms and conditions with LRIC-based unbundling charges. In this scenario investment should be triggered and a potential rate shock limited to the gap between current ARPUs of approx €29 to the marginally higher fibre Brownfield ARPUs of €36 associated with LRIC fibre unbundling charges. Consumers would immediately benefit from higher capacities offered by fibre.

- Our results are founded on a base case assumption that in the long run customers (including both consumers and business users) would be willing to pay an average of €40 per month for fibre-based services compared with €32 for copper-based services. If this price premium cannot be sustained – i.e. if customers value copper more highly relative to fibre than under this base case scenario (we examine copper ARPU of €33.50 compared with fibre ARPU of €37.50), copper would be profitable over a wider range of prices, and therefore the gap between the copper and fibre access charges would have to increase relative to the base case to trigger the investment in fibre.

- We have included cable as a player within our base case scenario. We assume that this technology offers capabilities which lie between copper and Point-to-Point fibre and that consumers’ willingness to pay for cable is determined accordingly. Whilst the retail prices for the market as a whole are strongly influenced by the underlying wholesale charges, the presence of cable adds an additional constraint in that higher copper (and/or fibre) charges will in the presence of cable, cause some customers to migrate away from the incumbent towards what is viewed as a superior (or cheaper) technology. Other things equal, lower profits for copper and fibre will result from the presence of cable. The effect of the presence of cable on the incumbent’s incentive to invest in fibre turns out to be ambivalent, since it affects both copper and fibre profits.

- The business case of an independent fibre investor is only viable either at copper charges which are so low (below SRIC) that the incumbent would logically exit the market, or at access charges which are so high, in both copper and fibre that consumer welfare would be significantly compromised.

- Unless access charges are very high, profitability of a technology usually requires a high market share, which can be achieved by a combination of incumbent's and entrants' end-user sales.

- Entrants help the incumbent of a particular technology because they take away customers from the other technology and because they buy access at wholesale charges that contribute to cover fixed network costs.

- We have modeled alternative consumer valuations of copper and fibre in the spirit of sensitivity analysis. However, there is also a dynamic interpretation, according to which the relative valuation of fibre against copper increases with time. This would hold because of expanding new applications for fibre only. This could mean that the increased valuation would be a function of fibre networks actually being built under the motto of the movie *(Green-) Field of Dreams*: "If you build it they will come."

- Welfare is mostly depending on the switch to fibre and the relative valuation of fibre against copper. Welfare under fibre is generally higher than welfare under copper, because of the higher consumer valuation for fibre that, in this case, exceeds cost differences. If fibre is valued highly a switch to fibre significantly increases welfare. Further increases could result from spillover effects not covered in our analysis.

- Consumer surplus is depending on both, the switch to fibre and the level of access charges. A switch to fibre generally increases consumer surplus, while increases in access charges tend to significantly decrease consumer surplus. The latter effect is augmented by the exit of entrants as a result of higher access charges.

- Under a Brownfield LRIC scenario in which fibre access charges are €11.65 and copper prices are set at or below the switching point of €3.42, the market supports one cable operator with 28% market share, the fibre incumbent with 23% and 3 unbundling-based entrants with 16% market share each. With copper charges at today's average rate of €8.55, no fibre investment would occur, and the market would support one cable operator with a market share of 33%, and incumbent with 20% and 3 entrants with just over 15% market share each. This market structure does not exist in many markets today and reflects an assumption of perfect regulation. In practice, incumbents in Europe maintain an average of 45% of retail market. In contrast, our model is free of margin squeeze and discrimination and therefore leads to higher market shares of entrants than we find in a less perfect world.

- The retail profits of entrants and the incumbent's retail operations generally decrease in access charges but the effect may go in the opposite direction for the remaining entrants if higher access charges force the exit of entrants. Higher access charges significantly increase the incumbent's total (wholesale and retail) profits. Cable profits always increase in access charges except for a switch to fibre triggered by an increase in aF.

- Entrants' profits mostly depend on the number of entrants and vary substantially. They are highest just before the point where additional entry is induced and lowest at the point at which entry has just occurred.

7 Regulatory policy conclusions

Although this study relies on theoretical and model-based economic analysis, some meaningful regulatory policy conclusions can be derived from our results. Most of these conclusions are independent of the specific numerical results of our models and only relate to the relative rankings and orders of magnitudes conveyed by our results.

1. Europe has formulated ambitious targets to switch its current communications network infrastructure to a fibre-based ultra-fast next generation broadband network. Substantial investment at an accelerated level as compared to current levels of investment will be needed to provide a sufficient coverage with fibre networks. It is a central result of this study that significant fibre investment can only be expected if the structure and level of wholesale prices and the structure of competition provides the proper incentives for this investment.

2. It is not only the wholesale prices for access to the new fibre networks which have an impact on the incentives to invest for incumbents and competitors. This study shows that nearly as important if not even more important for the switch to fibre networks is the pricing for access to today's copper access infrastructure and the approach towards migration of customers. The level of copper and fibre access charges as well as their relative relationship mainly determine the incentives to invest in fibre and to make the transition to a fibre network infrastructure.

3. Most NRAs in the EU are still applying the FL-LRIC cost standard to determine the wholesale price for LLU. FL-LRIC pricing has a long tradition as a pricing principle to provide economic efficiency for regulated services. FL-LRIC pricing has a lot of attractions for regulators: Prices on that basis reflect the competitive standard and consumers get the best deal. Incumbents get correct signals regarding investment decisions and competitors get the proper signals for their make-or-buy decision.

4. The prices for the monthly rental per fully ULL in the EU vary in the range of 6 to 16 Euro per month. These price differences are not (only) due to national differences in costs, e.g. the WACC. They reveal quite different applications of cost methodologies like cost standard, depreciation method, asset lifetime and averaging of costs as applied by NRAs.

5. Applying FL-LRIC to copper-based ULL at this time of competition from upgraded cable networks and substitution of copper by fibre becomes fraught with at least three potential difficulties:

   (4) FL-LRIC is conceptually based on an expanding market, where additional capacity is being installed. The market for copper-based access, however,

is shrinking and leads to excess capacities. Competitive markets would lead to price reductions in that situation. FL-LRIC would, instead, signal increased costs and prices.

(5) Access-related costs are increasing over time (e.g. copper, labour cost). This would signal c. p. higher ULL prices.

(6) FL-LRIC is based on a replacement by the most modern technology. This is no longer copper access.

6. Copper access prices regulated at FL-LRIC will lead to inefficiencies and welfare losses in such a market environment. One might even argue that FL-LRIC is not defined in case of shrinking demand. Increased copper access charges would foster even further volume decline and would induce unnecessary over-capacities and allocative inefficiencies in copper networks. The competitive position of the copper access network against cable and fibre networks would be artificially weakened and distorted.

7. The proper pricing principle and price level has to be derived from the more general opportunity cost-based pricing principle. This pricing principle finds the efficient pricing in a band which is determined by a lower and an upper limit. The upper limit is given by the conventional FL-LRIC as accurately determined before demand actually declined. The lower limit of the price band would be determined by the short-run incremental cost of operating the copper access network in case all the copper access network elements are sunk, network-specific and cannot be used for other purposes. If the price fell below that level, the incumbent would no longer run the network and close it down, because it no longer provides any contribution to him. If certain network elements, like ducts, are not copper access network-specific and can be used for other networks too, these networks elements have to be valued at traditional FL-LRIC criteria. The copper access network-specific elements include the copper cable, trenches for buried cable and some MDF facilities. The degree of ducting in the access network varies significantly in the Member States. The relevant range is from below 10% to above 80%. The exact point in the relevant range has to be determined based on demand and competitive conditions in the retail market. One implementation approach relies on the retail minus concept. It is however necessary to clearly define the upper boundary, since reliance on retail minus alone will deliver excessive retail and wholesale charges in the absence of effective competition. If LRIC has been correctly calculated in the past, the ceiling could be fixed at the level of the last calculated value – this would have the advantage of predictability and maintaining the status quo. If, however, LRIC for copper has not been correctly calculated such that copper access charges are excessive, the ceiling should be newly calculated on the basis of an

appropriate LRIC approach using parameters relevant at the moment before volumes were declining.

8. Some NRAs determine the ULL price on a valuation of the network assets at historic costs. In case of Ofcom in the UK only parts of the access network assets are valued at historic cost. Historic cost pricing better addresses the potential cost over-recovery problem than FL-LRIC pricing and better takes care of the actual depreciation of the assets. Historic cost pricing does, however, not meet any efficiency standard. It does, however, have the advantage that the resulting prices fall into the range of efficient opportunity cost-based prices as we have proposed it here. Wholesale prices determined on the basis of historic cost only coincidentally will meet the efficient price point in the relevant price range, they are, however, in the relevant price range.

9. In a situation of a shrinking copper access market incumbents face stronger incentives to engage in margin-squeeze activities: To be competitive in the retail market with cable, they tend to lower prices there without changing the level of wholesale charges. NRAs usually impose a margin-squeeze test. When the margin squeeze condition is binding higher wholesale access charges lead to higher retail prices, increasing excess capacity even more. The more efficient approach is to set the wholesale price such that it is at a given level of retail prices margin-squeeze free. Depending on the retail price level this may lead to wholesale prices below the level of FL-LRIC. Lower access charges resulting from such a margin-squeeze adjustment would not impose additional regulatory risk on incumbents. Rather, they would only reflect the market risk from declining demand for copper-based services.

10. We cannot recommend NRAs to distinguish between “bad” and “good” margin squeezes and to allow “good” margin squeezes. Bad margin squeezes have the intent of hurting rivals depending on wholesale access. Good margin squeezes are a response to outside competition from alternative technologies. We do not see that the market power in the copper access market will be vanishing in situations of declining demand which is in our view a prerequisite to allow good margin squeezes.

11. Since fibre access is a growing market, cost-based pricing on the basis of the FL-LRIC principle is the correct approach for access to fibre networks. The fibre wholesale price should appropriately reflect the fibre-specific investment risk. The fibre-specific risk premium as part of the capital costs and as a mark-up on the risk of the copper access business has to be determined carefully. Even small deviations from the risk premium as applied for the legacy network today negatively impacts retail prices, competition and consumer welfare. In case there are Brownfield savings for the incumbent from its legacy network in deploying fibre networks, these should be properly reflected in the wholesale

price; otherwise competition would be distorted to the detriment of users and competitors. This means in detail:

(1) Any model-based calculation of the FL-LRIC has to rely on an efficient architecture and an efficient structure of the relevant and necessary network elements. Model assumptions on CAPEX, operations and maintenance have to reflect efficient costs.

(2) Network assets have to be valued at current costs and have to be depreciated economically to send the appropriate and efficient signals as regards the build-or-buy decisions for assets which may potentially be duplicated.

(3) Assets that in the foreseeable future need not to be replicated and for which over-capacities exists should in principle be valued at an opportunity cost basis as advocated for the copper ULL. A pragmatic approach would be to value them at historic costs with straight-line depreciation and taking into account remaining lifetimes and the status of depreciation to avoid over-recovery of costs and inefficient use of such assets.

(4) Asset lifetimes have to be determined realistically which means around 35 years for the elements of the passive fibre network.

(5) The cost of capital (WACC) should properly reflect the fibre-specific investment risk.

12. The NRA in The Netherlands has applied a discounted cash flow method of determining the ULL charge for fibre where the wholesale price is derived from the business case of the investor. We have shown in this study that this approach is absolutely equivalent to calculating the FL-LRIC on the basis of a bottom-up cost model if economic depreciation is being used. The DCF method has the advantage that it explicitly takes care of the increased fibre penetration over time.

13. Our modeling results show that the (long-term) coexistence of copper and fibre networks is possible but unlikely and undesirable. It takes the very special circumstance of very high copper <u>and</u> fibre access charges to make the joint provision more profitable than the most profitable single network. Access charges have to be high enough to generate monopoly profits for both networks and to keep entrants virtually out. A coexistence scenario would then lead to high retail prices, low competition and low consumer surplus.

14. Once fibre is on the market, there is a strong rationale from the operator’s as well as from the overall economic perspective for a forced migration strategy to

fibre. Regulatory interventions and obligations which make migration more difficult or costly can therefore generate negative incentives to invest in fibre.

15. Our model suggests that at copper access charges which would be conducive to fibre investment, there could be a gap of about 11 – 15€ between the resulting copper retail price and fibre retail price. On the scenario reflecting the lowest combination of copper and fibre access charges (€3.42 and €11.65), this would result in an ARPU of €20 per month for copper and €36 for fibre at the retail level, whilst at the switching point for higher access charges of €8.55 for copper and €19.49 for fibre retail ARPUs for fibre would likely be in excess of €40 per month, which is substantially above current levels. It is important during the migration process to aim to avoid price shocks to end-users as the switch from copper to fibre occurs. This can be achieved in the scenario where fibre charges are set on the lower levels because ARPUs for fibre are close to those currently achieved with copper – customers could be migrated to the fibre-based products – taking advantage of the additional capacities – without any significant increases in broadband retail prices. Copper-based products could be withdrawn at the same time whilst offering potentially for a limited period, virtual copper wholesale services for customers not receiving broadband. However, in order for this scenario to materialize, there must be actual action or at least a credible threat that copper charges will be reduced to levels which would stimulate fibre investment. Otherwise the investment – and migration issues concerned with it – will simply not occur.

16. Our model results clearly demonstrate that a switch to fibre networks has the potential to increase welfare significantly, in particular if users recognize the potential of fibre and value services provided over fibre correspondingly relative to services provided over copper networks. The higher the valuation of fibre in terms of willingness to pay from users becomes, the lower the necessary difference of copper and fibre access charges in order to trigger a switch from copper to fibre.

17. An independent fibre investor requires special cost savings or other advantages in order to outcompete the copper incumbent who has such advantages investing in fibre, and may face the threat of the incumbent pre-empting its investment thereby rendering it unprofitable. Our model shows that only under rather high access charges would it be viable for an independent investor to install fibre alongside the existing copper network – the investment would be justified in this case on the basis that both the copper incumbent and fibre entrant would enjoy a monopoly on the respective technologies. The incumbent will only exit, leaving the access market to another entrant, if both continuing copper and investing in fibre appear unprofitable for him.

18. An integrated incumbent will switch from copper to fibre, where copper profit is below expected fibre profit. Since higher copper access charges increase profits from copper but leave fibre profits unaffected, high access charges for copper reduce the incentives for a switch, In particular, at today's nationally averaged copper access charge of 8.55 € there would be little incentive for the incumbent to invest in fibre. High levels of copper access charges generate negative incentives for incumbents to invest into fibre because of profit cannibalization.

19. Competition in any network is advantageous not only for the economy but also for incumbents. Entrant help the incumbent of a particular technology because they take away customers from the other technology and because they buy access at wholesale charges that contribute to cover fixed network costs.

Appendix: Theoretical background for the competition model

Firms

We assume there are a vertically integrated firm, the ``incumbent'', who runs both a FTTH and a copper access infrastructure, $m_1 \geq 0$ ``FTTH entrants'' who use access to the FTTH infrastructure, and $m_2 \geq 0$ ``copper entrants'' who use the copper infrastructure. The difference between retail products based on FTTH or copper access is captured by a higher gross surplus for consumers from FTTH access. The incumbent offers both FTTH- and copper-based retail products and gives both types of wholesale access. He takes these facts into account when setting his retail prices such as to maximize the sum of profits from his retail and wholesale businesses. The wholesale access prices are assumed to be exogenously fixed by a regulator.

The total number of products present at the retail level is $n = 2 + m_1 + m_2$. The retail products of the incumbent are numbered as products $i = 1$ (fibre) and $i = 2$ (copper), those of FTTH entrants $i = 3, \ldots, m_1 + 2$, and those of copper entrants as $i = m_1 + 3, \ldots, n$.

Consumers, and some technical notation

There are N consumers who opt between pairs of products and subscribe to some product in equilibrium. Each product is located at one of the n nodes of a complete graph (i.e. all n nodes are linked pairwise to each other by lines) of size N which describes consumers' space of preferences over which they are uniformly distributed. The length of each line is $l = 2N / n(n-1)$. Horizontal differentiation on the line between firms i and j is modeled in generalized Hotelling fashion as follows: A consumer at distance d to firm i has ``transport cost'', i.e. disutility of not being able to buy his perfect match, of $t_{ij} d$, while his transport cost for buying from firm j is $t_{ji}(l-d)$. A lower value of t_{ij} indicates that product i is more attractive. While in the standard Hotelling model $t_{ij} = t_{ji}$, we allow for these transport cost to differ and evolve over time as consumers' perceptions of products change.

We now introduce some technical notation which will be very useful below to solve the model. Let e_i , $i = 1, \ldots, n$, be the i th unit vector, $E_0 = e_1 + e_2$, $E_1 = \sum_{i=3}^{2+m_1} e_i$ and $E_2 = \sum_{3+m_1}^{n} e_i$, E be the $(n \times 1)$ vector of ones and I the $(n \times n)$ identity matrix (if $m_i = 0$ then we need to define $E_i = 0E$).

Let $\sigma_{ij} = \sigma_{ji} = 1/(t_{ij} + t_{ji})$ and $\tau_{ij} = t_{ji}\sigma_{ij}$. The former will be the resulting ``standard'' Hotelling differentiation parameter on the line between products i and j , while τ_{ij} will denote product i 's subscriber share at equal net surplus on the same line. Let $T_i = l \sum_{j \neq i} \tau_{ij}$ denote the corresponding total of subscribers for product i if all firms were to offer the same net surplus to consumers.

Let X^{int}, X^{sep} and Y be $(n \times n)$-matrices with entries $X_{ii}^{\text{int}} = X_{ii}^{sep} = Y_{ii} = \sum_{j \neq i} \sigma_{ij}$ for all $i = 1,..., n$; for $j \neq i$ let $X_{12}^{\text{int}} = X_{21}^{\text{int}} = -\sigma_{12}$ and $X_{ij}^{\text{int}} = 0$ otherwise; $X_{ij}^{sep} = 0$ and $Y_{ij} = -\sigma_{ij}$ for all $j \neq i$. Let Γ^{int} be an $(n \times n)$-matrix whose two first rows are equal to those of Y while the rest is zero, and Γ^{sep} be equal to Γ^{int} with elements corresponding to different platforms set to zero. That is, $\Gamma_{12}^{sep} = \Gamma_{1j}^{sep} = 0$ for all $j = 3,..., m_1 + 2$, and $\Gamma_{21}^{sep} = \Gamma_{2j}^{sep} = 0$ for all $j = m_1 + 3,..., n$.

Subscriber numbers

The number of subscribers of product i is $q_i \geq 0$, with $\sum_{i=1}^{n} q_i = N$, and market shares are $s_i = q_i / N$. Subscribers of firm i receive a net surplus[118] of $w_i = S_i - f_i$, where S_i is the surplus from buying product i (a vertical differentiation parameter derived from quality and brand image), and f_i is the monthly subscription fee. The S_i are large enough so that all consumers subscribe, with

$$S = S_1 e_1 + S_2 e_2 + S_F E_1 + S_C E_2$$

and $S_1 > S_2$, $S_F > S_C$.

We assume throughout that no segment ij is cornered by one of the firms, thus the indifferent consumer on line ij is located in its interior, at a distance x_{ij} from firm i defined by

$$S_i - f_i - t_{ij} x_{ij} = S_j - f_j - t_{ji}(l - x_{ij}).$$

Solving for x_{ij} yields firm i's part of segment ij as

$$x_{ij} = \tau_{ij} l + \sigma_{ij}\left(S_i - f_i - S_j + f_j\right)$$

Summing subscribers over segments yields firm i's subscriber number

$$q_i = \sum_{j \neq i} x_{ij} = T_i + \sum_{j \neq i} \sigma_{ij}\left(S_i - f_i - S_j + f_j\right)$$

With $\partial q_i / \partial f_i = -\sum_{j \neq i} \sigma_{ij}$ and $\partial q_i / \partial f_j = \sigma_{ij}$, product i's own- and cross-elasticities of demand are

$$\varepsilon_{ii} = -\frac{f_i}{q_i} \sum_{j \neq i} \sigma_{ij}, \varepsilon_{ij} = \frac{f_j}{q_i} \sigma_{ij}.$$

118 „“Net“ here means „after having paid the end-user price”.

Let T , f and q be the $(n \times 1)$ vectors of T_i , f_i and q_i . Then we can write

$$q = T + Y(S - f).$$

Consumer surplus is:

$$\begin{aligned} CS &= q'(S - f) - \sum_{i=1}^{n} \sum_{j \neq i} t_{ij} \int_0^{x_{ij}} x dx \\ &= q'(S - f) - \frac{1}{2} \sum_{i=1}^{n} \sum_{j \neq i} t_{ij} x_{ij}^2 \end{aligned}$$

Costs, access and profits

Firms have fixed retail cost

$$K = K_1 e_1 + K_2 e_2 + K_F E_1 + K_C E_2$$

and marginal per subscription retail cost of

$$c = c_1 e_1 + c_2 e_2 + c_F E_1 + c_C E_2.$$

These retail costs are assumed to contain any infrastructure-related cost not attributable to the wholesale FTTH infrastructure.

The wholesale cost of the infrastructure are fixed costs K_{01} and K_{02} for the fibre and copper parts, respectively, and marginal per retail client cost

$$k_1 = k_F (e_1 + E_1),\ k_2 = k_C (e_2 + E_2),\ k = k_1 + k_2,$$

i.e. FTTH and copper access have different costs for the infrastructure owner.

The wholesale access corresponding to retail product i is charged according to a two-part tariff $A_i + a_i q_i$, where $A_i = 0$ if the tariff is linear , and

$$\begin{aligned} \tilde{a}_1 &= a_F (e_1 + E_1),\ \tilde{a}_2 = a_C (e_2 + E_2),\ \tilde{a} = \tilde{a}_1 + \tilde{a}_2 \\ \tilde{A}_1 &= A_F (e_1 + E_1),\ \tilde{A}_2 = A_C (e_2 + E_2),\ \tilde{A} = \tilde{A}_1 + \tilde{A}_2. \end{aligned}$$

Product i 's retail profits are ($i = 1,...,n$)

$$\pi_i = (f_i - a_i - c_i) q_i - K_i - A_i.$$

Wholesale profits, including access payments by the network owner i to himself, are

$$\pi^{Wi} = q'(\tilde{a}_i - k_i) + E'\tilde{A}_i - K_{0i}.$$

A horizontally integrated incumbent has total profit $\pi^I = \pi_1 + \pi_2 + \pi^{W1} + \pi^{W2}$. Total welfare is given by

$$W = CS + \sum_{i=1}^{n} \pi_i + \pi^{W1} + \pi^{W2}.$$

Equilibrium subscription fees

Entrant i 's ($i \geq 3$) FOC for profit-maximization becomes

$$\begin{aligned}\frac{\partial \pi_i}{\partial f_i} &= q_i + (f_i - a_i - c_i)\frac{\partial q_i}{\partial f_i} \\ &= q_i - (f_i - a_i - c_i)\sum_{j \neq i} \sigma_{ij} = 0.\end{aligned}$$

A horizontally integrated incumbent

The horizontally integrated incumbent's first-order conditions for profit-maximization, taking into account both retail products $i,k \in \{1,2\}$, $k \neq i$, and wholesale access, are

$$\begin{aligned}\frac{\partial \pi^I}{\partial f_i} &= q_i + (f_i - a_i - c_i)\frac{\partial q_i}{\partial f_i} + (f_k - a_k - c_k)\frac{\partial q_k}{\partial f_i} + \frac{\partial q'}{\partial f_i}(a - k) \\ &= q_i - (f_i - a_i - c_i)\sum_{j \neq i} \sigma_{ij} + (f_k - a_k - c_k)\sigma_{ik} - e_i' Y(\tilde{a} - k) = 0.\end{aligned}$$

For the following let $X = X^{\text{int}}$ and $\Gamma = \Gamma^{\text{int}}$.

Horizontally separated access network providers

On the other hand, the horizontally separated access network provider i 's ($i = 1,2$) first-order condition is

$$\begin{aligned}\frac{\partial(\pi_i + \pi^{Wi})}{\partial f_i} &= q_i + (f_i - a_i - c_i)\frac{\partial q_i}{\partial f_i} + \frac{\partial q'}{\partial f_i}(\tilde{a}_i - k_i) \\ &= q_i - (f_i - a_i - c_i)\sum_{j \neq i} \sigma_{ij} - e_i' Y(\tilde{a}_i - k_i) = 0.\end{aligned}$$

In this case let $X = X^{sep}$ and $\Gamma = \Gamma^{sep}$.

Determination of equilibrium prices

With the corresponding definitions of X and Γ, stacking all n first-order conditions leads to:

$$q - X(f - \tilde{a} - c) - \Gamma(\tilde{a} - k) = 0.$$

Solving for f leads to equilibrium fees

$$f^* = (X + Y)^{-1}\left[T + YS + X(\tilde{a} + c) - \Gamma(\tilde{a} - k)\right].$$

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