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Abstract

This paper discusses the relevant cost standard for the economic replicability test for Next-Generation Access (NGA) networks, described in the Recommendation on Costing and Non-discrimination adopted by the European Commission. According to the Recommendation itself, in order to reconcile investment and competition, wholesale prices should have nonlinear characteristics and be only partly variable with the number of accesses. We demonstrate that a cost standard for the economic replicability test that implies fully fixed and variable cost recovery for the access seeker, including the total wholesale price, would be incompatible with the economics of NGA networks and that such a test would deter NGA investment. Therefore the cost standard for the economic replicability test should include only the variable part of the wholesale prices. However, we underline that during a transition phase, until competitors have secured access to NGA infrastructure, a temporary second test called the "competition migration test" should be added to ensure incumbent NGA retail prices do not foreclose copper-based efficient entrants. The tests we propose surpass the limits of the "ladder of investment" theory by including the "business migration effect" developed by Bourreau et al. (2012).

Keywords

Margin squeeze test; Regulation; Next-generation access networks

JEL codes: L51, L96

1. Introduction[*]

On 12 July 2012, Neelie Kroes, Vice-President of the European Commission (EC) charged with the Digital Agenda, announced a far-reaching set of measures to enhance the broadband investment environment in order to meet the objectives of the Digital Agenda for Europe (DAE) by 2020. Neelie Kroes considered that regulatory policy for next-generation access (NGA) must be based on the following key elements: stable copper prices based on BU-LRIC+ cost model and flexible, not cost oriented, NGA wholesale access prices combined with high non-discrimination obligations, including "a properly-specified *ex ante* margin squeeze test."

Details of the test are provided in the European Commission (2013) recommendation "Commission Recommendation on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment" adopted by the European Commission on 11 September 2013. In this Recommendation, the *ex ante* margin squeeze test was renamed "economic replicability test" to avoid any confusion with the margin squeeze test used ex post by competition authorities.

The Recommendation *(see Annex II p.27-29 for detailed specifications)*, suggests that the test should be done with a discounted cash flow (DCF) on an average customer lifetime and account for long-run incremental costs plus (LRIC+) as a cost standard. At the same time, for the EC, the costing methodology should guarantee an "appropriate balance between ensuring efficient entry and sufficient incentives to invest." According to the document, this would imply allowing operators investing in NGA networks a certain degree of pricing flexibility. This flexibility would enable significant market power (SMP) operators and access seekers to "share some of the investment risk by differentiating wholesale access prices according to the access seeker's level of commitment." The EC views volume discounts and/or long-term access pricing agreements as important tools for fostering NGA investment. This implies that the total wholesale price paid by the access seeker is not necessarily strictly proportional to the number of accesses, as the wholesale price may include elements such as a minimum fee, discounts above given volumes, upfront payment or co-financing arrangements. For the purposes of this article, we will conceptually model all these forms of nonlinear wholesale access price structures as "two-part tariffs". In this simplified model, the variable part of the wholesale "two-part tariff" is by definition the part of the wholesale price actually paid by the access seeker which is proportional to its number of accesses. All other components of the wholesale price will be considered as part of the fixed part of the wholesale price.

This type of price structure reflects the underlying investment cost structure for an operator which invests in fibre in order to replace its copper access network, since a large part of its investment cost is fixed, independent of demand that is otherwise uncertain. In this case, the economic analysis shows that optimal wholesale prices should include this type of fixed component in order to effectively allocate the risk that fixed costs may not be covered if demand is low. In this context, the proportion of the access network cost that may be legitimately subject to a form of nonlinear wholesale pricing depends of the proportion of the copper access network which the incumbent operator replaces with fibre. Thus when NGAs take the form of FTTN ("Fibre to the Node") or FTTC ("Fibre to the Cabinet") for which only a limited proportion of copper is replaced by fibre, wholesale prices are only weakly nonlinear, for instance through limited volume discounts: in this scenario, a large part of the wholesale price stays variable and the fixed part is relatively small. On the other hand, when NGAs take the form of FTTH ("Fibre to the Home") for which the copper access network is completely replaced by fibre, wholesale prices may be more strongly nonlinear, using approaches like co-financing of the fixed infrastructure, significant upfront payment or more significant volume or

[*] The views expressed in this paper are purely the authors' and may not under any circumstances be regarded as those of Orange.

duration discounts. In this case, the proportion of the total wholesale price which is actually proportional to the number of access is lower.

This paper addresses the question of how to implement the Recommendation, in particular how to use the economic replicability test to regulate NGA wholesale price. As we will see, the Recommendation itself suggests that wholesale prices may have a nonlinear structure. Determining how to implement the test when wholesale prices are nonlinear requires further investigation: academics and institutions have analysed "margin squeeze" in depth (see for instance Jullien, Rey, Saavedra (2013) for an overview) but only in the case of linear wholesale prices. To the best of our knowledge, the question of our how economic replicability or margin squeeze tests should be implemented when wholesale prices are nonlinear has not been formally analysed. Moreover, the test must be structured to fulfil the EC's dual objective of encouraging NGA investment and maintaining the competitive structure inherited from copper unbundling, while obeying the principle of fair investment risk distribution between access provider and access seekers[1]. The novelty of this paper is also our proposal for a solution for two-part wholesale prices, with different and complementary regulatory regimes for the variable and fixed parts of wholesale prices.

The paper mainly addresses the case of total replacement of the copper infrastructure by a NGA network. However, our proposal would remain valid in intermediate situations requiring partial replacement of copper network, but its significance would be reduced in due proportion.

Although the paper directly refers to the EC Recommendation on Costing Methodology and Non-discrimination, the economic arguments would also be suitable for a margin squeeze test under competition law.

The objective of this paper is to address a key implementation issue of the 2013 EC Recommendation on non-discrimination and costing. Therefore it does not cover important subjects for access regulation which are not covered in the Recommendation, such as geographical segmentation.

The remainder of the paper is organized as follows. Section 2 defines the notion of "economic replicability test" and details the EC formulation in the draft Recommendation on Cost Orientation and Non-discrimination. Section 3 is the core of the paper. In Section 3, we demonstrate that a test which implies full fixed and variable cost recovery would deter NGA investment. We show that to reconcile investment and competition, the economic replicability test should only include the variable part of wholesale prices. However, during a transitional phase until competitors have migrated from copper to NGA network, a temporary test called the "competition migration test" should be added to ensure that the incumbent does not foreclose copper-based efficient entrants. Finally, in Section 4, we discuss how our proposal of a dual-test system can be integrated into existing regulatory theory and practice.

2. Economic Replicability test: definition and EC formulation of the test for NGA Networks

In the Recommendation on Cost Orientation and Non-discrimination published on September 11, 2013, the European Commission advocates allowing for a certain degree of pricing flexibility for NGA services. This results in the non-imposition or lifting of regulated wholesale access prices on the NGA network. This flexibility is considered by the EC as without prejudice to the extent that the upstream and downstream prices are constrained by an *ex ante* economic replicability test.

[1] EC Recommendation C(2013) 5761 final, 11.9.2013 on non-discrimination and costing. Annex II «When setting the parameters of the ex-ante economic replicability test, NRAs should ensure that the SMP operator is not put at a disadvantage vis-à-vis access seekers regarding the sharing of the investment risk. »

2.1 General definition of ex ante economic replicability and margin squeeze test

The term "economic replicability test" has been used by the EC to avoid any confusion with the margin squeeze test used *ex post* by competition authorities. However, the term "*ex ante* margin squeeze test" is frequently used in the literature and the practice of National Regulatory Authorities (NRAs) on broadband access products that use the copper pair.

Regulatory policy and competition policy address the common objective of ensuring efficient market competition for the benefit of consumers. However, the two policies address different sides of the issue. Competition policy is designed to preserve competition in a market where competition is established, and would act *ex post* if a dominant company is alleged to have abused its position to harm competitors and consumers. Competition authorities base their margin squeeze test on case law. In the telecommunications industry, three notable cases (Deutsche Telekom in 2003, Telefónica in 2007 and TeliaSonera in 2011) substantially contributed to the definition of margin squeeze. Regulatory policy aims to promote competition and act *ex ante* to prevent abuses in specific markets characterized by a monopoly or a company with significant market power.

There is a margin squeeze when a vertically-integrated company that provides essential input to downstream competitors charges retail and input prices that do not leave a sufficient economic margin for efficient competitors to make positive profits. Therefore, there is no margin squeeze if the customer retail price for the incumbent's downstream branch covers its upstream and downstream costs (Gaudin and Saavedra (2013)):

$$p \geq a + c$$

where "p" is the retail price, "a" is the wholesale access charge per access and "c" is the downstream cost per customer.

This condition guarantees that an efficient competitor could not be excluded from the market. The equation above shows that the test is clearly specified only when wholesale prices are proportional to the volume of access.

European Union competition law, clearly expressed by the European Court of Justice (ECJ) in its TeliaSonera and Deutsche Telecom judgments, recognizes margin squeeze as a separate, stand-alone form of abusive behaviour prohibited by Article 102 of the Treaty on the functioning of the European Union. This view is in contrast to the US Supreme Court's view. In the Linkline case, the US Supreme Court rejected the very notion that a margin squeeze itself could constitute a separate form of Sherman Act §2 violation. Instead, it limited the claim to cases where vertically-integrated companies apply predatory pricing in the downstream market.

In the European view, the occurrence of a margin squeeze is, however, subject to several conditions explicitly mentioned in the Court's TeliaSonera decision, and it is not clear whether these conditions will be met if we apply the test to the NGA context. Our study, however, is not intended to debate this question. The present analysis is dedicated to constructive propositions for building the economic replicability test.

2.2 Economic Replicability test for NGA Networks in the European Commission Recommendation on cost Orientation and Non-discrimination

The deployment of NGAs is one of the core objectives of the 2020 Digital Agenda for Europe. The economic replicability test should therefore preserve the competitive structure inherited from unbundling regulation of the copper local loop and promote efficient investment and innovation in new infrastructures. The EC has to ensure that the *ex ante* economic replicability test for NGAs allows for an appropriate balance between these two objectives.

The Recommendation specifies the different parameters of the test, i.e. the relevant downstream costs, the relevant cost standard, the relevant regulated wholesale inputs, the relevant retail products and the relevant time period for running the test.

The relevant downstream costs are "estimated on the basis of the costs of the SMP operator's own downstream businesses (EEO test). NRAs should use the SMP operator's audited downstream costs, provided they are sufficiently disaggregated."

According to the Recommendation, the relevant cost standard is the long-run incremental costs plus (LRIC+) including sunk costs.

NRAs should identify the most relevant regulated input used or expected to be used by access seekers.

NRAs should also define the most relevant retail products including broadband services, i.e. "flagship products" offered by the SMP operator on the basis of their market observations. Those observations should include an assessment of retail market shares in volume and value.

Finally, NRAs should measure the profitability of the flagship products on the basis of a dynamic multi-period analysis, such as the discounted cash flow (DCF) approach on an average customer lifetime.

2.3 The EC Recommendation encourages nonlinear wholesale price structures

The Recommendationitself, particularly in Recitals (19)[2] and also (49), opens the way to using nonlinear wholesale prices. Pricing flexibility must allow SMP operators and access seekers to share the investment risks by differentiating wholesale access prices according to the access seeker's level of commitment. In this context, volume discounts and/or long-term access pricing agreements are considered by the EC as important tools for fostering NGA investment.

The use of nonlinear access prices is also in line with the principles adopted in articles 8[3] and12[4] of the framework directive. The principle of nonlinear wholesale access pricing was also already acknowledged in the September 2010 NGA Recommendation (2010/572/EU) in Recital (25)[5]. In this NGA Recommendation, the European Commission advocated mutualisation and co-investment, which are also forms of nonlinear access price and comprise two elements, one fixed and the other variable

In the NGA context, a nonlinear access charge would be composed of:

- A wholesale variable access price that is directly proportional to the number of customers;
- Other elements of the wholesale price which are not proportional to the volume of access and which will hereafter be considered part of the fixed wholesale price which does not vary with the volume of access.

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2 "Volume discounts and/or long-term access pricing agreements are an important tool to foster NGA investment. …"

3 Art.8.5.(d) FWD "promoting efficient investment and innovation in new and enhanced infrastructures, including by ensuring that any access obligation takes appropriate account of the risk incurred by the investing undertakings and by permitting various cooperative arrangements between investors and parties seeking access to diversify the risk of investment, whilst ensuring that competition in the market and the principle of non-discrimination are preserved;"

4 Art.12.3. FWD "…have the power to impose obligations in relation to the sharing of wiring inside buildings or up to the first concentration or distribution point where this is located outside the building, on the holders of the rights referred to in paragraph 1 and/or on the owner of such wiring, where this is justified on the grounds that duplication of such infrastructure would be economically inefficient or physically impracticable. Such sharing or coordination arrangements may include rules for apportioning the costs of facility or property sharing adjusted for risk where appropriate."

5 "Where SMP operators offer lower access prices for the unbundled fibre loop in return for up-front commitments on long-term or volume contracts, these should not be regarded as unduly discriminatory where NRAs are satisfied that the lower prices appropriately reflect an actual reduction of the investment risk."

This type of wholesale price structure is consistent with the cost structure of the investment, where there are necessarily both a fixed cost for shared infrastructure deployment, and specific costs incurred for each new customer on the NGA infrastructure.

The two-part wholesale price structures encouraged by the Recommendation on NGAs are also in line with lessons from the economics analysis, as based on the existing literature, two-part tariffs are a good instrument for solving the dynamic consistency and regulatory commitment issues by conciliating access obligations and investment incentives.

Most of the literature on competition policy considers linear access tariffs in accordance with the past practices of regulatory authorities. Until recently, regulatory authorities had been dealing with existing infrastructures without seeking to promote investment with an increasing return to scale, therefore linear pricing was sufficient. Furthermore, in the access and interconnection pricing literature, nonlinear access prices are hardly discussed, unlike nonlinear downstream prices (Vogelsang (2003)). However, nonlinear risk sharing arrangements were already been advocated in 2009 by Nitsche and Wiethaus (2009).

Later, Brito et al. (2010) suggested that as new technological developments provide an opportunity to invest in new infrastructures, "it comes as natural that, in light of these changes, regulators should use new regulatory instruments." In this context, the addition of a fixed fee appears to the authors as the obvious solution. Brito et al. (2010) study this specific issue in a duopoly model where a vertically-integrated incumbent and a downstream entrant compete. The regulator sets the access tariff to the incumbent's network. They point out that the trade-off may generate a "dynamic consistency problem." Before the network is deployed, it is socially optimal to a set high access charge to encourage investment. After the network is deployed, it is socially optimal to lower the access tariff to promote competition in the retail market. The authors show that this dynamic consistency problem has a negative impact on NGA investment. "The incumbent anticipates that it will be expropriated from the incremental profit of its investment and reduces investment." They demonstrate that two-part tariffs can solve this dynamic consistency issue because the regulator obtains an additional instrument—the fixed fee—to encourage the incumbent to invest. If the investment cost is low, the regulator can set the marginal price for the access tariff at marginal cost and use the fixed fee as an incentive for the incumbent to invest. If the investment cost amounts to an intermediate value, the fixed fee is no longer enough to induce investment. The regulator has to raise the marginal price of the access tariff above marginal cost. In these circumstances, a regulatory moratorium could emerge as socially optimal. Two-part access prices and a degree of price flexibility are thus complementary instruments. If the investment cost is high, investment is not socially desirable.

Lestage and Flacher (2011) also find in their model on investment games that a two-part tariff results in better social welfare than a linear access price. They found that the flat fee reduces the optimal variable fee and that the variable part should be cost-oriented only when service- based competition is feasible. The variable fee is above marginal cost when facility-based competition is possible. Raising the access price reduces welfare under service-based competition and makes duplication more socially desirable, which in turn improves welfare.

On the other hand, Tselekounis and Varoutas (2013) analyse the relationship between NGA investments and access prices under regulatory uncertainty, a contrario showing that under a linear wholesale price setting, it is difficult for regulation to provide socially desirable incentives.

To summarise, a degree of wholesale price flexibility appears necessary for NGA regulation.

- Flexibility in wholesale price structures: nonlinear or two-part access charges as advocated in the EC Recommendation are an adequate instrument, on the wholesale price side, to reconcile downstream competition and upstream investment.

- Flexibility in wholesale price levels: according to the EC Recommendation, NGA wholesale prices should not be cost-oriented if the NGA infrastructure is under the competitive pressure of other access platforms, including legacy copper infrastructure.

2.4 How an economic replicabilty test should be applied with two-part wholesale pricing ?

Variable fees are much easier for regulatory authorities to regulate than fixed fees. Fixed fees are particularly difficult for to regulate because they presuppose a rule for spreading the fixed costs among operators. It may be possible to spread fixed costs based on market share. However, in a growing market, this distribution is likely to become invalid very quickly. It would seem difficult and hardly effective to constantly adapt regulations to market characteristics. Moreover, this would de facto transform the fixed fee into a variable price, under the form of a mark-up on top of the variable price, thus eliminating the economic benefits of a two-part access price structure.

A two-part structure makes it possible to accurately consider the singularity of an NGA investor's cost structure characterized by a significant part of fixed costs.

However, the compatibility between the objectives of the European Commission and the parameters of the test is not self-evident. An LRIC + test as required by the Recommendation could be formally interpreted taking into consideration both the fixed and variable parts of the wholesale price, if the fixed part of the wholesale price is included in the cost base, for instance in reference to the "+" of the LRIC + cost standard. But since the fixed part of wholesale prices reflects high NGA investment costs with a long and uncertain payback period, it would be inappropriate to include the fixed wholesale price in the test using a DCF method on a customer lifetime. Applying this method yields systematically negative test results. If we consider an infrastructure's lifetime, results would be at least as uncertain as the long term profitability of the NGA investment itself.

It is difficult to find a formal way to regulate both fixed and variable fees based on a single condition, particularly given that, as we have seen, fixed fees are by nature very difficult to regulate.

In the section 3, we will demonstrate that these reasons imply leaving the wholesale fixed price out of the test; only the variable price is constrained in the economic replicability test we propose in this paper. It guarantees there is no discrimination on the basis of variable costs for all operators with access to NGA infrastructure.

The issue of the level of the wholesale fixed price and the migration of competitors from copper infrastructure to NGA infrastructure will be addressed separately and introduce a second complementary "competition migration test."

3. Two tests that resolve the dilemma of maintaining competition while encouraging NGA investment

In this section, we first demonstrate that an economic replicability test that includes fully fixed and variable cost recovery for the access seeker would be inappropriate in an NGA context because all NGA investment risk would be concentrated on the access provider and none on the access seeker, in contradiction with the objective formulated in Annex II of the Recommendation "not to put the SMP operator at a disadvantage", thereby discouraging investment. We then describe the characteristics of the economic replicability test that should be applied. This test includes only variable costs and excludes the fixed part of the wholesale price from the cost standard to guarantee fair and vibrant competition between access providers and access seekers, once access seekers have managed to secure access to the NGA infrastructure. Lastly, we describe a second "competition migration test" designed to put access providers and seekers on a level field for negotiating wholesale fixed prices and ensure a competitive market structure is maintained during the migration from copper to NGA infrastructure.

3.1 A cost standard that includes fully fixed and variable cost recovery in the economic replicability test for NGA networks would be inappropriate and discourage investment

The European Commission Communication (2013) states on page 4: "Divergent regulation of fixed networks often means overregulation, or regulatory uncertainty and unpredictability, making it hard to plan investment in fast, "next generation" broadband networks." and on page 7: "Legal certainty is particularly important given that investment in fast broadband networks incurs significant costs, while demand for end product remains uncertain." The European Commission Recommendation (2013) states on pages 2 and 3 that investment in broadband networks must be promoted and triggered. Instilling confidence in investors is essential, as is long term predictability "beyond the lifetime of an individual market review". These quotes show that the Commission does not take NGA investment for granted and acknowledges that the profitability of NGA investment is uncertain. The NGA market in most European countries is entering a transitional phase. For the moment, the demand for NGA networks is still weak and gradual. It is following an S-curve where the initial investment is massive and deployment time is long.

The weakness of the demand is inherent to the small number of services which are only possible over very fast broadband. This undoubtedly has an impact on consumer willingness to pay for NGA services. Rosston et al. (2010) point out that the difference in American consumer willingness to pay for fast or very fast broadband is low (about $3.00).

However, a short-term pricing policy aimed at achieving immediate economic equilibrium would be counterproductive because it would lead to prohibitive prices. There is thus a conflict between retail prices that allow retail earnings to cover full costs and retail prices that consumers are willing to pay[6].

This analysis of NGA investment profitability is highly relevant for the specification of the test since it affects the economic replicability test results. If the cost standard of the test includes all fixed and variable costs (LRIC + approach), as in the analysis of NGA investment profitability, and if the latter is uncertain in the long term and negative in the short term, then a positive test result (i.e. proof that a potential sufficient margin lets competitors enter the market, a guarantee of positive business for access seekers) can be obtained only if the access provider's wholesale business is uncertain in the long term and negative in the short term, as we will formally demonstrate below. Using this type of test, access seekers and access providers would compete on equal footing in the retail market, but access seekers would benefit from guaranteed profitability thanks to the economic replicability test, while the access provider would bear all the investment risks. Access seekers would be much better off than access providers and no one would have an interest in investing.

This can be formalised by the following simple reasoning. The profit of NGA activity (or NGA Business Case "NGA BC") for a regulated network operator investing in NGA and which has NGA retail and wholesale activities can be expressed as follows:

$$NGA\ BC =$$

$$m \times (retail\ revenues - downstream\ costs - upstream\ costs)$$
$$+$$
$$(1 - m) \times (wholesale\ revenue - upstream\ costs)$$

[6] This is also true on the wholesale market: a conventional BU LRIC+ cost-oriented linear wholesale access price applied to NGA infrastructure with low penetration rates would lead to prohibitively high values which are incompatible with adoption by any customers.

Where *m* is the market share of the access provider in the retail market, *retail revenues* are revenues per unit of market share for the regulated operator, and *downstream costs* and *upstream costs* are costs per unit of market share for the regulated operator for its retail activities and wholesale activities (including investment in NGA infrastructure) respectively. As the regulated operator is subject to non-discrimination obligations, its *upstream costs* per unit of market share are identical for self-supply for its own retail business and for providing access to its retail competitors on the wholesale market. If the regulated operator has a retail market share *m*, then its competitors have an overall market share *(1 - m)* generating *wholesale revenues* per unit of competitor's market share.

The above mathematical equation can be modified as follows:

$$NGA\ BC =$$
$$m \times \begin{pmatrix} retail\ revenues - downstream\ costs \\ -wholesale\ revenue + wholesale\ revenue\ - upstream\ costs \end{pmatrix}$$
$$+$$
$$(1 - m) \times (wholesale\ revenue - upstream\ costs)$$

After some elementary algebra, this leads to:

$$m \times (economic\ replicability\ test) = NGA\ BC - (wholesale\ revenue - upstream\ costs)$$

This expression indicates that whether an economic replicability test is positive or negative directly depends on the sign of the difference in profitability between NGA investment and NGA wholesale business. The profitability of the NGA wholesale business activity has to be below the NGA Business Case for the economic replicability test to be positive. More specifically, the expression shows that if the NGA business case is negative, then the NGA wholesale activity (*wholesale revenue - upstream costs*) in the above formula will be even more negative if the economic replicability test is positive.

The quotes provided at the beginning of this section indicate that it is already known, including by the European Commission, that the profitability of NGA investment is uncertain in the long term and certainly negative in the short timeframe of a customer lifetime. Therefore, a positive NGA economic replicability test that includes the fixed part of wholesale prices and is calculated for a customer lifetime can be obtained only if the profitability of the wholesale activity is negative. This type of test would thus guarantee the business profitability of the access seeker while weakening the upstream business, thereby making upstream investments economically irrational for investors. This formulation of the test is thus inconsistent with the EC's assigned objective of sharing investment risks between SMP operators and access seekers (see precise quote from EC in this respect in footnote 4 page 2).

The same point can be demonstrated using a simplified but representative numerical example based on Fibre to the Home (FTTH) investment (See the Appendix for a detailed hypothesis and an analysis of this numerical example). In this example, we demonstrate that if fixed wholesale prices are included in the test, then a negative result (implying a supposed foreclosure strategy) is obtained, even if it is abundantly clear there is no form of discrimination whatsoever. The example simulates an LRIC+ test using a DCF method and including all of the access seeker's fixed and variable costs in the cost standard.

We consider a case where the access seeker benefits from a fully cost-oriented non-discriminatory access from the FTTH investor (price equals cost in level and structure) and achieves a 50% market share. Therefore the access provider and the access seeker are facing exactly the same economic situation, which excludes any form of discrimination from the access provider against the access seeker.

We consider two *ex ante* demand scenarios:

- Positive scenario: the spontaneous migration of customers from a copper network to an NGA is achieved in five years[7] : the penetration rate *p* is equal to 20% in year 1, 40% in year 2, 60% in year 3, 80% in year 4, 100% in year 5;
- Negative scenario: the migration is achieved in 20 years: the penetration rate increases by 5% each year

We used two alternative calculation hypotheses where we conducted the test by alternately applying a customer lifetime of, for instance, 5 years and an infrastructure lifetime of 20 years. As mentioned above, the DCF method on a customer lifetime is recommended by the European Commission in the Recommendation published in September 2013.

If we use a DCF method on a customer lifetime, we find that the profitability of FTTH investment is always negative, regardless of the speed of migration.

If we then run the estimation using a DCF method on an infrastructure lifetime (20 years), results are uncertain because it depends on the length of the migration from copper to fibre network. The FTTH investment profitability is positive if we consider the optimistic scenario that the migration is achieved in five years and negative if the migration takes 20 years. Thus, assuming that the profitability of fibre investment is negative, the profitability of the wholesale business has to be negative to obtain a positive result in the economic replicability test.

Consequently, in a case where it is abundantly clear there is no form of discrimination, an economic replicability test, including the access seeker's fixed and variable costs, would however find that the operator behaves in a discriminatory manner; leading to a false positive.

Therefore this formulation of the economic replicability test would squeeze upstream investments. The access price would have to be adjusted to secure the access seeker's downstream business, thus transferring all the investment risk to the upstream wholesale business. This type of policy, which guarantees the access seeker's profitability and weakens the upstream business case, would make extensive upstream investments economically irrational for fibre investors.

This type of test, which is prone to systematic false positives, would be a powerful deterrent for investors. The specific analysis presented in this section holds as long as the cost standard of the economic replicability test fully covers the wholesale price paid by the access seeker: it holds for nonlinear wholesale prices with the fixed wholesale part included, e.g. as a mark-up on top of the variable wholesale part. It would also hold for fully linear wholesale prices, for which the above analysis would be strictly the same.

3.2 An economic replicability test based on variable wholesale prices

As mentioned before, the two-part wholesale price, in an NGA context, would be composed of:

- A wholesale variable access price that directly depends on the number of customers;
- A wholesale fixed cost which does not vary with the access seeker's number of customers.

The two-part structure makes it possible to accurately account for the singularity of an NGA investor's cost structure characterized by a significant share of fixed costs. The economic replicability test could be operational only if the fixed wholesale costs are excluded from the test for two reasons:

[7] A scenario of spontaneous and fast migration of the demand should not be confused with a scenario of forced migration related to a mandatory copper switch-off. A forced migration would generate additional migration costs which are not considered here

- Difficulty in regulating fixed wholesale prices because the regulator is supposed to find a rule to spread the fixed costs among operators. It is possible to spread fixed costs based on market shares. However, in a growing market, it is likely that this distribution would rapidly become invalid. It seems difficult and hardly effective to constantly adapt regulations to market characteristics. In addition to these logistical impediments, and on a more fundamental level, adjusting fixed fees to market share would change fixed fees into variable fees and defeat the entire purpose of two-part prices;
- The impossibility of running an LRIC+ test (including variable and fixed costs) using a DCF over a customer lifetime for the reasons described in subsection 3.1. Even over an infrastructure lifetime, the test would have a unpredictable outcome, depending on market conditions rather than incumbent operator behaviour.

We therefore propose excluding the investment infrastructure fixed costs from the economic replicability test insofar as these fixed costs are translated into a fixed wholesale price.

Hence, the economic replicability test becomes:

$$p_{rf} \geq a_{vf} + c_f$$

The NGA retail prices, p_{rf}, would be compared with the sum of wholesale variable NGA prices a_{vf} and to the NGA downstream cost c_f. In this expression, the subscript "r" refer to "retail" (as opposed to wholesale), "f" to "fibre" for NGA networks (as opposed to copper), "v" to "variable" (as opposed to fixed).

This formulation of the economic replicability test makes it possible to regulate the variable part of wholesale prices and guarantee fair competition between all competitors that access the NGA infrastructure. The test results would not be subject to the uncertainty of the NGA Business Case.

However, this economic replicability test does not explain how to determine the fixed part of wholesale prices and, more specifically, it does not guarantee that a competitor as efficient as the investor can pay the fixed costs and migrate from a copper infrastructure to an NGA infrastructure and compete on NGA products.

The introduction of a second "competition migration test" provides our answer to these questions. The wholesale fixed price will not be regulated by the NGA economic replicability test but can be efficiently negotiated between access providers and access seekers, if the access provider is also subjected to a second "competition migration test" designed to even out the bargaining balance in these negotiations.

3.3 A transitory test to secure access for efficient entrants to NGA infrastructure: "the competition migration test"

As mentioned in the introduction, this paper addresses the issue of designing the economic replicability test in cases for which nonlinear wholesale prices may be appropriate to fairly share investment risks. These cases are only relevant to the extent to which the roll out of the NGA network implies a replacement of the copper infrastructure by fibre investment. If only a small part of the copper infrastructure is replaced by fibre, e.g. If FTTN or FTTC solutions are used, then wholesale prices should be only weakly nonlinear (e.g. take the form of limited volume discounts) and the difference between our proposal and a conventional test will also be limited. However, if the entire copper infrastructure is replaced with fibre as in the case of FTTH architecture, wholesale prices will have strong nonlinear characteristics (e.g. co-financing, significant upfront payments or higher volume discounts) and the difference between our proposal and a conventional test will also be more significant.

We consider a situation where the initial retail market structure based on the copper market is competitive[8] and the incumbent operator does not have significant market power in the retail copper-based broadband market. This means that it cannot directly control the migration of the bulk of retail customers from copper to NGA infrastructure. The market share resulting from the sole migration of its clients is presumably insufficient for amortising its NGA investment, otherwise its competitors could also develop and amortise profitably with their own alternative infrastructure and migrate their own retail customers to this alternative infrastructure. Complete infrastructure competition would be sustainable in this case, which is not the scenario analysed in this paper or covered by the European Commission Recommendation (2013).

In other words, in the situation we are discussing, the NGA investor has no opportunity to make a profit from an NGA investment unless its copper-based competitors' broadband customers migrate from its copper infrastructure to its NGA infrastructure. For the purposes of this paper, we assume that all relevant competitors initially offer copper services[9]. They all are at the top of the "copper" ladder and have to decide whether to enter the NGA market. During the technological transition, the operators that develop NGA access continue to offer copper services.

To attract the greatest number of customers, the investor could then be tempted to practice very low retail prices—lower than those offered in the copper broadband market. At the same time, the investor could also be tempted to set high fixed prices for access to infrastructure to foreclose its competitors from the market insofar as the fixed costs are left out of the test. An economic replicability test based on variable prices, taken by itself, would not discourage such behaviour by investors. To prevent this, we introduce a second transitory test called the "competition migration test.

The following parts of section 3.3. detail the mechanisms by which this additional test meets these objectives.

3.3.1 The "competition test"

The second test is meant to ensure migration of the broadband market's competitive structure to the NGA market.

The "competition migration test" ensures that the investor's NGA retail prices do not foreclose copper-based efficient entrants.

For this purpose, this test stipulates that an access provider's retail NGA price should conduct an LRIC+ margin squeeze test on copper. At first glance, as the NGA network offers better quality than copper, it appears natural to also include an NGA premium which could be measured by the difference in consumer utility between copper and NGA networks. The test is thus formulated as follows:

$$p_{rf} \geq a_C + c_C + U_f - U_C$$

Where p_{rf} as in §3.2. is the retail price for the NGA offer, a_C is the wholesale regulated copper access charge, c_C is the leader's downstream cost, U_f is utility for a consumer with access to an NGA network and U_C is utility for a consumer with access to a copper network. Subscripts have the same meaning as in §3.2.

However, the integration of the NGA premium raises the question of its real existence in the market and how to estimate it.

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8 Complementary provisions would be needed in the event of significant market power on the retail market.

9 Here, the concern of the paper as well as the Recommendation is "intra-platform competition".

Consumer utility does not depend solely on the technical quality of the products. Increasing technical quality entails increasing usage value and safeguarding the overall quality of the consumer experience. Today, an observation of market data in most regions of the world does not indicate any significant difference in value between NGA and copper services. There is little or no premium observed in the pricing for NGA products around the world, particularly for the following reasons:

- Currently few or no NGA-specific services;
- A perception that copper networks are well-suited for customer usage: no perception of network congestion specific to copper access networks and copper and NGA networks share resources in the backhaul and transport networks;
- From the consumer standpoint, the costs of migrating from copper to NGA (time and complexity of home NGA installation, compatibility issues with the customer's existing equipment, change in how services are navigated, etc.).

Furthermore, from an operational point of view, it appears difficult to estimate the difference in consumer utility between copper and NGA services. It could be possible to approximate it using the difference in consumer willingness to pay between fast and very fast broadband, but initially the data available would be only those of the incumbent which induces a problem of endogeneity. In the short term, the test should therefore be formulated as follows:

$$p_{rf} \geq a_c + c_c$$

More fundamentally, the question of whether to include the NGA premium in the test is not limited to the observation of market practice or to technical constraints. Its integration may prove to be a strategic decision by the regulator in order to promote investment.

If the analysis of market data reveals the existence of a premium, a regulator may consider whether to introduce it in the test, given that integrating the NGA premium tends to decrease both the incentive to migrate for access seekers and the incentive to invest for SMP operators in comparison with non-inclusion (see subsection 3.3.2. which describes the negotiation process). Furthermore, these behaviours are intrinsically linked.

If the NGA premium is integrated into the test, the NGA retail price offered by the investor is likely to be less price competitive than the copper retail price chosen by the access seeker. The access seeker could thus decide to stay in the copper market and offer lower quality but also lower prices which can be a relevant short term strategy to minimise its costs. Access seekers are thus willing to pay less to have access to the NGA infrastructure; this reduces the investor's returns on investment and thus discourages investments.

At the same time, the investor can decide to increase its copper retail price to make NGA services more competitive and encourage its customers to migrate. However, if only its customers migrate, its benefits will be insufficient to amortise its investment. The lack of competitiveness of NGA services could lead the investor to underinvest.

On the other hand, if the NGA premium is not included, the NGA prices proposed by the investor may be at least as competitive as the copper prices offered by its competitors while providing higher utility to consumers. Access seekers will feel strong pressure to adopt the new infrastructure and will thus be willing to pay more for fixed access to the NGA infrastructure. Hence, the utility of NGA investment will be returned to the investor, encouraging it to invest at a socially optimal level.

Finally, since there is still competition between copper and NGA networks, the investor cannot set a high NGA retail price, otherwise too few customers would migrate and it would be unprofitable.

We will consider in subsection 3.3.2. that the "competition migration test" does not include the NGA premium for all the reasons provided above.

3.3.2 Negociation process between the investor and the access seeker to determine the fixed infrastructure price

By design, the "competition migration test" introduces a constraint in determining fixed infrastructure prices. The only way to achieve consumer migration on a sufficient scale is to encourage alternative operators to migrate along with their customers. Therefore, the investor must agree with each of its competitors on a wholesale fixed price that allows them to access the NGA infrastructure and operate in the NGA retail market. The constraint of the transitory "competition migration test" gives the alternative operators bargaining power to negotiate the wholesale access fixed price.

As the "competition migration test" prevents the investor to lower its prices to attract the maximum number of clients to the NGA network, the only way to monetize its investment in new infrastructures is to ensure a level of fixed prices that would allow operators and their clients to migrate to the NGA network.

Indeed, as mentioned above, the two alternative conditions for which the investor would not need its competitors' clients to migrate *en masse* would be as follows:

- The investor starts from a strongly dominant position in the copper-based broadband retail market, which would allow it to control the migration process of the whole copper customer base to NGA; this is not the standard situation considered in the EC Recommendation, which assumes that the initial copper-based broadband market is competitive, and therefore it is not the hypothesis retained in this paper.
- The NGA investment is profitable, even with a limited number of customers. In this case, several operators could build their own profitable networks. The existence of such infrastructure-based competition would make the economic replicability test irrelevant. But this is not the hypothesis retained in the EC Recommendation and therefore in this paper.

Outside of these two specific cases, investors need their competitors' retail clients to migrate from copper to NGA to make their activity profitable.

At the same time, as recommended by the European Commission, significant market power (SMP) operators and access seekers have to "share some of the investment risk by differentiating wholesale access prices according to the access seeker's level of commitment."

In the absence of strong dominance by the incumbent in the broadband market, there is at least one large access based competitor. The incumbent and this access seeker will be in a position to negotiate the fixed fee the access seeker will accept to pay to access the NGA infrastructure. The two forces we just described will be in opposition:

- The access seeker's willingness to pay the lowest fixed fee and the investor's need for the access seeker to migrate to the NGA network;
- An objective where the investor and the access seeker share some of the investment risk in proportion to the market share that they anticipate obtaining in the retail market.

It should be noted that both parties have reason to reach an agreement reasonably quickly: the incumbent because the profitability of its investment depends on its competitors' customers migrating quickly and its largest rival because it would be a commercial risk to leave the incumbent alone on the NGA market or let the incumbent be the first to reach an agreement with another competitor.

Moreover, once the incumbent has reached an agreement with one competitor on the fixed wholesale fee for accessing the NGA infrastructure, and as long as authorities apply the transitory "competition migration test," it will feel strong pressure to agree with other competitors on their fixed fee. First, because a competitor that gains access to the NGA infrastructure may undercut its retail price and second, because these other competitors may negotiate access with both the incumbent and its initial competitor.

Once the authorities consider that negotiations on fixed wholesale access fees have generated an adequately competitive market structure on the NGA infrastructure and that each efficient access seeker has secured access to the NGA infrastructure, the second transitory test may be removed.

As mentioned in the introduction to this section, the reasoning developed here is designed for situations where the copper infrastructure is completely replaced by the NGA infrastructure. In intermediate cases of partial replacement, our proposal remains valid but with less significance to the extent that a two-part wholesale price structure would affect only the replaced proportion of the access infrastructure.

Obviously, a formal microeconomic model on this qualitative reasoning would provide more rigorous insight into the likely outcome of the proposed process. In further research, it would be interesting to theoretically model the negotiation process described above to determine the level of the fixed equilibrium price.

4. The proposed dual-test system in terms of existing regulatory theory and practice: overcoming the limits of the ladder of investment approach

In this section, we discuss how our proposal of a dual-test system can be integrated into existing regulatory theory and practice. In particular, it is meant to overcome the well-known limits of the "ladder of investment" approach in the context of NGA investments and integrate the "business migration effect" developed by Bourreau et al. (2012).

The "ladder of investment" (LoI) is a regulatory approach proposed by Cave (2006). The idea is to provide entrants with several levels of access to the incumbent network, the "rungs of the ladder," in such a way that alternative operators can climb up the ladder and progressively develop their own infrastructure. From a theoretical point of view, this approach considers that service-based and facility-based entries are complementary and not two alternative ways of promoting competition.

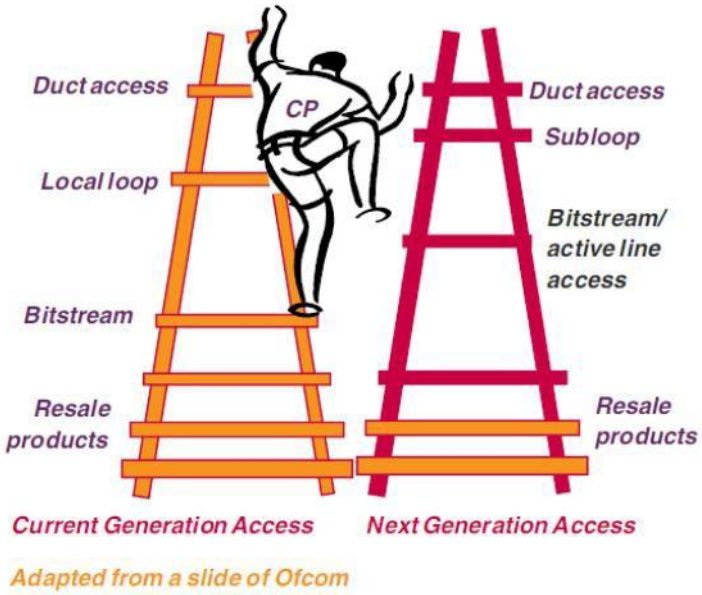
Since the very beginning, the "ladder of investment" approach has widely influenced the European telecommunications policy areas and broadband regulation. In its 2005 broadband market competition report, the European Regulators Group (ERG) analysed and explained the impact of regulatory intervention with the "ladder of investment concept." In the Commission Recommendation of 20 September 2010 on regulated access to Next- generation Access Networks, the European Commission indicates that "The appropriate array of remedies imposed by an NRA should reflect a proportionate application of the ladder of investment principle."

Some papers have already studied the application of the LoI approach in the NGA context (see Hori and Mizuno (2006), Vareda and Hoerning (2007), Cave (2010)). They recommend using instruments that are basically the same as those applied to regulate copper broadband (access prices increasing over time and regulatory holidays). The limits of the LoI approach in the NGA context are highlighted by Bacache et al. (2013). They used an empirical model with data from the European Commission to test the "ladder of investment approach" in the NGA context. The "ladder of investment" is composed of three rungs: bitstream access, local loop unbundling and new access facilities. Bacache et al. found no empirical support for the LoI hypothesis in the transition from local loop unbundling to NGA infrastructures. In other words, they found that the number of unbundled lines has no impact on investment in new access infrastructures by new entrants.

However, the literature considers a hypothesis where new technology is the next rung of this ladder and should immediately replace old technology: the investment decision is classified as "zero-one." As Cave (2010) emphasised, the issue is more complex for NGAs. Regulators have to think vertically (i.e. how competing providers can climb the ladder by building their own fibre network) but also horizontally about movements from one ladder to another (see Figure 1). European operators are specifically in between the two ladders and operate on both networks; however, he "ladder of

investment" approach fails to explain this intermediary situation where different generations of technologies coexist.

Figure 1. Migration between the ladders (Cave (2010))



The importance of analysing incentives to migrate from "old" to "new" technology has been put forward by Bourreau et al. (2012). Bourreau et al. (2012) use game theory to analyse the incentives for incumbents and entrants to migrate from "old" technology to "new" technology (the NGA network). They find that NGA-related investment incentives are impacted by access regulation charges in the "old" copper networks via three effects:

- A "replacement effect" that reduces investment incentives for alternative operators when the "old" infrastructure access price is low;
- A "wholesale revenue effect" where the old infrastructure revenue decreases with the access price. The incentive to invest in new infrastructure is related to the profitability of the access services on the old infrastructure;
- The "business migration effect" which stipulates that there is a link between the wholesale and retail prices of the old infrastructure and the retail price of the new infrastructure. According to Bourreau et al. (2012), if the access price of the old infrastructure is low, then retail prices based on that network are low. To encourage customers to switch from the "old" infrastructure to the "new" infrastructure, operators should thus also offer low prices for NGA. In this case, the profitability of the new infrastructure is also low, as is the incentive to invest in NGA networks. Consequently, they demonstrate that "regulators cannot treat the two access prices to the two different technologies independently."

The objective of their paper is to determine the right level of copper prices to spur investment in an NGA network. Bourreau et al. (2012) conclude that if regulators want to encourage the incumbents to invest in NGA, they cannot set wholesale copper prices at a low level.

The "competition migration test" we propose is in the same vein as Bourreau et al. (2012), but we address a slightly different question. The idea is not to evaluate the impact of the legacy network's wholesale access price on the incumbent's NGA investment, but rather to analyse how copper prices can interfere with the implementation of NGA regulations. The interdependence between copper and fibre prices is materialized through this specific "competition migration test." This test overcomes the limits of the "ladder of investment" approach integrating what Bourreau et al. (2012)

named the "business migration effect." The formulation of the second test demonstrates that the interdependence between copper and NGA prices must also be considered when determining NGA retail prices.

As explained previously, for the purpose of this paper, all competitors offer copper services and have to decide whether to enter the NGA market. During the technological transition, they develop NGA access keep while maintaining copper services for a smooth migration between both generations of access networks in the presence of high infrastructure costs.

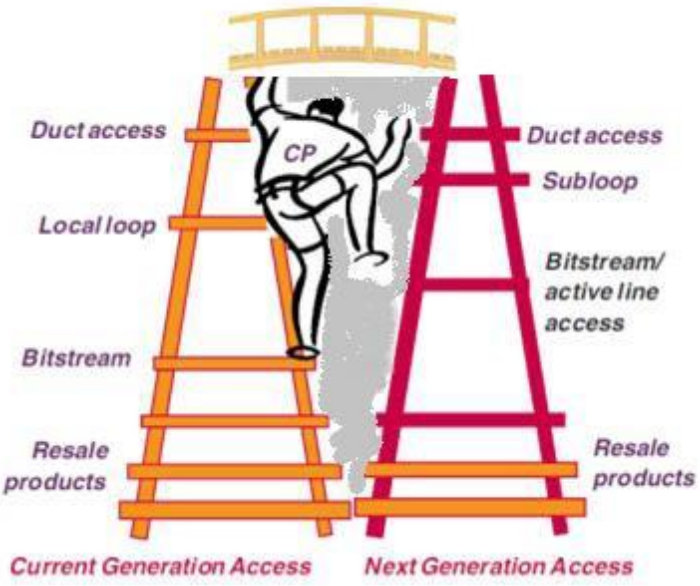
Thus, a competitive provider could be in a transitional phase, represented by the "grey zone" in Figure 2 where the investment decision is not 0 or 1 but somewhere between the two. Through the NGA regulation, one of the objectives of the regulator is to make sure that the entrants migrate from the "copper" ladder to the "NGA" ladder, in other words to help operators cross the bridge depicted in Figure 2.

The set of two tests proposed in this paper, notably with the introduction of an interdependence condition between old and new infrastructure prices are innovative tools to ensure "the business migration" but also the "competitive structure migration."

The economic replicability test based on variable wholesale prices regulates the variable part of the wholesale price and thus guarantees fair competition between all competitors that access the NGA infrastructure. The second test ensures that efficient operators can pay the fixed price to secure access to the NGA.

Migration between the ladders accounting for interdependence between old and new infrastructures (adapted from Cave (2010)

"Business migration effect"



5. Conclusion

Defining the economic replicability test for NGA services is a highly topical issue. It must be accurate in order to avoid discouraging investment because, as we have demonstrated in this paper, NGA economics are incompatible with the conventional margin squeeze test used by regulators.

This paper addresses the question of how to implement the economic replicability test for NGA networks. This test is required by the Recommendation to regulate wholesale prices and

takes into account the fact that, as the Recommendation itself suggests, nonlinear wholesale pricing is appropriate to better reconcile investment and competition than linear wholesale pricing.

The test must also be built in a way that fulfils the EC's double objective of encouraging NGA investment and preserving the competitive structure inherited from copper unbundling while obeying the principle of fair allocation of investment risks between access providers and access seekers.

This paper demonstrates that in order to be operational and consistent with the Recommendation's objectives, the NGA economic replicability test must exclude the fixed part of wholesale prices. However, while excluding the fixed part of wholesale prices from the cost standard of the NGA economic replicability test is necessary to meet the European Commission's policy objective, it is not sufficient. A single economic replicability test cannot explain how to determine fixed wholesale prices and, in particular, it does not guarantee that an operator which is as efficient as the investor can pay the fixed costs and have access to the NGA infrastructure. We therefore propose adding a second transitory test called the "competition migration test" which ensures that during the transition phase the incumbent's NGA retail and wholesale prices will not foreclose copper-based efficient entrants, and gives access seekers sufficient bargaining power to reach a balanced agreement on the fixed wholesale price with the access provider. The second test is meant to preserve the competitive structure inherited from unbundling regulations on the copper market by ensuring that a competitive market structure can migrate from copper to NGA infrastructure.

This pair of tests overcomes the limits of "the ladder of investment" theory by integrating "the business migration effect" concept developed by Bourreau et al. (2012). These two tests solve the dynamic consistency issue that Europe is facing: encouraging NGA investment while preserving the benefits of competitive markets. This economic analysis would also be relevant for a margin squeeze test under competition law.

The concept of two-part access prices, with a different form of regulation for each part of the tariffs may have broader applications than the one described here. However, this specification does not claim to be a general theory that is robust in all circumstances. It is only relevant for meeting the double requirement of infrastructure investment and competitive structure safeguards in European fixed telecommunications markets.

Appendix: Numerical example showing that a conventional interpretation of the LRIC+ NGA economic replicability test would be an inappropriate benchmark to identify discriminatory behaviour

In this appendix, we use a numerical example to perform an LRIC+ test using a DCF method over a customer lifetime, including the fixed and variable parts of the wholesale price in the cost standard, following what we refer to here as a conventional interpretation of the economic replicability test presented by the European Commission in its Recommendation. The example shows that this type of test would almost certainly produce a negative result, even absent any form of discrimination between the access provider investing in an NGA network and the access seeker. If the test is performed as a DCF over the infrastructure lifetime instead of the customer lifetime, the numerical example shows that the outcome may be positive or negative depending on the market conditions and absent any form of discrimination between the access provider and the access seeker.

This numerical analysis serve as a counter example to prove that a conventional interpretation of the "economic replicability test" is not a reliable benchmark for detecting economic discrimination between the access provider and the access seeker, although this is the role assigned to this test in the EC recommendation. To prove the irrelevance of a conventional interpretation of the test as a means of detecting discrimination, there is no need to provide a comprehensive analysis of all the possible results of the test in a large spectrum of configurations. A single counter example for a reasonable configuration is logically enough to discard the belief that a conventional version of the test could adequately identify economic discrimination.

The test is done using the specific case of an FTTH investment rather than a more general NGA example. FTTH is one of the main cases of interest, corresponding to the full replacement of the copper loop by an investment in fibre infrastructure. Any other form of NGA would be an intermediate case, with the effects reduced proportionately as compared with FTTH.

The figures given in the numerical example have been chosen to be reasonable and are to be taken as an illustration only. They are drawn from public sources or from internal sources which are in line with generally known figures, although they should not be considered directly representative of any specific operator.

Here we will describe the effects of an LRIC+ economic replicability test in a scenario with asymmetric access to passive infrastructures where the fixed and variable parts of wholesale prices are both included in the cost standard.

We first describe the general cost and demand features of the FTTH investment case before considering the case of an access seeker, and performing the conventional version of the LRIC+ economic replicability test.

1. Costs estimation

Companies face both investment costs and operational variable costs when deploying fibre infrastructure for their clients.

1.1. Investment costs

We consider a global average investment cost of €1000 per FTTH customer, which may be split roughly 70%-30% into two parts:

- To serve FFTH customers, an operator must first deploy its infrastructure, which generates an investment cost per eligible customer (a customer who has access to fibre infrastructure). For all eligible FTTH customers, we suppose that the investment cost of access to the passive mutualised FTTH infrastructure is €700 per eligible customer.

- For commercial FTTH customers, the investment cost to build an individual fibre drop line is €300 per contracted FTTH customer.

These hypotheses are globally consistent with consensus among consultants and experts[10].

We assume an infrastructure lifetime of 20 years, in line with the accounting lifetime used in documents such as Orange's published accounts. We use a 5 year customer lifetime, which is in the high range of the figures typically used by regulatory and competition authorities.

1.2. Variable downstream costs (DC)

When an eligible customer adopts the service and becomes a commercial customer, the operator faces a variable cost per commercial customer. For commercial customers, the company has to bear three types of variable downstream costs:

- Costs of networks, commercial resources and activities shared with ADSL customers, which can be estimated around €15 per month per customer;
- Costs of specific FTTH commercial network resources and activities, outside the access infrastructure estimated at €10*(1-p) per month per customer, p being the ratio of commercial FTTH customers to all eligible FTTH customers, i.e. the penetration rate. These costs represent the specific technical and commercial efforts that the operator must deploy to encourage and support the migration of ADSL customers to FTTH infrastructure (door-to-door campaigns, initial specific processes and problem solving, higher core network costs due to higher usage). These extra costs are high when FTTH is marginal and drop as the FTTH penetration rate increases, thanks to the learning curve and the (hopefully) increasing appeal of FTTH access to customers.
- Cost-oriented price for duct usage, i.e. € 3 per month per customer, on top of FTTH infrastructure cost.

To summarise, in our model, variable downstream costs per month per customer are DC = € (15+10(1-p)+3)

2. Demand estimation

As mentioned above we call *p* the ratio of commercial FTTH customers to all eligible FTTH customers, i.e. the penetration rate. We consider two *ex ante* demand scenarios:

- Positive scenario: *p* = up 20% per year after investment, which indicates that the migration is achieved in five years (*p* = 20% in year 1, 40% in year 2, 60% in year 3, 80% in year 4, 100% in year 5);

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[10] In Analysys (2006) : "Fibre in the last mile: le business case for FTTP and VDSL", Analysys Research Limited, Cambridge (UK) as quoted in WIK-consult "The Economics of next generation access" (2008), page 12, FTTP-GPON costs around €1000 in investments.

J-L Silicani, Chairman of Arcep, French regulator 16th Nov 2011, Idate Digiworld summit, 21 billion to cover all 25 million French, excluding costs for final drop and customer premise.

Minimal optimal FTTH investment cost for dense urban, should cost €809 following a cost model from an equipment manufacturer (Juan Rendon Schneir, Yupeng Xiong, Huawei, Communication at the 24th Regional Conference of the International Telecommunications Society, Florence, Italy October 2013.

In "NGA network deployment costs" Idate Research M12304-December 2012, the Executive Summary p.5 indicates €229 billion in investment for full FTTH/B of the 212 million households of Europe 27.

In "FTTx business models" Idate Consulting&Research M81508 – January 2009, p.25 Fig 8, indicates around €1500 in investments for FTTH technology, 25-30% for subscriber connections.

- Negative scenario: *p* = up 5% per year after investment, which implies that the migration is achieved in 20 years.

The positive scenario of spontaneous and fast migration of the demand should not be confused with a scenario of forced migration related to a mandatory copper switch-off. A forced migration would generate additional migration costs which are not considered here.

The average revenue per user (ARPU) for an FFTH commercial customer is estimated at € 35 per month, in line with values observed in Western Europe's most competitive retail markets.

3. Modelled access seeker

We will suppose in this example that the access seeker benefits from a situation where it does not suffer from any form of disadvantage or discrimination compared with the investor:

- 50% market share;
- Cost-oriented wholesale price, which here means 50% of a €700 upfront investment per potential customer, plus €300 investment per commercial customer,
- Wholesale duct price is €3 per month per FTTH commercial customer;
- Same downstream cost as the incumbent: DC = € (15+10(1-p)+3) including duct price, following the EEO (Equivalently Efficient Operator) hypothesis supported by EC Recommendation.

4. Calculation of a conventional LRIC+ economic replicability test.

Consistently with the model of the access seeker detailed in the above paragraph, the discounted cash flows outcome reflect the results of the LRIC+ economic replicability test when the competitor has exactly the same business case that the investor (50% market share, same costs and same revenues). So it is clear that the access seeker does not suffer from any form of discrimination when compared with the access provider. However, applying a conventional version of the LRIC+ economic replicability test would lead to opposite conclusion: according to the test, the access seeker would be supposedly discriminated, as the test will be negative. Thus the exercise shows that such a version of the test cannot be used as a reliable tool to characterise discrimination.

Further information is required in order to fully specify the DCF calculation:

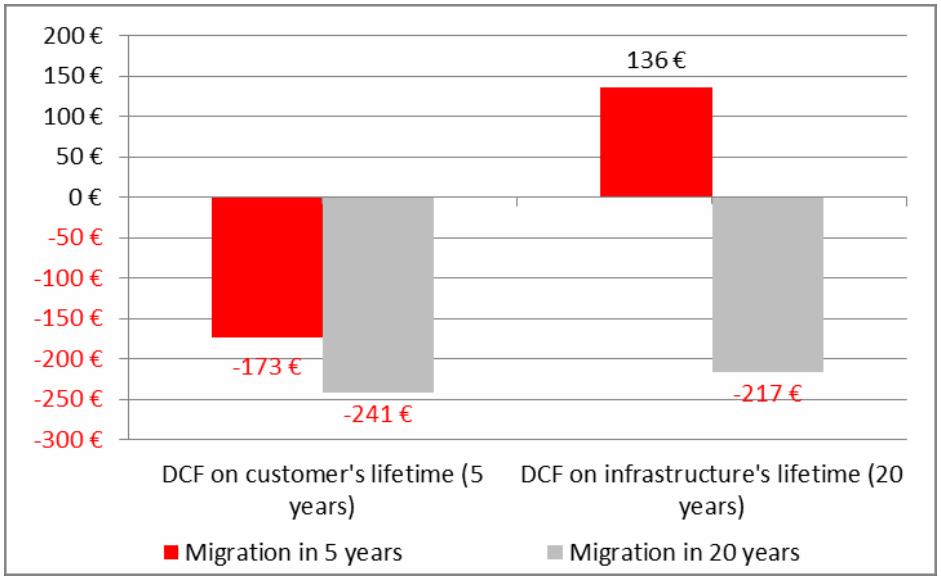
- The cost of capital is presumed to be 10% (WACC: weighted average cost of capital).
- We considered two alternative durations to calculate the DCF: we conducted the test by alternating between a customer lifetime of five years and an infrastructure lifetime of twenty years.
- The terminal value at the end of duration of the DCF calculation in principle reflects the residual economic life of the physical asset and acquired customers. The European Commission defined the terminal value which should be taken into account for a DCF calculation as follows in the Telefónica case[11]: the terminal value should be equal to the net accounting value, i.e. the cumulated investment minus the cumulated linear depreciation of assets[12].

The above elements fully specify the DCF calculation. Test results are given in Figure 3 below:

[11] COMMISSION DECISION of 04.07.2007 relating to a proceedings under Article 82 of the EC Treaty (Case COMP/38.784 – Wanadoo España vs. Telefónica)

[12] "The size of this terminal value is the cost of unrecovered assets (physical assets and acquisition costs) remaining to be recovered after the five-year period of the analysis". (Commission decision of 04.07.2007, (363))

Figure 3. Economic replicability test results



The test is systematically negative (infringement of the economic replicability condition) when performed using a DCF method for a customer lifetime (five years). When we ran the test using a DCF method and the infrastructure lifetime (twenty years), the results were uncertain depending on the length of the migration from copper to fibre network. The test is positive only under the favourable hypothesis that the migration is achieved in five years and negative if the migration takes twenty years.

Thus with this formulation of the test, an FTTH investor could be accused of not complying with the economic replicability test in a situation where there is no actual discrimination and where the result of the test depends of market conditions and not on discriminatory behaviour.

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