How incumbents can shape technological choice and market structure – the case of fixed broadband in Europe

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Abstract

Purpose – *The purpose of this paper is to consider circumstances when technological neutrality in fixed broadband (according firms the power to determine technological choices untrammelled by regulation or the operation of specific incentives) should be adopted.*

Design/methodology/approach – *The paper reviews the likely effect of such a policy on the competitive structure of fixed broadband markets, taking four case studies as examples.*

Findings – *The paper finds that choices made by broadband firms with respect to the adoption of fibre to the home versus fibre to the premise, the use of vectoring and the variant of fibre to the home adopted (point to point or point to multipoint) can have a significant effect on the nature of access products which can be provided and thus in the market structure of fixed broadband markets. Access providers can, thus, abridge or foreclose competition in downstream markets. Accordingly, regulators may decide to seek to influence such technological choices to promote competition. But this should be done carefully.*

Originality/value – *These issues are part of the on-going debate concerning the revision of the European regulatory framework for electronic communications services.*

Keywords *European Union, Communication technologies, Broadband networks, Cable television*

Paper type *Research paper*

1. Introduction

One of the often repeated principles, or even boasts, of the European regulatory framework (ERF) is that it embodies technological neutrality (TN). In a way, this is slightly surprising, as an earlier, much acclaimed, triumph of the European telecommunications model was the worldwide success of GSM, the mobile standard adopted in 1987, which imposed a single and therefore non-neutral technology for 2G mobile, which was compulsory in Europe and which later conquered the world[1].

The 2002 framework explicitly introduced the concept of TN, describing it as "desirable" rather than essential. This nuanced approach can be seen as a continuation of the commission's previous line, which, in essence, was that it was best to leave technology choice to industry and not try to choose a technology winner. There were exceptions permitted in this approach; thus, the promotion of specific technology might be read as permissible where industry has already reached a conclusion that it was the best (the GSM case) or where other exceptional circumstances might apply.

It should also be noted that the significance of TN and its interpretation in Europe is evolving over time. If mentions in speeches and other communications from the commissioner of the time is a guide, TN is of diminishing importance as Figure 1 shows.

This paper reconsiders the implications of TN in the specific context of the current review of the ERF and the technological choices which may be in play. The focus here is fixed broadband, which is usually regarded as being the more problematic mode of supplying

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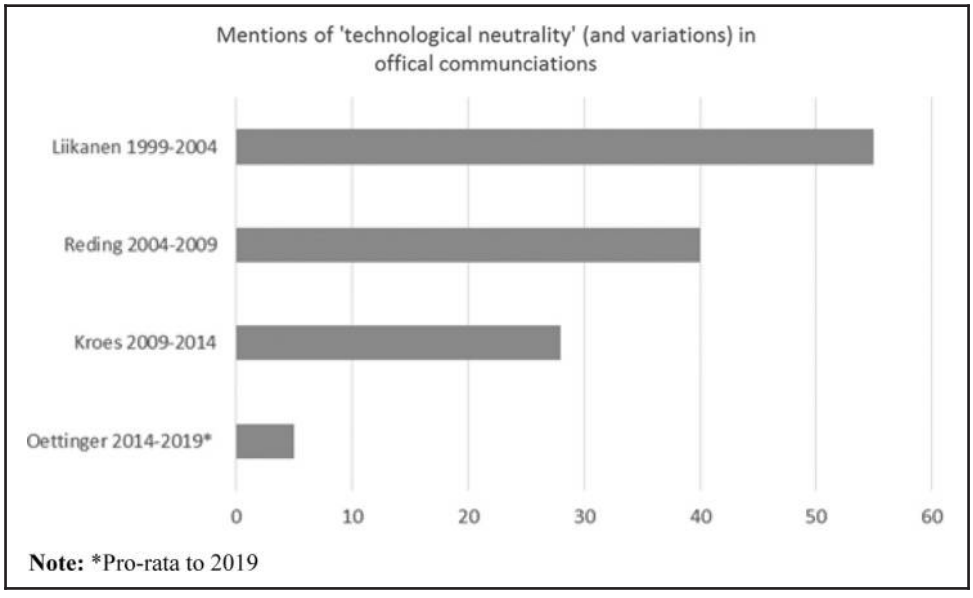
Figure 1 The diminishing focus on TN



connectivity because it requires more intrusive regulation than its mobile complement and rival.

Accordingly, Section 2 examines what TN means in this context and asks whether it is subject to being over-ridden on market failure grounds and whether other policy objectives might successfully trump that of securing TN.

The subsequent Sections 3-6 examine four issues of technological choice in fixed broadband: the adoption of vectoring; the issue of whether fibre should be provided by fibre to the premise (FTTP) or by fibre to the node (FTTN, FTTC or vDSL), a technology which continues to rely on the incumbent's copper and which may impede certain forms of competition; the degree of neutrality in the regulatory treatment of services provided by telecommunications and cable companies; and the choice of technology within FTTP between the so-called point-to-point (P2P) or point-to-multi-point (PMP) variants. Section 7 contains our conclusions, which can be summarised as saying that technology choices in network design made by incumbents can have a major impact on the form and extent of subsequent competition and end-user outcomes. Accordingly, policymakers and regulators should not fetishize TN as they have tended to do in recent years, but neither should they blithely or carelessly overrule firms' technological choices.

2. What is technological neutrality and when should it be pursued?

Maxwell and Bourreau (2015) helpfully distinguish three meanings of TN:

1. TN means that technology standards are designed to limit negative externalities, such as radio interference or pollution, in a minimally intrusive way. As so often happens, this is normally best achieved by regulating outputs rather than inputs – i.e. policymakers should describe the result to be achieved, but should leave companies free to adopt whatever technology is most appropriate to achieve the result.
2. A second interpretation of TN is simply that the same regulatory principles should apply regardless of the technology used. Thus, regulations should acknowledge convergence and not treat similar services in different ways. This is exemplified in approaches to spectrum management which prohibits the inclusion in spectrum licensing of terms which mandate the use of particular technologies. This was expressly intended in provisions of the 2009 Better Regulation Directive[2] which

offered mobile operators more freedom in their choice of technology – clearly a complete reversal of the approach adopted in the GSM Directive[3]. (This has to be distinguished from the much stronger notion of service neutrality, which would allow a licensee to switch the service produced, for example, from broadcasting to mobile communications, which is far more likely to lead interference problems).

3. The third and final interpretation is that TN is protection against attempts to nudge the market in a direction which is considered desirable by policymakers or regulators. In essence, policymakers should not try to pick technology winners.

These overlapping approaches suggest an underlying issue. Most statements of the merits of competition (and of limiting opportunities to intervene in well-functioning or effectively competitive markets) emphasise the importance of decentralising the choice of technology to those organisations which:

- are likely to have the best information about it at their disposal; and
- by virtue of carrying the can for any poor choice, have the strongest incentive to make the right choice.

These are, of course, the firms in the marketplace and their investors, rather than government officials or regulators.

But there is the familiar corollary to this reasoning. If there is any reason to suppose that TN will lead to market failure, or if some overwhelming non-standard policy objective applies in relation to the activities in question, then the presumption in favour of TN might be rebutted.

The specific reference to TN in the regulatory framework not only describes TN as "desirable" rather than essential but also suggests that promoting a specific technology can be justified[4]:

> The requirement for Member States to ensure that national regulatory authorities take the utmost account of the desirability of making regulation technologically neutral, that is to say that it neither imposes nor discriminates in favour of the use of a particular type of technology, does not preclude the taking of proportionate steps to promote certain specific services where this is justified, for example digital television as a means for increasing spectrum efficiency.

We now consider such possibilities in relation to fixed broadband.

2.1 Market failure

The two major sources of market failure relevant here are externalities and adverse effects of TN on competition. We note above that in the case of spectrum use, producer-to-producer negative externalities can occur through interference. In the case of fixed broadband, the more plausible externalities are indirect positive effects of the following kinds:

- *Enhanced speed and quality of information flows*: Sometimes, it is suggested that the combination of more information processing and faster communications are necessary to deliver the benefits, with one alone producing less spectacular results.
- *Better access to markets*: Because of lower barriers to entry, an increase in the geographical scope of markets (the "death of distance"), better job matching, better access to customers via the Web, etc.
- *New business processes and organizational structures*: This includes better stock control, quicker contracting, just-in-time production, etc.
- *More innovation in general*: This is made possible by the availability of new communications services; examples can be multiplied – social networks being a particularly significant one.

In a discussion of technology choice, the key question is whether these benefits are available in different degrees from different technologies. One can imagine such benefits depending, for example, on the speed and other characteristics of the broadband service produced by each technology and the speed and cost at which the technologies could be applied.

A study conducted by Ericsson, Arthur D. Little and the Chalmers University of Technology found that doubling a country's broadband speed would lead to a 0.3 per cent increase in gross domestic product (GDP) growth (Ericsson, 2011). The positive effects of increases in broadband speed for the economy are broken down into three main categories, with direct and indirect effects providing a short- to medium-term stimulus, and "induced" effects having a long-term impact. The direct effects include job creation through civil works, construction and equipment required for building the new infrastructure. The indirect effect includes the spill-over arising from efficiency improvements resulting from the availability of high-speed broadband. Induced effects capture new styles of business caused by the increased speeds including the creation of more online services.

Elsewhere, Katz *et al.* (2009) considered the level of investment that would be required to meet the German National Broadband Strategy and the number of jobs and level of growth that would be generated by this investment. Using input–output tables from the German Federal Statistics Office, the study estimated that 541,000 new jobs would be created by network construction alone. A further 427,000 jobs would be created once infrastructure had been deployed, as a result of network externalities, "such as enhanced innovation resulting in new services, additional business growth, and the attraction of jobs from other countries as a result of a re-composition of industrial value chains". The authors also showed that there would be significant benefits in terms of economic growth concluding that the effect of significant investment in ultra-fast broadband networks on GDP would likely be equivalent to 0.6 per cent of annual growth over the 10-year period from 2010 to 2020.

Both of these (and other) studies suggest that there may be external benefits from offering higher broadband speeds which are not fully captured by the private investor in the broadband.

The second form of market failure arises via a chain of reasoning which links different fixed broadband technologies, the potential which they carry for either competition or, in the alternative, for the abridgement or partial foreclosure of competition[5], and their impact on end users, in light of any remedies adopted by regulators to counteract expected detriments.

It is worth noting that European regulators have a clear history of deliberately seeking to influence the competitive outcomes in broadband markets by regulatory interventions, through the design of access products and in their pricing: this is shown by the preference for outcomes which favour infrastructure competition and "ladder of investment" strategies. There would, therefore, be nothing novel or remarkable in intervening in technological choice if that were shown to have an impact on the form of downstream competition. However, what is unusual in the current decision process is that regulators are not so much choosing as being forced to accept technological increments which increasingly narrow and restrict access choices. This evolution is explored in Sections 3 to 6 below.

This generalises to a more topical concern regarding market failure in broadband markets. Even if technological choice is best left to firms for the reasons previously outlined in competitive markets, in the presence of dominance, the best technological choice for a firm might be at odds with that which would emerge in a competitive market for a variety of reasons, of which one might be a desire on the part of the dominant firm to preserve its existing position in the market and simultaneously constrain its competitors' options and strategies by foreclosing certain forms of competition.

The decisions made by European regulators in market reviews since 2002 – which have almost uniformly found that dominance exists in each and every European physical access market – suggest that the means are there as well as the motive. But the same detriment can arise even in the presence of entirely innocent technological choices made by firms, if they have the effect of abridging competitive options. In other words, as noted in footnote 9, it is the effect which matters, not the intent.

In particular, as we discuss below, it is quite possible that absent intervention in favour of one technology (FTTP) that the default technology choice of dominant entities will be FTTN. And FTTN seems, in practice, to lead ultimately to the effective removal of physical access remedies, to limit the range of telecom access products and to condemn competitors to dependence on the dominant entity's development path. This *de facto* limitation on access products would bring regulation of dominant telecommunications into much closer approximation with the status quo in cable regulation, at a time when, as we discuss in Section 5, that is increasingly being regarded as unsatisfactory[6].

2.2 Other policy objectives

Examples of this kind – often of a questionable nature – may also be in play. For example, in some jurisdictions, industrial or protectionist policies may be pursued by favouring, openly or covertly, national or regional technologies. This occurred in relation to GSM; it has been observed in the nuclear power industry, for example, where successful demonstration projects can be seen as providing a springboard for subsequent overseas sales.

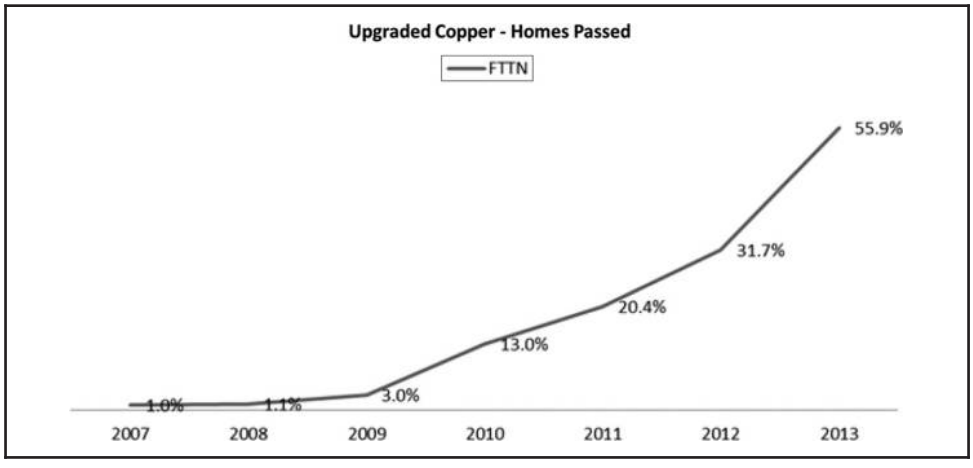
The justification, if any, for such interventions often hinge upon highly specific circumstances, and they are not considered further here: but it is worth noting that the legislation "does not preclude the taking of proportionate steps to promote certain specific services where this is justified"[7]. Instead, the next four sections discuss particular technological choices in the field of fixed broadband.

3. Fibre to the premises vs copper upgrades

The first case study considered here combines both importance and topicality. It concerns the major question of whether the form of fibre should be FTTP or FTTN. The latter can be characterised as a "cheap and cheerful" version of the former – considerably less expensive to install, but not capable of the same speeds or other quality parameters as FTTP. There are interesting intermediate stages between the two: one of which is the technology known as G-fast, which takes the fibre closer to, but not right up to, the premises – for example, to a telephone pole close to the house. The feature distinguishing FTTN and G-fast from FTTP is that, in the former, the incumbent continues to provide a form of bottleneck access to its competitors. This both gives it considerable control over technology and limits competitors' ability to compete in access markets by giving them access to less of the value chain[8]. It also opened the door to retail minus forms of price control, which put the incumbent in the driving seat over retail and wholesale prices as well. Given entrants' vulnerable position, the emphasis that has been placed on margin squeeze testing is understandable.

The contrasting strategic choices made by NRAs illustrate how regulation can override TN. Figure 2 shows the powerful position that FTTN has achieved in Europe. But, within this overall picture, it is possible to make a vivid comparison between Belgium, Germany and the UK, on one hand, where FTTN has predominated, and France, Portugal and Spain on the other, where FTTP has predominated. This divergence may have been due in part to the somewhat troublesome and lengthy gestation period of the European Commission (EC)'s 2010 NGA Recommendation (Cave and Shortall, 2011). While the final version essentially endorsed the FTTN approach, the 2008 first draft proposed that NGA regulation should rely on good access to passive infrastructure, to facilitate competitive network build-out; this would be accomplished by discouraging copper upgrades relative to FTTP and limiting

Figure 2 FTTN deployment as a percentage of all access lines



virtual access products for third parties to rural areas where competitive networks were unlikely (Shortall and Cave, 2015).

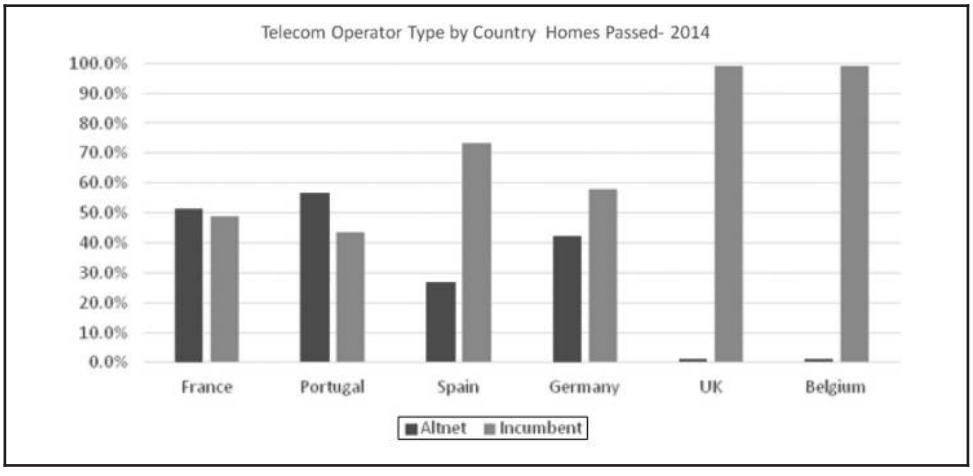
While the FTTN approach was an extension of the existing regulatory copper regime (save for the major difference that the key access product switched from unbundled loops with copper to bitstream or VULA over FTTN), the FTTP approach embodied major changes:

- Virtual access was signalled to be unavailable on the FTTP infrastructure into the future at least in urban areas. In practice, this meant that once copper network capacity was overtaken by fibre, entrants would not survive on unbundled loops. Spain was the exception because it did grant access to the fibre network but capped that capacity at copper performance. France indicated it was too early and Portugal also proposed to deal with it "later".
- Significant emphasis was placed on ensuring that access to passive network elements (ducts, trenching etc.) was the best in class and that a symmetrical regime existed to deal with in-building access to cabling.
- An urban-rural divide was central to the approach; thus, while urban areas were subject to the "build your own" approach indicated above, rural areas had a much easier access regime. While Portugal went for a straight urban/rural geographic segmentation, France opted for a division based on building density, but the net impact was essentially the same.

As noted earlier, in the absence of strong policy interventions on technology parameters, the strategic choice of dominant entities in access markets was overwhelmingly FTTN as can be seen in Figure 2 where it should be noted that the Commission switched from seeking to suppress FTTN to giving it "NGA" status on an equal footing to FTTP. Indeed, the revised 2009 draft NGA Recommendation coincided with the start of substantial investments by network operators in upgrading copper.

By 2014, the proportion of homes passed by vDSL in Belgium, Germany and the UK, and by FTTP in Portugal and Spain had reached 60-90 per cent[9]. But the striking difference between the two cases can be seen in Figure 3, which shows that the regulatory strategy used in the FTTP countries (a strong version of the conventional "ladder of investment" combined with symmetrical regulation of in-building wiring), is associated with an appreciably more equal split of homes supplied between the incumbent, on one hand, and competitive providers on the other than is the case in FTTN countries[10]. Not surprisingly this makes the approach palatable to competitive providers with deep pockets[11].

Figure 3 Telecom network operator type across countries in 2014



In those countries that adopted FTTP, policymakers put in place extensive sharing regimes for passive outside-plant infrastructures such as duct or cabling and very extensive in-building wiring sharing regimes. These were co-ordinated by the regulator and extensive industry co-ordination took place. This was further backed by measures to ensure FTTP extended to rural areas, normally with public finance to support the measures either now or with a clear path in the future[12][13].

It should be noted that, in general, there is little or no overlap in these FTTP networks. The typical pattern is of independent deployment, followed by the striking by network owners of deals which were commercial or not conventionally regulated, once a critical mass has been achieved. In Portugal this took the form of a barter deal between Portugal Telecom and Vodafone. Agreements in Spain are a combination of co-investment and indefeasible rights of use (IRU)[14], while the French operators are likely to operate in a more tightly controlled IRU model at least outside the denser areas[15]. Without subsequent overbuild, this creates scope for symmetrical, as opposed to asymmetrical regulation. It may also lead to overbuild and the *option* of deregulating access entirely.

The hypothesis is, thus, that the technological choice made by the incumbent can mould the market structure, and that FTTP leads to a more even balance between incumbent and competitive access seekers, creating opportunities either for more symmetric regulation or even for deregulation. In other words, there is a potential "market failure" case for intervening in technology choice.

4. The regulatory treatment of vectoring

The decision of operators to choose FTTN creates a technological path dependence which continues long after the initial decision. FTTN networks notionally facilitate access at the street cabinet via sub-loop unbundling (SLU), but the economics of such networks render such access very difficult as a matter of practice[16]. The more active vDSL lines at a street cabinet, the more interference between lines requiring management of the spectrum. Implicit, therefore, in the choice of FTTN technology is the need for the adoption of noise-cancellation technology such as vectoring at some point, once the take-up crosses a critical threshold.

Vectoring is incompatible with third-party physical access given the need to manage harmonics, although this may be a design issue rather than an inherent constraint. DG Connect first accepted the withdrawal of SLU as a remedy explicitly in Belgium and implicitly in The Netherlands.

A more recent example worth noting arises in Italy where one operator, Fastweb, has sought to make the case for multi-operator vectoring (MOV) and has been deploying its own FTTN solution together with Telecom Italia. In this case, the NRA – AGCOM – is trying to facilitate an industry solution which would be a first. The EU Commission describes this a "novel development", and there is suggestion in the Commission's comments on this approach that it has doubts that a viable multi-operator solution can be delivered in Italy in a timely fashion:

> Additionally, the Commission urges AGCOM, in the event that a technically and economically viable MOV solution is not in place within a reasonable timeframe, to devise an alternative solution that does not unnecessarily delay network upgrades. The positive experiences implemented in the field of vectoring by other EU Member States should be considered by AGCOM[17].

Certainly, no one else in Europe has sought to find a technical solution to vectoring, it may be that by being the last large market to deploy FTTN, some technological evolutions will facilitate a multi-operator vectoring model.

However, the Italian case and indeed the Italian regulator appear to be increasingly isolated. BEREC (2014), in its report which looked at Belgium, Austria, Germany and Denmark, pessimistically concluded:

> This means it is not possible that more than one operator can use vectoring on VDSL2 lines in the same cable (binder). Furthermore, if only a single operator uses vectoring on VDSL2 lines of a cable, the other operators not only cannot use vectoring but also not VDSL2 systems without vectoring on lines of the same cable. Therefore, the introduction of vectoring may require modification of the existing regulation to take this into account and to enable a single operator to use VDSL2 vectoring exclusively. The countries analysed consider multi-operator vectoring, at least currently, not as an appropriate option.

It remains to be seen, however, if the technology can be delivered, and if it can, at a reasonable price. The scepticism of the Commission in that Italian case may inform to some extent the approach that BNETZA will take in Germany where a further decision is expected on how to deal with those loops where the MDF is located in cities and where a large number of the access lines can support vDSL without further investment (i.e. the sub-loop is the local loop because of proximity to the exchange). By permitting vectoring, BNETZA would effectively remove even SLU as a possible remedy on technology grounds where the normally economic challenges are less. This would follow a series of similar decisions which effectively removes SLU as a remedy in Europe on the promotion of technology grounds (Table I).

The problem for regulators and, in many ways, an even bigger problem for putative entrants, is that this is not the end of the technological evolutions on the copper network. The next technology increment is called "G.Fast" which can deliver higher speeds but requires a very short copper component, often requiring the fibre component to go to the building itself. Formal specifications have been drafted as ITU-T G.9700 and G.9701 in 2014, and large-scale deployments have been suggested but not delivered to date[18]. An entrant opting to invest in an FTTN infrastructure, where a multi-operator vectoring solution can be found, could easily find itself sitting at the wrong aggregation point in the network and being forced to endure another round of investment with the prospect of even further investments (FTTP) subsequently.

The suggestion from the Commission that network upgrades should be facilitated over entry concerns – cited above in the Italian case, would surely unnerve most investors. What cannot be known is to what extent these path dependencies are contrived or inherent in the technology. Incremental copper upgrades create path dependencies with difficult choices for regulators and operators alike. FTTP is also not immune from such problems, although the choices are less stark or absolute in terms of access implications.

Table I Overview on the regulatory decisions on vectoring

MS	*Austria*	*Belgium*	*Denmark*	*Germany*
Legal basis of the specific decisions regarding vectoring	Market analysis decision (Market 4) as of December 2013 (stipulated scope of SLU-/LLU-access obligation due to possible vectoring deployment; AT/2013/1475-1476) Detailed vectoring "deployment rules" by A1 Telekom Austria (publicized 03/2014)	Market analysis decision of July 1st 2011 (BE/2011/1227-1228) Reference offer decision of 19 February 2014	Extra decision (of 19 December 2013) concerning vectoring at street cabinets to the Market 4 decision of 16 August 2012 (DK/2012/1339)	Extra Decisions: Regulatory Order BK3d-12/131 from 29/08/2013 (DE/2013/1484) Reference Offer from 29/07/2014 (DE/2014/1628)
Area	Sub-loop and (full) loop	Sub-loop and (full) loop	Sub-loop	Sub-loop
Symmetry	No, only SMP operator	No, only SMP operator	No, only SMP operator38	Yes (with some restrictions)
SLU/LLU obligation entirely lifted or on a case-by-case basis	SLU/LLU: Remains, but lifted subject to conditions	Entirely lifted for SLU (all DSL systems) and LLU VDSL2	SLU: Remains, but lifted subject to conditions	SLU: Remains, but lifted subject to conditions
Frequency spectrum	SLU/LLU: > 2.2 MHz39	SLU: whole spectrum LLU: > 2.2 MHz40	SLU: Not specified in detail41	SLU: > 2.2 MHz
Refusal of first time SLU/LLU possible	SLU/LLU: Yes	N/A	SLU: Yes	SLU: Yes
Termination of existing SLU/LLU possible	SLU: No42 LLU: N/A43	SLU: N/A (no SLU) LLU: N/A (no LLU VDSL2)	SLU: Yes	SLU: Yes

Source: BEREC (2014)

5. Neutrality between cable and telecommunications networks

5.1 The back story: the recommendations on relevant markets

We now briefly outline the discussion on fixed-access markets which concerns the interaction between cable and telecommunications networks and their regulatory treatment. We do so by examining the Commission's three successive recommendations on markets subject to ex ante regulation, published in 2003, 2007 and 2014. The three versions embody a developing view of the issue of neutrality in regulation of cable and telecommunications firms.

In its first recommendation (European Commission, 2003), the access products chosen with respect to fixed broadband were as follows:

> 11. Wholesale unbundled access (including shared access) to metallic loops and sub-loops for the purpose of providing broadband and voice services.
>
> [. . .].
>
> 12. Wholesale broadband access.
>
> This market covers '"bitstream' access that permits the transmission of broadband data and other wholesale access provided under other infrastructures, if and when they offer facilities equivalent to bitstream access."

While the latter market was specified in a manner consistent with TN, applicable in principle to both cable and copper networks, the former is tied to copper loops. In the then state of knowledge of the scope for unbundling fibre networks, this was not unreasonable.

When the recommendation was revised in 2007, the explanatory document accompanying the second recommendation (European Commission, 2007) noted:

> In the initial Recommendation, the wholesale broadband access market was said to cover "bitstream" access that permits the transmission of broadband data in both directions and other wholesale access provided over other infrastructures, if and when they offer facilities equivalent to bitstream access. In this context, the question has arisen as to whether wholesale access to cable networks that provide a return path is part of the relevant market. Across the EU, cable represents 15.5 per cent of broadband connections compared to 81.8 per cent of DSL lines and its relative importance has been declining, although broadband delivered via cable has a high market share in Malta, Austria, Belgium, The Netherlands and Portugal. Experience under the market analysis and Article 7 notification procedures so far has indicated that, where cable networks exist, their geographical coverage is often limited and wholesale access to such networks does not constitute a direct substitute for DSL-based wholesale access products from the demand or the supply side, so that inclusion in the same product market is not justified.

The note goes on:

> The presence of cable (or other broadband-capable networks) in a given Member State may, however, exercise an indirect constraint on the provider of DSL-based wholesale broadband access, through the substitutability between both products at retail level. Broadband subscribers may have a choice between the services provided by the integrated incumbent, by other vertically integrated companies (such as a cable operator), or by firms using inputs supplied by the incumbent. If alternative integrated undertakings have high market shares compared to firms exploiting inputs, (and the former choose not to offer wholesale inputs), it is likely that indirect constraints will be more important than direct ones. Such indirect pricing constraint, where it is found to exist, should be taken into account when assessing if the incumbent DSL operator has SMP on the relevant market.
>
> The Commission sought to insist (possibly to emphasise the distinction between direct and indirect effects) that notional cable broadband wholesale access fell outside the market occupied by broadband provided by a telecommunications provider. The successors to the two markets in the first Recommendation were thus broadly the same in the second, except that the reference to "metallic loops" was replaced by on to "wholesale (physical) network infrastructure access."

The explanatory note accompanying the third recommendation (European Commission, 2014) took account of the changes wrought by the growth of fibre in the network, and the installation of NGAs. It noted that:

> CATV upgrade bears important consequences for the assessment of competitive dynamics on the broadband markets. In order to be able to match the cable operators' offers, fixed telecoms operators tend to upgrade their copper networks to NGAs primarily in the geographic footprint of the coaxial cable operators. Also, it has been observed - although this has occurred in practice in a very small number of Member States to date - that cable operators are now technologically able to make economically viable offers of some type of wholesale access products on a commercial basis. The question of the inclusion of such an infrastructure in the relevant wholesale broadband access markets at a fixed location should therefore be assessed carefully.

Several factors evolved over these 11 years, which we might be described as a period of "benign neglect" of cable by the Commission[19]. There is a gradual recognition of the growing significance of cable in terms of high-speed broadband penetration, and perhaps also of the effects of technological choices which cause telecommunications and cable access to converge in important respects. This latter factor poses challenges in respect of the regulatory treatment of the two technologies.

5.2 Cable developments

The first instance of cable being regulated in Europe occurred in Denmark, where the Commission agreed to regulate it on the ground of the cable's common ownership with the infrastructure of the telecom incumbent, on the basis of Article 8 of the Framework Directive[20]. Unusually, although the Commission considered WBA over cable outside the

defined market, the Commission also set aside the question of SMP on the YouSee cable network in its decision, arguing that:

> [. . .] [. . .] the Commission is not convinced that it is justified to include cable in the relevant market. However, the Commission is of the view that, taking account of the exceptional circumstances unique to the Danish broadband access market, even if cable was not considered to be part of the relevant wholesale broadband access market the competitive concerns identified by NITA would still require an adequate regulatory intervention.

The Commission's position in Denmark is summarised again in its decision relating to the 2012 notification relating to the then Market 5 in a way that reinforces this point[21]. Essentially, the Commission restated that the obligations placed on the cable network are only there to ensure the effectiveness of the primary remedy – imposed on the DSL network. The cable access products in Denmark have been available since 2009, but no real demand for such access has emerged to date. An attempt to further extend the CATV access remedy was withdrawn by the NRA during the Phase II process[22].

Similarly, in Belgium, the Commission acquiesced to a very unusual solution, whereby the issue of whether cable networks should be in the relevant broadband markets was settled with the conclusion that they were not[23], but after a finding of SMP in the broadcasting transmission market, access to wholesale broadband access was granted as an ancillary remedy to the primary broadcast transmission remedy[24]. Just as in the case of Denmark, no demand has manifested itself to date in Belgium (this may suggest that the Commission's traditional position may be correct).

Nevertheless, the 2014 Recommendation on Relevant Markets is strongly suggestive of a willingness to reconsider its position regarding the inclusion of cable in a virtual access market [25]. In essence, telecom networks have evolved or are evolving to a point where their limitations for third part access mean they can only grant virtual access, something which cable networks can also do, even if the technical solution has its own peculiarities.

Against this changing background, in 2015, The Netherlands' NRA made a notification[26] to the EC under the Article 7 procedure which began with a finding that the country's retail market for fixed internet access was characterised by potential joint dominance on the part of the fixed telecommunications operator and the dominant cable company. In the wholesale access market, which excludes the cable company, the telecommunications company has significant market power, which the regulator proposed to deal with by a variety of remedies, including access, transparency, non-discrimination and (safeguard) price cap.

In response, the Commission issued a "serious doubts" letter, raising, in particular, the inconsistency of an exclusion from the wholesale access market of the prospective availability over the relevant future period of virtually unbundled cable access. It also noted, in apparent contradiction of its previous approach, that the regulator should have taken into account the cable operator's self-supply of its own cable infrastructure when delineating the wholesale market. More broadly, it was concerned about the disjunction between the combination of a finding of joint dominance in the retail broadband market and one of single dominance by the telecommunications company in the upstream market. At the end of 2015, ACM re-notified their analysis giving more reasons why cable was neither a direct nor an indirect substitute to the DSL network but went further and claimed that even if cable was in the same market, the DSL network would still be the SMP operator. Joint dominance as a motivator for the intervention was dropped, and, while the Commission did not seek to block the market analysis, it is clear that the Commission view has changed:

> Given the ubiquitous presence of cable in The Netherlands and the potential for cable to act as a competitive constraint on KPN's access network, the Commission asks ACM to monitor developments on cable networks with a particular focus on whether developments lead to (virtual) cable unbundling being both technologically and economically feasible[27].

One way of looking at these developments is that the Commission has chosen or been forced by market developments in cable to move from an attitude of benign neglect to one of increasing interest and increasingly symmetrical regulation. Another way to view this evolution is simply in technological terms. As vDSL has spread in many jurisdictions, the absence of a physical unbundling remedy has that there is a narrower gap between the only available virtual access product (telecom) and the rival virtual access product represented by cable. Such technical differences are likely to narrow further in the future.

It is not entirely fanciful to see a parallel between this case and the famous "cellophane fallacy" in the 1920s. In that case, Du Pont had increased the prices of cellophane to such an extent that it appeared that other forms of wrapping were substitutes. In the present case, the forms of vDSL access available has become so degraded that, unexpectedly, a cable access product suddenly looks attractive to access seekers. In a competitive market, network evolution might not have taken this course.

6. The form of FTTP

It is well known that FTTP can take two distinct topological forms: P2P, in which each customer is provided with an individual unshared fibre from the point of presence, or PMP – in which each user has its own fibre access line up to a distribution point in the same way that copper networks are deployed today. Over these topologies, different technologies can be layered such as GPON or Ethernet and though GPON is often associated, synonymous even, with PMP, it can equally be deployed on a P2P network. However, the fibre PMP can only be physically unbundled at the splitter locations which are normally very close to the end customers. Because these serve a limited number of customers, unbundling at these locations is commercially harder to justify. Further dimensions of choice can be identified, the most important of which concerns the form of PMP deployed (Shortall, 2011; Jay *et al.*, 2014).

The issue discussed here is whether the choice between P2P and PMP should be left to the firms concerned, or whether (and if so, how) the regulator might depart from TN to influence the extent and form of access technology which the alternatives can support – essentially to counteract the "partial foreclosure of competition" motive to which an operator installing a fibre network might be subject.

The limitation on physical unbundling of a PMP network has already been noted. There is, however, another possibility, wavelength division multiplexing (WDM), in which multiple signals on laser beams are combined at various infrared wavelengths and then separated. This turns a PMP network into a virtual P2P, with the difference that (unlike bitstream and VULA virtual access products) the virtual access path is unfettered; that is, an access seeker controlling the light-wave would enjoy technical independence in the same way as if it held a physical access path. Considering a WDM deployment introduces further technical refinement: the difference between splicing and "pre-connectorising" the fibres in the network – a distinction which influences the deployment cost of a WDM (or rather a "WDM-ready") network[28].

The question of unbundling of fibre networks is expressly addressed by Analysys Mason in a consultancy report for Ofcom, covering case studies in seven countries of interest[29]. This notes that in the six countries where FTTP is used, one used P2P and five solely or primarily GPON.

In terms of passive access remedies, there is a mixed picture:

- In Singapore, most access seekers purchase passive PON network access for their customers, including the splitter which is managed by the (separated) network operator; it provides access back to one of the nine central offices which serve the country[30].
- Spain and Portugal have concluded that it is not (or not yet) possible to unbundle a GPON network.

- In New Zealand, the availability of passive access products for the residential market has been deferred to 2020.
- In France, the network is either PON or P2P: that is, it is P2P from the mutualisation point to the end customer, allowing splitters to be used at or above the mutualisation point.

In summary, the consultants conclude that "while several regulators have commented that it is not feasible to unbundle a GPON network, others have simply implemented this, proving that it can be done (at least for certain deployments)"[31].

It is worth noting that the choices that are made today will influence greatly what the future upgrade path looks like. Operators that wish to deploy WDM would be likely to build it with that upgrade in mind (as in the USA, Portugal, Spain where short-term pressure from cable and competing FTTP networks means much higher bandwidth will be desirable in the foreseeable future) than in areas where access competition is weaker or more limited (as BT did in their limited trials in the UK). It could be argued that being WDM-ready – i.e. adopting a pre-connectorised solution – may change the perspective over five years in terms of whether light-wave unbundling is proportionate or not: if the network is WDM-ready, then its use may be proportionate, but if the network is spliced, then it may not be. However, as in the FTTP/FTTN evolution described above, policy decisions made today may push it one way or the other.

One piece of evidence which is worth noting is that of all the standards proposed at European Telecommunications Standards Institute (ETSI)[32] for WDM (also known as NG PON2), only one supported third-party access functionality. While this was the standard ultimately adopted[33], this outcome seems to have been against the odds. This raises another important point in the TN debate: the role of standardisation bodies in determining the functionality of adopted standards. If these bodies can be influenced, then the standardisation process might be used to ensure that more competitive architectures do not feature in the standards adopted.

On the brighter side, if operators choosing between P2P and PMP and the type of PMP, could have been influenced by a partial foreclosure motive, that goal may not be sustainable on a durable basis. An operator may gain time, and may also be able to raise rivals' costs (as in the above discussion of pre-connectorisation) but technical developments seem destined to mitigate the worst outcomes.

7. Conclusion

It is apparent from the four case studies above that technological choices exercised by firms can have a major impact and cumulative impact on market structures and hence end user outcomes. A very comprehensive version of TN which gives no guidance at all in terms of outcomes can lead to (innocent or deliberate) choices which foreclose competition to a high degree.

Nevertheless, the underlying rationale for TN remains valid in many instances. Maxwell and Bourreau's first conception of TN (see Section 2 above) identifies the outline of a compromise. On this view, policymakers might set the desirable characteristics which they wish to see, and then reward them and punish their absence. That was the policy implicit in the 2008 draft Recommendation on NGA, which required an incumbent opting for FTTN to maintain an equivalent to LLU at no additional cost to the access seeker, while FTTP was associated with significant concessions for investors. We believe that the decision to step away from this position in the final NGA recommendation had an impact on technology choice and the subsequent form of access competition.

The cumulative impact on market structure on technological decisions is illustrated by the growth of vectoring. The move to invest in FTTN masked a nearly simultaneous decision to deploy vectoring, which closes off competing FTTN solutions on technology grounds. While the Italian regulator is seeking to find an alternative path, it remains to be seen whether this

will be successful. Even if it is successful, it is becoming clear that the next technology increment on copper will require even shorter copper segments meaning that the same issue might arise again even if a solution can be found to this problem. It is not entirely clear to what extent these path dependencies are contrived or inherent in the technology. It appears for now that the Commission's position is that a network upgrade should be facilitated as a higher priority that any entry concerns. This policy favours the incumbent investor.

The general experience in Europe, to date, is that FTTN ultimately leads to the end of physical access competition (and thereby heralds competition over a smaller part of the value chain). One interesting aspect of this technological evolution is that telecom networks become more like cable networks in this regard. Consequently, many NRAs are expending considerable efforts considering the need and desirability of mandating access to cable networks. However, on balance, this appears to be driven not by cable access possibilities evolving towards telecommunications capacities, rather it is driven by a regression of telecommunications access possibilities.

Technology choice issues may also arise for today's policymakers in the treatment and the design of design of FTTP networks. At present, there may be some benefit in terms of the promotion of competition in the P2P variant using WDM over PMP, as it is a minor variation on the dominant technology choice that opens up future access possibilities. Again a policy-making body would be better advised to indicate its preferred technology in terms of characteristics to be delivered or outputs, than in terms of network design or inputs. Thus, it might say it wants to see speeds in excess of some level (as happens already), which can also go to some other limit in the future. The regulator might say it has targets in terms of latency (1 millisecond) because it sees real-time virtual services as important and so on. However, to make use of firms' knowledge of comparative costs, such targets are better realised via price-based incentives than through instruction or prohibition.

However, two factors make such intervention decisions more difficult. The first is the optimal scale of FTTP deployment. The discussion above essentially applies to more densely populated areas where the more expensive technology is feasible. In choosing between FTTN and FTTP or among alternative FTTP technologies, such private cost differences must be traded off against the effects of the more competitive market which the more expensive alternatives may bring. Second, path dependence may be involved: that is, a country's decision to sink investment in one technology model, rather than going straight to preferred technology, may affect the desirability of the preferred technology as a the ultimate goal. We have not examined this aspect here.

So where does this leave TN? It was noted at the outset that, within the range of objectives currently set for regulators, and specifically within the current ERF, there are persuasive grounds for departing from a "rule of thumb" such as TN, if it can be shown to conflict with a fundamental objective, such as consumer benefits. But such departures require full and careful appraisal.

Notes

1. See Council Directive 87/372/EEC of 25 June 1987 on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community.
2. Directive 209/140/EC.
3. For an optimistic review of the consequences of this Directive, see Pelkmans (2001).
4. Recital 18, Framework Directive.
5. We use the word "foreclosure" here in a neutral sense. This means the focus is on whether an action precludes competition in any part of a vertical chain, not on whether that outcome arose innocently or deliberately: in other words, we adopt an "effects-based" rather than an "intent-based" definition.

6. We suggest in Section 5 that the greater current focus on cable access may precisely be inspired by the diminution under FTTN of the range of telecommunications access products.
7. See footnote 5 above.
8. For instance, if the access value chain is €10 and the raw copper access is €2, then the access seeker could potentially compete and differentiate over the remaining €8. Selling access with bitstream enhancements costs say €7, leaving the entrant to compete over the remaining €3.
9. The figure for France was much lower, at 20%.
10. Note that the data on Germany in Figure 3 may overestimate the altnet (alternative network) element, as vDSL is essentially only deployed on those lines where SLU is also LLU.
11. Thus, the responses of Sky and Vodafone to Ofcom's UK telecommunications strategy review strongly favour this approach.
12. For instance, France permits public investments in vDSL only if the investing Authority has identified its path to FTTP including finance www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000024473100&dateTexte=&categorieLien=id
13. IDATE data for FTTH Council Europe. Alternative operators in France are Bouygues, SFR, Iliad and local authorities. Alternative operators in Portugal are Vodafone, Sonaecom and about 14 smaller operators. Alternative operators in Spain are Jazztel and Orange, as well as some local initiatives. In Germany, Vodafone is an alternative vDSL provider that still relies on DT's sub-loops and the German alternative figure is heavily influenced by these "near-shore" lines which may be removed in the next German market review. There is no meaningful alternative competition in the UK or Belgium.
14. See http://inversores.bolsa.jazztel.com/documents/10156/219926/JAZZTEL+signs+a+Vertical+Infrastructure+Access+Agreement+with+Telef%C3%B3nica
15. www.arcep.fr/uploads/tx_gspublication/consult-modele-tarifs-FttH-160514.pdf
16. ACM in The Netherlands published a report it had commissioned that found SLU was effectively non-viable for that market, the most densely populated in Europe: www.acm.nl/en/publications/publication/9155/The-business-case-for-sub-loop-unbundling-in-the-Netherlands/
17. Case IT/2015/1778: Wholesale local access provided at a fixed location in Italy.
18. www.btplc.com/news/articles/showarticle.cfm?ArticleID=c3cbfdcd-832a-40e4-a31f-04dfd5f84d09
19. It was symptomatic of this period that when a number of NRAs sought to include cable products within the defined wholesale market, the Commission was generally able to disagree with that analysis without feeling obliged to veto it because it did not have any effect on the outcome in terms of the regulatory remedies applied. Thus, telecommunications' firms continued to be designated with SMP, and incipient attempts to regulate cable were justified on other grounds than SMP.
20. See Case DK/2008/0862: Wholesale broadband access in Denmark.
21. Case DK/2012/1340: wholesale broadband access in Denmark.
22. The proposal put forward by DBA (formerly NITA) proposed to extend access obligations on the cable network to also include content. The decision DK/2014/1672 was withdrawn when it became clear that the Commission was about to instigate a Phase II investigation. This was an unusual change in direction by DBA, as Denmark was one of the first countries in Europe to declare that the broadcast market does not meet the minimum criteria for regulation in 2007 Case DK/2007/0618.
23. Case BE/2011/1228: Wholesale broadband access.
24. BE/2011/1229: Retail market for the delivery of broadcasting signals and access to broadcast networks.
25. See, in particular, European Commission (2014, pp. 46-47) which states: "Experience under the Article 7 process has shown that in a growing number of Member States direct or indirect constraints stemming from CATV-based WCA offers do exist, though occurring generally at an infra-national level (given the lack of ubiquity of the CATV networks). Given the upgrade of CATV to DOCSIS 3 which is expected to continue, it may become increasingly appropriate to include CATV bitstream in the relevant product market, especially when sub-national geographic markets have been defined".
26. Case NL/2015/1727.
27. Case NL/2015/1794: Wholesale local access provided at a fixed location in The Netherlands.

28. The key change to move from a current generation PMP to WDM PMP would be to upgrade the splitters in the network. In a spliced deployment, this is difficult and expensive, in a pre-connectorised network it is not.

29. See Analysys Mason, *International case studies: final report for Ofcom,* July 2015. The countries appear to have been chosen for their intrinsic interest, rather than as being to be representative. They are Belgium, France, The Netherlands, New Zealand, Portugal, Singapore and Spain.

30. This small number limits the investments required by access seekers to provide ubiquitous service.

31. Ibid. pp. 20-21, 24-25.

32. ETSI was created by CEPT in 1988 and is officially recognized by the EC and the EFTA secretariat. Based in Sophia Antipolis (France), ETSI is officially responsible for standardization of Information and Communication Technologies (ICT) within Europe.

33. ETSI TS 105 174-4-1.

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