

Next Generation Access Networks: The Post-Investment Conundrum

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Abstract: Next Generation Access (NGA) networks entails significant investments but brings with it promises of a "brand new world" in telecommunications. In this paper, we provide an overview of some of its implications. In particular, we argue that it is not clear whether the "old" vertical integration model, where network operators provide end-to-end services, is likely to be maintained. But we also argue that, irrespective of that, network operators must look with increased interest at their wholesale revenue stream, i.e., at the possibility that, even if vertically integrated, profits can be reaped from providing access to (potentially rival) retail operators. Moreover, content providers will significantly increase their relevance in the future value chain. Therefore, we argue that revenue sharing mechanisms between content, infrastructure and service providers are likely to (re)emerge.

Key words: next generation access networks, revenue sharing.

Telecommunications services, for historical and technological reasons, were for a long period provided by vertically integrated (and often monopoly) operators. The sector's liberalisation in Europe allowed the entry of new service providers, which required wholesale access services from incumbents at an early stage of development of their networks – the 'ladder of investment' principle' (CAVE, 2006). The ultimate goal of the European Regulatory Framework was to promote network competition (ERG, 2004).

The deployment of next generation access networks (NGAs) raises significant new challenges which are only now beginning to be looked at. On the one hand, the main policy objectives remain – the development of competition in service provision – but it is expected that the market cannot sustain more than one or two providers in a given geographical region

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(OECD, 2011), which significantly limits network competition (see also SORIA *et al.*, 2010). Alternative forms of competition, based on wholesale access products to unbundled fibre loops, also appear to be technologically more challenging (ERG, 2007).

Thus, an important question is whether the "old" vertical integration model is likely to be "revived" under NGAs. This is still unclear. The current discussion focuses on whether some form of (vertical) separation should be required to achieve the policy objectives (OECD, 2011). Whilst separation may bring about benefits, it also entails costs and a careful analysis, possibly yielding different results for different countries, should be carried out ahead of its potential implementation (GONÇALVES & NASCIMENTO, 2010; OECD, 2011).

We argue that even for operators which are, at present, vertically integrated, the provision of wholesale access to (potentially rival) retail operators is likely to be seen as an opportunity (generating wholesale revenues) rather than a threat (foregone retail profits). Therefore, irrespective of whether the vertical integration model is kept, the current business model is likely to be challenged, with a greater emphasis placed on the recoupment of investments made in NGAs through the provision of (possibly voluntary) wholesale access to other operators.

In addition, a new and important player is likely to emerge: content providers. Whilst in the past telecommunications services were valuable 'on their own' – being able to telephone or use the internet had substantial value to consumers – and could be provided directly by telecommunications providers, such services are currently more a 'means to an end', insofar as consumers use them in order to access differentiated (or premium) content, often not provided by telecommunications operators.¹

Therefore, firms along the value chain are likely to reposition themselves in order to accommodate this. Again, rather than viewing this as a threat, infrastructure operators which have invested in NGAs may view this as an opportunity to recover the investments made. In particular, we conjecture that revenue sharing mechanisms – which may be more successful at extracting value from differentiated and willing-to-pay subscribers – are likely to emerge between content, infrastructure and service providers, particularly

¹ That being said, there may be a close relationship between the demand for contents and the demand for telecommunications services.

under regulatory frameworks, such as those of the US and Europe, which generally abide by the net neutrality principle.² This business strategy is not novel in the sector: the narrowband (dial-up) business model relied on such revenue sharing mechanisms and, as we know, contributed significantly to the emergence of internet service provision which radically shaped and changed the sector in the last decade.

An important discussion surrounding NGAs and their deployment, which has taken centre stage in the recent literature, is the intricate relationship between regulation (or the threat of regulation) and investment incentives (CAMBINI & JIANG, 2009, provide an excellent overview of this topic for broadband access). In particular, in such contexts there is inherent tension between static and dynamic efficiency: whilst, once an infrastructure is built, (access) regulation which aims at promoting competition contributes positively to welfare (static efficiency), it also contributes towards lower investment incentives (e.g., in maintaining or upgrading the infrastructure), thus, in the long-run, decreasing welfare (dynamic efficiency). For NGA deployment, the literature clearly highlights this tension, showing that 'stricter' access regulation following deployment generally reduces an operator's incentives to invest in the first place.³ Whilst this topic is of crucial importance, our contribution is more related to an *ex post* situation where the investment has already occurred and the applicable regulatory framework has also been clarified.⁴ Therefore, our focus is on potential business strategies, conditional on the existing regulatory framework, which may allow operators to more successfully or quickly recoup the investment made.⁵

² However, with notable exceptions, such as the Netherlands, net neutrality is not protected by law. We thank an anonymous referee for this observation.

³ We define 'stricter' access regulation quite broadly: for instance, the obligation to provide access (versus an alternative where such obligation does not exist); or, if mandatory access is enforced, a decision to regulate access prices (versus an alternative where access providers are free to set access prices); or, if access prices are regulated, a decision to set them in a cost-oriented way - e.g., based on total-element long-run incremental cost (TELRIC) or forward-looking long run average incremental costs (LRAIC). See CAMBINI & JIANG (2009) for a more detailed analysis of access regulation and its impact on investment incentives (both theoretically and empirically). More recently, the work of BOURREAU & DOGAN (2012), BOURREAU *et al.* (2012), BRIGLAUER *et al.* (2012), BRITO *et al.* (2012), CAMBINI & SILVESTRI (2012), INDERST & PEITZ (2012a, 2012b), NITSCHKE & WIETHAUS (2011) and SICILIANI (2010) also highlight this tension.

⁴ This does not necessarily imply that the regulatory framework is 'clear': uncertainty is likely to surround the early stages of service provision through NGAs, and, hence, the particular details of any applicable regulation.

⁵ Nevertheless, it is also true that some of the business strategies we discuss here may critically depend on the regulatory approach adopted (we thank a referee for this observation). Whilst our discussion aims to be more general (and not dependent on the details of the

This paper is structured in the following way: the 2nd section discusses the increased relevance of wholesale revenues under NGAs; the 3rd section discusses other (potential) revenue sources, namely revenue from content providers, and puts forward the possibility of a revenue sharing business strategy; finally, the 4th section concludes.

■ Potential revenues from wholesale services

OFCOM (2006) defines next generation access as "broadband access services that are capable of delivering sustained bandwidths significantly in excess of those currently widely available using existing local access infrastructures or technologies" (p. 10). Whilst no explicit reference is made to the introduction of fibre-based technologies in the access network, these will, undoubtedly, allow a significant increase in bandwidth to final consumers and, thus, "qualify" for the next generation status.^{6 7} At a later date, OFCOM (2011) makes a more explicit reference to fibre by defining 'superfast broadband networks' as those capable of delivering speeds in excess of 24Mbps – the current limit of copper networks.⁸ With the observed evolution of mobile networks (3G and 4G), these could already be considered next generation broadband services as well.⁹ However, in this paper, we focus exclusively on fixed networks, although quite clearly many of the issues we raise here are also potentially relevant for the mobile broadband vertical chain.¹⁰

regulatory framework applicable to NGAs), we have tried (when relevant) to identify when such a dependency exists.

⁶ Notice that in the definition of next generation access networks, it is implicitly assumed that there are no constraints in the core networks which prevent such bandwidths from being obtained.

⁷ Typically, the deployment of fibre in the access network is either through Fibre to the Cabinet (FTTCab) or Fibre to the Home (FTTH) – intermediate variants exist which depend on "how close" to the subscriber the fibre-based access network is. Under a FTTCab architecture, subscribers are connected through their copper loops, but fibre is deployed from the exchange to the street cabinet. By contrast, under a FTTH architecture, the copper loop is fully replaced by fibre.

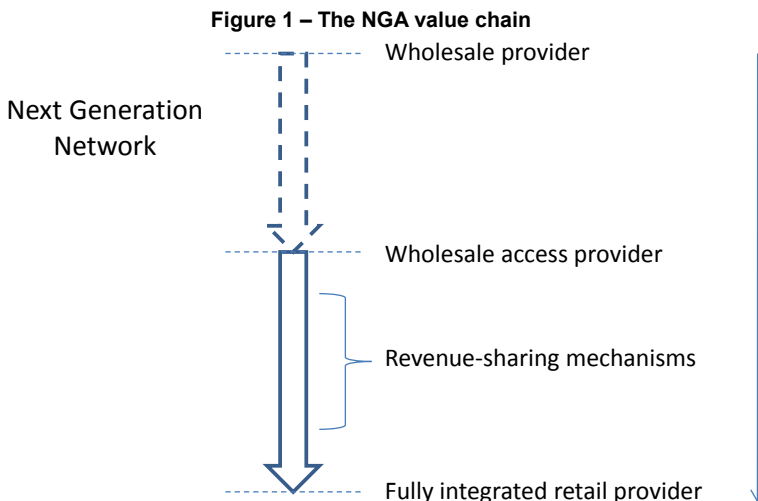
⁸ Using ADSL2+.

⁹ For instance, with the implementation of HSPA+ in 3G UMTS networks, download speeds of up to 42Mbps are possible. With 4G LTE broadband networks, download speeds of up to 300Mbps are expected.

¹⁰ We thank a referee for highlighting the increasing importance and potential competition to NGAs of mobile broadband. In fact, convergence means that mobile and fixed broadband services are, at the same time, complements and substitutes.

The deployment of NGAs is currently evolving in most European countries, although at clearly different speeds and under different roll-out strategies. Although debatable, it is probably not far from the truth to say that NGA deployment is typically country-specific. Now imagine an operator which has made a significant investment in order to deploy a NGA. Such an operator is likely to differ across countries, insofar as (i) it may be the incumbent or an entrant which benefited from the sector's liberalization, (ii) it may be a vertically integrated provider (which owns the network infrastructure and provides retail services) or it may be a network owner providing wholesale access services only (i.e., it does not provide retail services), (iii) it may face significant competition from other infrastructure-based operators (e.g., other NGA operators or cable-based operators), both at the retail and wholesale levels, or (iv) if vertically integrated, it may face retail competition for the provision of various services (television, internet and voice), as well as bundles of services (double play and triple play). Naturally, these possibilities are not exhaustive and merely highlight that country specificities are the rule rather than the exception.

Figure 1 contains a stylized representation of the several possibilities regarding that operator's strategic choice along the vertical value chain. For the sake of simplicity, we concentrate on the two opposite poles of the spectrum: a structurally separated operator of the access network and a vertically integrated operator.



A key issue for an operator which has deployed a NGA is whether providing wholesale access to other operators is an interesting business

strategy. For structurally separated operators, the answer is obviously affirmative: in this case, the operator is essentially a wholesale access provider and, thus, its revenues are entirely dependent on providing wholesale services to other operators. In particular, in the presence of economies of scale, there are strong incentives for expanding capacity utilization. By contrast, for vertically integrated operators, the answer is not as obvious. Typically, in the "old" Public Switched Telephone Networks (PSTN) days, regulation (e.g., wholesale price regulation) had as one of its main rationales the possible adverse effects of vertical integration (typically of incumbent operators) to potentially competitive segments. This is known, in economic theory, as the foreclosure doctrine. Following REY & TIROLE (2007), imagine an upstream monopolist that sells an essential input to downstream (competing) retailers. This is a typical economic bottleneck situation, with clear parallels in the telecommunications sector. Under the foreclosure doctrine, the upstream firm has incentives to distort competition in the downstream segment, e.g., by favouring a retail firm (for instance, its own subsidiary) and thus "forcing" its competitors out of the market. In practice, in doing so, the upstream firm "extends" its market power to the downstream (potentially competitive) segment.

Foreclosure may be complete or incomplete (REY & TIROLE, 2007). An example of complete foreclosure occurs when the upstream firm refuses to supply the input to one (or several) downstream firms, thus preventing them from operating. Alternatively, the "refusal to supply" may be (slightly) more subtle, e.g., through the setting of a (prohibitively) high price. Partial foreclosure, whereby the upstream firm favours some firms in the downstream segment, can be achieved in various ways: through vertical integration, when economies of scope exist, through exclusive vertical arrangements or through price discrimination (REY & TIROLE, 2007). In the telecommunications sector, the often heard of DDD (Deny, Delay, Degrade) strategy of incumbents towards new entrants is a clear foreclosure example. Indeed, recent literature on sabotage and non-price discrimination (ECONOMIDES, 1998; BEARD *et al.*, 2001; KONDAUROVA *et al.*, 2003; SAND, 2004) suggests that a vertically integrated network operator, particularly if regulated, will have incentives to sabotage (e.g., through quality degradation) downstream rivals. ^{11 12}

¹¹ Under access regulation, foreclosing through price discrimination is typically not possible, as operators have the obligation to provide services at the regulated access price levels. In this case, foreclosure is only possible through non-price discrimination, as suggested by BEARD *et al.* (2001).

NGAs appear to bring along a different paradigm. The work of several authors highlights that the vertical integration model of PSTN-based service provision is no longer expected. In particular, it is quite possible that even vertically integrated operators will realise the potential gains (at the wholesale level) from providing access to (possible) retail competitors at competitive price levels. The literature (which we analyse in more detail below) presents three main arguments which support this: (i) with NGAs, service differentiation is the rule rather than the exception and, thus, it is not necessarily true that a new wholesale client (of a vertically integrated operator) is a lost retail client; (ii) the coexistence of 'old' regulated (PSTN) and 'new' – possibly regulated – networks (NGAs) generates an incentive for a vertically integrated operator to 'attract' wholesale clients migrating from the 'old' network; and (iii) economies of scale and scope appear to be more significant under NGAs than under PSTN, which implies that more clients (including wholesale clients) are necessary to achieve minimum costs.

Under PSTN, the (now) classical results for one-way access of LAFFONT & TIROLE (1994, 2000) and ARMSTRONG *et al.* (1996) point towards social welfare being maximized under regulated access prices and foreclosure is identified as the main competition risk. The assumed baseline scenario is one in which services are homogenous. Optimal access prices are shown to include two elements: the direct cost and the opportunity cost of providing access, that is, the access provider's lost profits associated with the provision of access.¹³ The latter critically depends (among other things) on whether there is product/service differentiation. Indeed, both LAFFONT & TIROLE (1994) and ARMSTRONG *et al.* (1996) show that product differentiation reduces the opportunity cost of access, because (roughly speaking) an additional wholesale client does not necessarily imply a lost retail client for a vertically integrated operator; therefore, product differentiation implies lower (socially optimal) access prices. By contrast,

¹² The view that foreclosure constitutes a serious and significant threat to competition is not, however, consensual: "[d]uring the 1970's and 1980's, vertical merger enforcement policy fell dormant in the wake of Chicago School arguments that vertical integration was most likely procompetitive or competitively neutral" (RIORDAN, 1998, p. 1232). The underlying rationale is that only one retail market exists, and therefore only one "monopoly profit" can be reaped. A vertically integrated firm would thus capture this monopoly profit by exerting market power in the upstream segment, e.g., by charging a monopoly price for the essential input it sells (to all downstream firms). In other words, a fully integrated firm could not have higher profits than those obtained by the upstream monopolist, provided there is competition in the downstream retail segment. This, however, has now been shown not to be a general result (see in particular ORDOVER *et al.*, 1990).

¹³ This is shown to be a relatively more complex formulation of the Efficient Component Pricing Rule (ECP). See also VOGELSANG (2003).

most of the literature under NGAs assumes that services are differentiated, as consumers have heterogeneous preferences.¹⁴ Under this assumption, "[...] in differentiated product markets, the incentive to foreclose competitors is limited" (INDERST & PEITZ, 2012b, p. 408). Although the particular details of service differentiation (horizontal and/or vertical) differ across this literature, the main conclusion that can be drawn is that, for a vertically integrated NGA operator, an additional wholesale client is not necessarily a lost retail client and, as such, its incentives to foreclose retail rivals are (arguably) lower than under PSTN.

It is quite likely that, for a period of time, the 'old' (regulated) fixed network (PSTN) will coexist with new networks (NGA), and the latter may also be subject to regulation. The work of several authors generally shows that this coexistence may constitute an incentive for a NGA to provide access to other (rival) retail operators, thus reducing the risk of foreclosure.

BRITO *et al.* (2012) focus on the incentives of a vertically integrated (incumbent) operator to invest in the deployment of a NGA (which improves the quality of retail services) and to give access to its retail competitors. Importantly, the old (PSTN) network and the new (NGA) are assumed to coexist and access to the former is regulated, but access to the latter is not.¹⁵ The incumbent faces two opposite incentives in its decision to grant access to the NGA. On the one hand, granting access allows the downstream retail operator to capture a share of its profits, because it can now sell a higher quality retail service – a negative (retail) effect. On the other hand, granting access leads to higher wholesale profits, because the NGA will allow the provision of a higher quality service (compared to the old PSTN) and thus attract a higher wholesale price – a positive wholesale effect. If the old network's (regulated) access price is low and provided the NGA leads to a non-drastring increase in quality¹⁶, the incumbent prefers to grant access to the NGA: in this case, the NGA allows for a 'diversion' of wholesale clients from the old to the new network, thus increasing wholesale profits – and this wholesale effect is shown to outweigh the retail effect.¹⁷

¹⁴ See for instance INDERST & PEITZ, 2012b; KOTAKORPI, 2006; BRITO *et al.*, 2012

¹⁵ The European Commission has already expressed its view that access to NGAs should also be regulated (European Commission, 2010).

¹⁶ A non-drastring improvement in quality is defined by the authors as a situation where the downstream entrant, using the old network, can compete with the incumbent using the new network.

¹⁷ FOROS (2004) reaches a similar conclusion. In a setup where a vertically integrated incumbent also competes with a downstream retailer, unless access prices are regulated, the

This is further magnified if access prices to the old network decrease – which serves to show that the coexistence of these two networks and particularly the access price to the old network may increase or decrease the incumbent's incentives to give access to the new network (and the price at which it does so).¹⁸

BOURREAU *et al.* (2012) also assume the coexistence between an 'old' and a 'new' technology, but allow both the (vertically integrated) incumbent and the (unintegrated) entrant to invest in the new technology. Unlike BRITO *et al.* (2012), they look at two different scenarios: one in which only access to the old technology is regulated (as in BRITO *et al.*, 2012) and another one in which access to the new technology is mandated if only one firm decides to invest in it. In the second scenario, access prices in the old and new networks are positively related and the access price in the new network is 'capped' by that of the old network, so that the entrant finds it appealing to switch to the new technology at the wholesale level.¹⁹

CAMBINI & SILVESTRI (2012), similarly to BRITO *et al.* (2012), also look at an incumbent (vertically integrated) operator's incentives to invest in a NGA, which allows for the provision of higher quality services, but consider its (positive) impact on demand to be uncertain – in particular, if the NGA fails to expand demand, the old (PSTN) network is still available. Additionally, they analyse the influence of the access regime for the NGA (full and partial regulation, as well as risk sharing) on such investment incentives. The 'fall back' possibility on the old network's access services implies that, unlike FOROS (2004), the incumbent does not always have incentives to foreclose even when it has a higher ability to offer value-added services (through the NGA) than the non-integrated retail firm.²⁰

incumbent will foreclose the rival in the retail market by choosing too high an access price. However, this does not occur when the rival retailer has a higher ability to make use of the increased quality of service that a better network allows, i.e., if it has the ability to add more value to the consumer than the incumbent. SPIEGEL & YEHEZKEL (2003) also reach the same type of conclusion in a similar context.

¹⁸ BRIGLAUER *et al.* (2012) provide some empirical evidence which supports another of BRITO *et al.*'s (2012) results: stricter broadband access regulation (lower access prices) appears to have a negative impact on NGA deployment, i.e., on the incumbent's investment incentives.

¹⁹ INDERST & PEITZ (2012a, 2012b) are two additional and relevant discussions of investment incentives when both the old and new networks coexist.

²⁰ From a welfare perspective, risk sharing (an agreement between the operators to share the investment cost, with no further side payments among them) emerges as the preferable (from a welfare viewpoint) regulatory tool when the non-integrated retail firm is better at offering value-added services.

Finally, NGAs entail a different cost structure (compared to PSTN) which necessarily changes the economic rationale, from a cost efficiency viewpoint, of providing wholesale access. HOERNIG *et al.* (2012) point out that NGA costs have a very significant fixed element, which necessarily implies that the average cost per customer strongly depends on the total number of customers.²¹ SORIA & HERNÁNDEZ-GIL (2008), by analysing a cost model, found that (i) both NGAs based on cable as well as on fibre exhibit strong economies of scale and (ii) NGAs based on cable achieve minimum cost with lower penetrations.²² SICILIANI (2010), comparing current (DSL) and next generation (fibre) access, points towards an increased importance of local economies of scale because of network topology at the sub-loop level. This is confirmed by WALCZYK & GRAVEY (2012), who report a capital expenditure for a GPON-based NGA which (depending on population density) is two to three times higher than for current generation DSL. Therefore, from a cost efficiency point of view, providing wholesale access would certainly contribute towards lower average unit costs and, hence, towards a higher profit margin.

In conclusion, it is not at all obvious that a NGA that positions itself as a vertically integrated provider (one of the extreme business strategies mentioned earlier) will behave in a different way from another one which positions itself as a mere wholesale access provider: both will have to view (potentially rival) downstream retail operators as sources of additional (wholesale) revenue and as potential means of market expansion, as we now explore in more detail.

■ Potential revenues from content and service providers

It is likely that technology and consumer demand for media and entertainment services will lead the industry into a new direction where infrastructure may or may not be separated from the services available to final consumers, but where the cost of investment and maintenance of the infrastructure is divided between consumers, content and service providers. In this section, we argue that the revenue distribution is also likely to change,

²¹ The very significant fixed cost element is also present in current generation DSL networks (GONÇALVES, 2007).

²² Cable networks are HFC with DOCSIS 3.0 and fibre networks are FTTH or FTTCab based on GPON or VDSL2.

and, in particular, more explicit forms of 'sharing' revenues (such as revenue sharing agreements) between the elements in the supply chain may be exploited.

CROCIANI (2011) succinctly describes the vertical chain: consumers have access to content and applications through an internet Service Provider (ISP), and the latter typically makes use of existing access network operators (through wholesale access) to reach consumers ²³; at the internet core, ISPs rely on peering agreements to ensure consumers a wide access to content and applications, even if such content and applications is not 'hosted' in the consumer's ISP (in essence, this is typically referred to as 'internet connectivity'); therefore, content and application providers (CAPs), in order to have a global reach, typically only need a few ISPs as 'hosts'. As an early sign that costs are likely to be shared throughout the value chain, CROCIANI (2011) notes that large CAPs have set up their own distribution networks, i.e., in order to minimize the problems associated with congestion at the internet core, they have made their content or applications available through their own host servers (or through third parties' servers) located closer to consumers' ISPs. ²⁴

The increased role of content providers

In sharp contrast with the PSTN vertical chain, it becomes clear that, under NGAs, a new player will gain increased importance: content and application providers. For instance, media and entertainment services (e.g., TV) will play a significant role in the new industry structure. Subscribers are willing to pay for content that best serves their interests and in catering for such differentiated subscribers, an intricate relationship between content, infrastructure and service providers is likely to emerge. With differentiated subscribers who have a willingness-to-pay for premium content, service providers will need to have access to valuable (premium) content in order to compete with rivals; in turn, content providers will want to analyse how their

²³ It is possible that many ISPs also rely on existing network operators for what CROCIANI (2011) defines as 'backhaul' and which, in figure 1, we refer to as Next Generation Network (providing core – rather than access – services).

²⁴ The iPhone business model example also puts the value chain into perspective, illustrating that there might be revenues and profits to be shared between various industry players: content providers, service and infrastructure operators. The iPhone allows the end user to benefit from a wide variety of services for which it typically has to pay CAPs (e.g., by purchasing applications or services compatible with the iPhone) in addition to the mobile subscription.

content is "distributed" along the supply chain, e.g., exclusively or non-exclusively, as well as through conventional access networks or through NGAs.

For instance, GANUZA & VIECENS (2013) analyse possible market outcomes when NGAs are structurally separated from retail service provision.²⁵ In this context, retail service operators need two inputs: content and network access. The key question addressed in the paper is whether the NGA benefits from downstream retail competition in the presence of vertical differentiation, i.e., when only one retailer has access to premium content. It is shown that if vertical differentiation is not too high (i.e., if the premium content is not too "exclusive" or valuable), then the NGA can increase its profits through retail competition (by lowering its wholesale access prices) and the latter benefits consumers. Interestingly, access price regulation would be redundant in this scenario, as the NGA's (wholesale) pricing incentives are aligned with retail competition and consumer surplus.²⁶ HAGIU & LEE (2011) observe that many sectors have this type of characteristics, whereby consumers must access a platform or network in order to "consume" a variety of services: e.g., IPTV or cable television or online music stores. They conclude that provided the content producer does not relinquish pricing control, it prefers to make high quality content available to several networks.²⁷

The net neutrality issue

A critical issue when looking at potential new forms or sources of revenue along this vertical chain relates to net neutrality and (particularly in the US) the intense debate on its desirability.²⁸ Broadly speaking, net neutrality is a principle whereby all data packets circulating in a network are treated

²⁵ They argue that this is not an implausible assumption, either because NGAs were financed by public funds or because access regulation is unlikely to disappear.

²⁶ If premium content providers can reach consumers directly (i.e., by purchasing access from a NGA and bypassing retailers), it is expected that non-exclusivity of content provision will occur, i.e., content providers prefer to sell their premium content to other retailers rather than to market it exclusively. WEEDS (2009) also reaches this type of conclusion: at the retail level, if one operator possesses some exclusive or premium content, it will typically prefer to make it available to its competitor and charge a (wholesale) fee, i.e., non-exclusivity is preferred.

²⁷ Exclusivity, whilst generating greater rents from the chosen network prevents that content from reaching the rest of the market – in that context, the volume effect outweighs the price effect and the content producer prefers non-exclusivity.

²⁸ For an overview of the discussion, see SCHUETT (2010) or FAULHABER (2011).

equally (SCHUETT, 2010). Among others, its main implications are that (i) network operators cannot charge the originator (e.g., the content provider) a (possibly differentiated among originators) fee for data transmission and (ii) network operators cannot engage in (and possibly charge for) 'unreasonable' data traffic management practices which prioritize traffic or favour certain types of traffic over others.²⁹

How may net neutrality affect a NGA (vertically integrated or not)? Firstly, rather obviously, if a NGA were allowed to charge CAPs for content delivery to its customers (thus, violating net neutrality), this would be an additional revenue source. As LEE & WU (2009) and SCHUETT (2010) note, such a charge would, in effect, constitute a termination fee. For historical reasons, the internet has evolved in the absence of such termination fees and LEE & WU (2009) (amongst others) argue that the vertical chain has two-sided markets' properties which may justify its absence.³⁰ The internet is a set of interconnected networks mediating the interaction between CAPs and users. The value of this interaction depends on the quantity (and quality) of content and users: CAPs whose revenues depend on the number of users (e.g., because of advertising) benefit from an increased number of users and users benefit from increased, more varied and higher quality content. This externality between these two (different) groups of economic agents is a common characteristic of a two-sided market. Therefore, whilst charging CAPs for content delivery could constitute a revenue source, this would inevitably affect the price structure (the fraction of the total price charged by the intermediary to each side of the market), possibly with a negative 'net' effect on revenue. In fact, as LEE & WU (2009) observe, no ISP has actually tried to levy termination fees for content delivery.³¹

Secondly, by not being able to prioritize certain types of traffic, net neutrality is, in effect, a no-discrimination rule which forces ISPs (quality-wise) to offer a single type of product to CAPs (SCHUETT, 2010).³² Whilst abandoning this no-discrimination rule would be a violation of net neutrality, LEE & WU (2009) note that providing a 'fast lane' (for a price) to content providers could be well accepted provided all content could still travel for

²⁹ In the U.S., the FCC has imposed a limited form of net neutrality; in Europe, the 'open internet' principle is enshrined in the revised EU telecommunications framework.

³⁰ See RYSMAN (2009) for an excellent overview of two-sided markets.

³¹ This is one possible explanation, but LEE & WU (2009) also note that the threat of regulation may also explain ISPs behaviour.

³² CROCIONI (2011) observes that ISPs already manage traffic to a certain extent, e.g., by limiting or blocking consumers' use of traffic intensive applications, such as peer-to-peer.

free if CAPs chose not to pay the fast lane price for content delivery. Again, and more generally, departures from the no-discrimination rule could allow NGAs to obtain additional revenues, although (as we mention above) changes in the price structure could (because of the two-sided market nature of the vertical chain) have a negative net effect on revenues.

Revenue sharing under net neutrality

Back in the early internet days, (narrowband) dial-up access was provided by a multitude of internet service providers (ISPs), all of which required access to telephone networks in order to provide the service. Naturally, some ISPs were vertically integrated with network operators. Although some issues arose related to the market foreclosure potential, by and large retail competition was observed. As discussed earlier, it was the migration to broadband access that revived the foreclosure doctrine, and thus fostered and supported the introduction of wholesale access regulation to prevent distortions of competition. CRANDALL & SINGER (2007) argue that the dial-up access model cannot be replicated in this new context, because independent broadband ISPs do not add value to the service. They further argue that although different in nature, competition in the broadband era, without many independent ISPs, is nevertheless sufficient to spur growth.

It is worthwhile remembering the dial-up internet business model. We highlight the UK case because of its pioneering role in the regulatory approach of internet services. Oftel (1999a, 1999b) created a formula, in 1996, which determined how operators shared revenue for calls using specific numbers, which gave rise to local, national and premium call charges, or to no retail charges (free calls).³³ The services benefiting from the formula were designated as Number Translation Services (NTS): a user who placed a call would not know that the number he dialled was "translated" to a geographic number, which could be near or far away from the user's geographic location. More importantly, the user knew that the (per minute) price of the call did not depend on the distance. Whilst initially designed for innovative services such as radio/TV phone-ins and generally other call centre activity, the greatest beneficiary was (by far) dial-up internet

³³ In particular, 0800 or 0500 numbers were free, 0345, 0645 or 0845 numbers were charged at the local rate and 0870, 0990 or 0541 numbers were charged at the national rate.

traffic, as ISPs made use of these non-geographic numbers to allow users to dial in to the internet.

Without going into details, the formula "allocated" a portion of the call revenue to the ISP, namely the retail price of the call (e.g., the local rate) minus a wholesale call origination charge paid to BT (the incumbent). In particular, this wholesale call origination charge was "generous", insofar as it more than covered the underlying costs. Depending on the time the call was made, BT kept between 32 and 59% of the call revenue (Ofitel, 1999a). Whilst BT argued that the effective price it received from NTS services was lower than that obtained from geographic numbers and demanded a higher share of the revenue, Ofitel (1999a) considered that price to be more than fair, as it was well above cost and because most traffic was carried in off-peak periods (when network usage is low). In doing so, it also acknowledged the contribution given by ISPs towards the value of internet services. In addition, Ofitel (1999b) made clear that originating operators other than BT (the incumbent) were free to negotiate with ISPs how they shared (retail) call revenue.

This leads us to put forward the idea of a new positioning of NGAs along the value chain. In addition to making wholesale access available to downstream service operators (which may compete with the NGA, if it is vertically integrated), we wonder whether a revenue sharing mechanism, such as that adopted for dial-up internet services, may be an interesting business model.

The supply chain management literature has a significant body of literature looking at revenue sharing agreements as possible mechanisms to achieve efficiency and coordination along the supply chain. In the absence of centralized control – where a unique decision maker possesses all the relevant information on the supply chain and has the contractual power to enforce its decisions –, the interaction of different decision makers with different objectives along the supply chain may lead to coordination problems and inefficiency unless proper mechanisms – such as revenue sharing agreements – are adopted to "align" their interests with those of the supply chain as a whole (CACHON & LARIVIERE, 2005; GIANNOCCARO & PONTRANDOLFO, 2004). Therefore, GIANNOCCARO & PONTRANDOLFO (2009) note that such agreements should be both *effective* – fostering coordination along the supply chain – and *desirable* – ensuring that all partners along the supply chain increase their profits.

The value consumers can extract from the network depends on the services it supports. As mentioned above, the service and infrastructure provider, if vertically integrated, is supplying services to two different customers: on the one hand, the content provider, which is willing to sell the content to the final consumer at a high margin in order to maximise its profits, and, on the other hand, the final customer, who wants high quality service and might be willing to pay a premium for the access service. Furthermore, insofar as NGAs allow bilateral communication, the ability of the infrastructure to facilitate the link between content provider and final consumer is directly associated with the price charged, the level of the service and the stake of the infrastructure and service provider in the industry value chain. Given that wholesale access is likely to be regulated, by positioning itself as a wholesale access provider, the operator is subject to regulatory risk and downward pressure on its wholesale prices. On the other hand, if it vertically integrates, in addition to this regulatory risk, there is the possibility of competition problems and investigations by the competition authority. A revenue sharing mechanism significantly reduces these two risks. Firstly, by tying its revenue to the retail prices charged by downstream operators, the NGA will not accept any revenue sharing scheme that does not offer adequate compensation for investments made. Secondly, some regulatory pressure is alleviated, as revenues depend on the (competitive) retail prices. Finally, by providing a viable alternative to the vertical integration model, the NGA significantly reduces the risk of potential competition problems in the downstream market.

Looking into the future, from a strategic point of view, it is thus quite likely that the different firms in the value chain are willing to discuss a revenue sharing mechanism that allows an efficient use of the infrastructure and offers an adequate return on investment. As we have seen above, several authors show that, under normal conditions, the content provider is not interested in exclusive contracts with the access provider, given that this restricts its potential market and the lack of competition might jeopardise the quality of service delivered to final consumers. On the other hand, the access provider is willing to maximize the traffic in the network so as to benefit from economies of scale and increase its wholesale revenues. Therefore, even if it is vertically integrated, it should be keen to open the network to retailers and other firms – such as content and billing aggregators – in order to maximize the return on investment.

The incentives to open the network are a necessary but not sufficient condition for the appearance of a revenue sharing scheme. That comes into play on a second round, as premium content and service providers may

want to capture premium customers which can only be reached provided minimum technical infrastructure standards are met. In fact this might be in the interest of both consumers and content providers. The access network plays an interface role, because the "distribution channel" is central to the variety and quality of the services demanded and supplied.

Even subject to the net neutrality principle, the idea of differentiating consumers in the access market according to a price linked to quality or capacity is not new. In fact, this is the current standard of the industry, as there are customers who pay different prices to access the infrastructure. The novelty here is the way through which this price differentiation may come about – through a revenue sharing mechanism – as the content and other service providers might be interested in relinquishing part of their revenue to the access network operator in order to ensure standards of quality in the service. Note, in particular, that this may well constitute the strategy through which operators and content providers circumvent potentially adverse effects of net neutrality in service provision. In a way, this would be similar to LEE & WU's (2009) suggestion that it is possible to introduce forms of second-degree price discrimination that do not collide head on with the net neutrality principle.³⁴

Therefore, such revenue sharing mechanisms may be better suited to reflect the relationships along the future value chain, where content providers play a new and important role, but where both infrastructure and service providers are also essential in order to provide valuable services to willing-to-pay customers.

■ Conclusion

There is a fear that the deployment of NGAs will 'revive' the vertically integrated service provision model that existed prior to the sector's liberalisation, and particularly that such a model will hinder the development of competition. Therefore, the policy discussion is currently focused on finding solutions that might prevent such an outcome from materialising (e.g., vertical separation regulatory solutions).

³⁴ We thank an anonymous referee for suggesting this analogy.

We argue that NGAs present a novel paradigm and, thus, a more significant sector shift than previously considered: given the significant investments made in its deployment, NGA providers, even if vertically integrated, are likely to look at (rival) retail providers as sources of (wholesale) revenue instead of causes of foregone retail revenue. In addition, under NGAs, content providers gain a more prominent role. Telecommunications services are no longer 'an end in themselves', but rather a 'means to an end', as consumers increasingly view them as the 'access platform' to valuable differentiated content.

These two factors trigger a new perspective on the telecommunications section, one which may foster the (re)emergence of revenue sharing mechanisms, whereby content and service providers might be interested in sharing revenues with the access operator. This allows for a new pricing mechanism to (re)emerge in the industry, driven by the strong upward trend in demand for media and entertainment services. Though this topic certainly deserves further investigation, there appear to be some indications that the adequate contracts under NGAs should envisage some type of revenue sharing mechanisms between access, content and service providers.

At the moment, NGAs have already been deployed in a significant number of countries. The overall regulatory approach is, as CAMBINI & JIANG (2009) observe, clearly different: in the U.S. we observe a deregulatory approach; in East Asia we observe an interventionist approach and the EU approach lies somewhere in between. Therefore, a detailed review of what is happening in different countries is clearly necessary.³⁵ In particular, such a review should look carefully at the business strategies of NGA operators and their implications for the vertical chain, both from a theoretical and empirical perspective.

A particular issue which certainly also warrants further research is whether broadband mobile services also present these challenges. Indeed, technological convergence and the observed evolution of broadband mobile services suggest that both competition and cooperation with NGAs is to be expected. To this extent, it may raise similar issues, particularly in the way revenues are (or will be) shared along the vertical chain. This is a topic we wish to pursue in further research.

³⁵ We thank a referee for this suggestion.

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