Exclusive Contents and Next Generation Networks*

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July 2011

Abstract

This paper analyzes the interaction between the market of contents and the development of the next generation network (NGN) industry. We assume structural separation between the network and service operators (platforms) and the comparative advantage of the service operators depends on the access to premium contents. On one side, we analyze how the structure of the market of contents (the scope of exclusivity contracts) may affect deployment and competition in an NGN setting. On the other side, we endogenize the structure of the market of contents given the presence of NGNs, where a content provider can sell their contents directly to consumers, by-passing telecom operators (disintermediation). In this context, we show that exclusivity only occurs when the content is not highly valued by consumers. Finally, the implication of our analysis for the evolution of the telecommunications industry is discussed.

Keywords: Content exclusivity, next generation networks (NGNs), telecom industry.
JEL Classification: L1, L2, L8.

*We thank J.P. Eggers, Doh-Shin Jeon, Bruno Jullien, Gerard Llobet, Diego Moreno, Andras Niedermayer, Martin Peitz, and participants at FEDEA seminar, the 9^o Seminar on Telecoms Regulation (Universitat de Barcelona/CMT), the Conference on Platform Markets: Regulation and Competition Policy (ZEW, Mannheim), the XXV edition of the Jornadas de Economía Industrial, the Conference "ICT & Economic Growth" (LMU, Munich), the M-MIAOW Seminar, the CNColoquios, the 9th Annual International Industrial Organization Conference (Boston) and the 2nd Workshop on the Economics of ICTs (Évora). We are also grateful to Microsoft for the award as an outstanding paper on Firm Strategy in ICT Markets at the Conference "ICT & Economic Growth" and to Karla Perca for excellent research assistantship. The usual disclaimers apply.

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1 Introduction

There is an upcoming revolution in the telecom industry. After 100 years of a stable technological framework based on copper networks, we are in front of a drastic innovation in the industry to grant consumers with the advantages of the optical fiber. The deployment of fiber based Next Generation Networks (NGNs) will increase drastically the speed of broadband services (up to more than 100 Mbps). The NGNs will multiply the demand and possibilities of existing Internet services and applications (P2P, Online Games, and so on), and will allow for new services as HD Television on demand, and public applications to e-Education and e-Health. From an economic policy point of view, the deployment of the NGNs may have an important impact over the whole economy: it may foster the digital content industry, it may increase productivity due to the efficiency gains in the production processes, it may improve public services, and so forth.[1] Consequently, the deployment of NGNs is at the center of the public debate on telecommunications and it is expected that the investment in NGNs will be huge in the next decade around the world.[2]

Besides, and crucially, the structure of the telecom industry may change drastically. The shadow of the old incumbent national monopolies may disappear. The NGN is based on IP (Internet Protocol) world and it does not require a centralized network, so that, small independent networks may be efficient.[3] Moreover, some countries have taken the opportunity of the deployment of the NGN to change the regulatory framework towards structural separation (the firm that operates the network cannot provide final services to consumers).[4] Finally, the most important investment efforts have been done by (or with the help of) governments and public administrations that promote neutral operators of the networks.[5]

[1]Many papers and reports document the positive effect of telecommunication infrastructure on competitiveness (MICUS (2008) for the EU and Reynolds (2009) for the OECD), and economic growth (Holt & Jamison (2009) and Koutroumpis (2009)).

[2]See for example, the dimension of the NGNs in the national broadband plans, http://en.wikipedia.org/wiki/National_broadband_plans_from_around_the_world.

[3]In fact, we are observing how many local public authorities or regional development agencies have decided to build their own infrastructure in order to boost the delivery of new services to their inhabitants. See "Asturcom" in Asturias, Spain, "Xarxa Oberta Project" in Catalonia, Spain and "Pau Broadband Country" in France, to mention a few of several cases. See also Jullien et al. (2010) that consider investment in a next generation access network by local authorities. They focus on the interplay between the national regulator, an incumbent and the local authority.

[4]Many of the operating NGNs and the existing plans follow this structural separation pattern (the NBN project in Australia, the Next Gen NBN in Singapore, the Asturcom network in Spain, etc.)

[5]See for instance the NBN projects in Australia, New Zealand and Singapore for plans that consider the deploy-

In a nutshell, NGNs are likely to change the structure of the industry, the availability of consumer's services and the role of telecom operators. We need to understand how market competition is going to be in this new telecom world. This paper is one of the first attempts to do so. We will take as given a market framework based on structural separation and focus on the impact that the exclusivity of media contents can have over the competitive behavior of telecom operators. The distribution and the level of welfare that the NGNs may generate are linked with the market of contents since the added value of the new technology (especially from the private perspective) mainly relies on the consumption of audiovisual contents.

In this respect, this is the first paper studying specifically the interaction between the development of the NGN industry and the market of contents. Firstly, we analyze how the structure of the market of contents (the scope of exclusivity contracts) affects deployment and competition in an NGN setting. Then, we endogenize the structure of the market of contents given the presence of NGNs. In particular, we study the likelihood of exclusive contracts between providers of contents and service operators in NGNs. We also analyze who in the production chain (network operators, service operators and providers of contents) is going to get the largest share of the created value. This is an important question, since the distribution of the rents within the value chain affects the incentives of the agents to promote and invest in NGNs.

We propose a model where the owner of the network does not operate in the downstream market and gives access to two operators. These two operators are competing platforms that, on one side, compete for consumers that singlehome (join one operator) and on the other side have access to contents. This accessibility determines competition on consumers' side. In particular, the platforms will be vertically differentiated as long as only one of them has access to a premium content. In the first part of the paper we take the exclusivity of the premium content as given, but we parametrize the scope of this exclusivity. We show that the less concentrated is the market of contents, the larger are the network profits and the consumer welfare.

In the second part of the paper we introduce the content provider as a strategic player. He takes two decisions: whether or not to provide in exclusivity (by singlehoming) its premium content to an operator, and second, whether or not to charge a positive price to consumers for its premium content. This second model is motivated by the fact that NGNs will allow content

ment of a public NGN with national coverage.

providers to reach consumers directly with their contents (via streaming, for example).[6] It means that NGNs generate a new valuable outside option for content providers and the possibility of disintermediation.[7] Under this possibility we show that, in contrast with the previous literature on the market of premium contents, non-exclusivity is the expected outcome when the premium content is highly valued by consumers. The complete characterization of the equilibrium involves exclusivity when the differentiation due to premium content is low. This result is driven by the complex pricing interaction between the network (access fee), operators (service price) and content provider (operator payment for exclusivity and content price).

Important industry implications are derived from our results. We show that the presence of the NGNs (and the capacity of content providers to reach directly the potential consumers) will result in a rent reallocation among different agents in the value chain. In particular, we show that there will be a transfer of rents from the network and service operators to the content providers. The current policy debate is focused on the lack of investment effort by traditional telecom operators in NGNs and the potential need for public intervention. In fact, as we said before, the public sector is nowadays the most active investor in NGNs. Our results may help to explain this lack of incentives of traditional telecom operators to invest in NGNs, and therefore, this paper provides arguments to the voices that advocate that without public intervention there will be a delay in the deployment of NGNs.[8] The results are also undoubtedly linked to the debate about the net neutrality. Traditional telecom operators are becoming aware about the reallocation of rents towards content providers and try to find ways to reverse this trend.[9]

The paper is organized as follows. In the rest of this section we offer a review of the related literature. In Section 2 we present and solve the baseline model that takes exclusivity as given. In

[6]See *Ultraviolet*, www.uvvu.com, a platform recently created by the major Hollywood movie studios (Paramount Pictures, Sony Pictures Entertainment, Twentieth Century Fox, Universal Pictures, and Warner Bros among others) to give consumers great choice and freedom to purchase, manage, and watch digital movies, TV shows, and other entertainment by streaming. Some other premium rights owners are also responding with new strategies including the launch of their own web TV services, as NFL, NBA (see Analysis Mason (2010)).

[7]See the announcement in www.free-football.tv: *"Do you want to avoid costly set up fees or monthly subscription costs? ...If the expense of your cable service has got you down, you'll love how affordable it is to catch football games through our service!. In a matter of minutes, you can sign up for an account right here at www.free-football.tv and use our secure encrypted payment processors to purchase your membership"*.

[8]On the top of that, there are other factors that may lead to a telecom company to consider the investment in NGNs as an expensive and risky choice. It reduces drastically the value of its current assets and business model (ADSL, fixed telephony, etc.), the return is uncertain and the regulatory framework has not been established in most of the countries.

[9]See also Huigen and Cave (2008) for a discussion about how market power is "gravitating" to content and threatening the current business model of telecom operators.

Section 3, we introduce the strategic content provider within the model, and we analyze whether or not the exclusivity of the premium content arises in equilibrium. Section 4 contains a brief discussion of the implications and concludes. All the proofs are exposed in the Appendix.

1.1 Related literature

The seminal paper that studies the media market and the role of premium contents is Armstrong (1999). The main prediction of that paper and the subsequent branch of literature is that exclusive provision of premium contents is the likely outcome.[10] We show that in the forthcoming NGN setting, if the content is of very good quality, the provider decides to sell it directly to the consumers and with no exclusivity.[11] In fact, this result confirms (and qualifies) the prediction made by Armstrong (1999): *"if a per-subscriber charge could be levied (which might only be possible with new technology), then exclusivity would no longer be optimal for the seller".*

This paper also contributes to the literature that analyzes how online industry is threatening traditional industries. For instance, Athey et al. (2010) focus on the ability of the online content to make it easier for consumers to switch between outlets. They characterize the impact of greater consumer switching on firms profits. Seamans and Zhu (2010) empirically analyze the effect on incumbent local newspaper market of the entry of a website providing classified ads services. In this article, we consider the fact that NGNs generate for content providers the possibility of disintermediation, and this means that, they may by-pass the telecom operators to reach consumers. We analyze the impact of this element on the incentives of content providers to sign exclusivity contracts and on the telecom industry profits.

Our paper is also related to the literature on next generation networks and since it is an issue that has begun to arouse interest in recent years, there are only a few specific papers on this. Brito

[10]This is not only a theoretical result. In fact, there are many concerns in the policy arena about the supply of premium contents and contracts of exclusivity. For instance, in March 2001, in UK, Ofcom began an investigation into the pay TV market after receiving a submission from BT, Setanta, Top Up TV and Virgin Media. They complained about Sky's dominance of the pay-TV industry, where it has an estimated 85% share of the market due to near-monopolies on key sport coverage. In March 2010, Ofcom published a wholesale must-offer remedy for Sky Sports (http://consumers.ofcom.org.uk/2010/03/delivering-consumer-benefits-in-pay-tv/) and in August 2010 Ofcom asked the Competition Commission to investigate concerns regarding the sale and distribution of subscription premium Pay TV movies (http://media.ofcom.org.uk/2010/08/04/ofcom-refers-pay-tv-movies-to-competition-commission/).

[11]Hagiu and Lee (2009) is the first paper to analyze the impact of the allocation of control rights over content pricing between content providers and platforms on whether content is exclusive to one platform or not. In a similar vein, but in a different setting, they show that non-exclusivity may arise as an equilibrium outcome.

et al. (2008, 2009, 2010), Nitsche and Wiethaus (2010) and Goetz (2009) model the NGN industry as a duopoly, where a vertically integrated incumbent competes with a downstream entrant that requires access to the incumbent's network. Brito et al. (2009) analyze the performance of two-part access tariffs in promoting investment in next generation networks. In particular, they focus on the interplay between access prices and infrastructure investment and study if two-part access tariffs solve the dynamic consistency problem of the regulation of NGNs. [12] Another paper by the same authors, Brito et al. (2008), studies the incentives of an incumbent to invest and give access to an NGN. They assume that access to the old network is regulated, but access to the NGN is not. Nitsche and Wiethaus (2010) compare the effect on investment and consumer welfare of different regimes of access regulation to NGNs. Goetz (2009) examines the effect of regulation on both penetration and coverage of broadband access to the Internet. Brito et al. (2010) investigate if separation of a vertically integrated firm reduces non-price discrimination and increases welfare, where the wholesaler can degrade the quality of input it supplies to either of the retailers. They find that the welfare effects of separation are ambiguous. All of these papers model the industry as a duopoly, where a vertically integrated incumbent competes with a downstream entrant that requires access to the incumbent's network. The traditional copper and cable networks have followed a structure of vertical integration between network and customer services. Because of this, as far as we know, all existing models in telecommunications literature are set up in a market with vertically integrated firms, or with a vertically integrated incumbent and an entrant that asks for access to the incumbent's network. In contrast, our model considers a firm that will operate a network but is not going to compete in the service market. This is a relevant analysis given that with new deployments of fiber, this industry structure is emerging around the world and we assist in the birth of many separated networks that give open access to service operators.

To the best of our knowledge there are two papers that model, as we do, a vertical structure where retailers are vertically differentiated, Bolton and Bonanno (1988) and Spiegel and Yehezkel (2003). Bolton and Bonanno (1988) compare outcomes of a complete vertically integrated struc-

[12]The tension between promoting competition and promoting investment has been largely analyzed in the telecommunications economics literature (see Cambini and Jiang (2009) for a literature review). This literature is being retested today, in need of new deployments and the preoccupation of governments to prevent a resurgence of monopoly networks. Cave and Hatta (2009) identifies current government policy towards NGNs and de Bijl and Peitz (2008) discuss the challenges for telecommunications regulation from a European perspective.

ture with a non integrated one. They analyze how optimal is the linear price contract and other kinds of vertical restraints. In a similar setting, Spiegel and Yehezkel (2003) show that when markets cannot be vertically segmented and the cost difference between the retailers is not too large the manufacturer will foreclose the low quality retailer.

Papers in telecommunications assuming vertical differentiation, but also vertical integration, are Kotakorpi (2006) and Foros (2003). Kotakorpi (2006) considers a model with a vertically integrated monopolist network provider who gives access to a fringe of rival operators in the retail sector. She examines the network operator's incentives for infrastructure investment and assumes that the final products of the incumbent and the fringe are vertically differentiated. Foros (2003) examines the interaction between a facility-based vertically integrated firm and an independent competitor in the retail market for broadband Internet connectivity. The vertically integrated firm undertakes an investment (broadband upgrades) that increases the quality of the input and the retailers may differ in their ability to offer value-added services.

Although they analyze a very different setting, our baseline model (with no strategic content provider) is very close to the one proposed by Casadesus et al. (2010). They study how competition between microprocessors affects the profits of a firm producing operating systems. The basic difference between our model and theirs is the timing that we use. While they assume that the three firms set prices simultaneously, we assume that the network sets the access price first, and then operators set prices to consumers in a second stage, something that seems more appealing for our setting.

2 Model

There is a continuum of uniformly distributed consumers indexed by $\theta \sim U\left[0,1\right]$. They decide about subscribing to the service to one of two operators (platforms), A and B, that provide services and contents through a network. We assume that both of them offer a basic service and that operator A has a set of premium contents in exclusivity. We assume that a customer of type θ values the basic service at $\lambda\theta$ and the set of premium contents at $\left(1-\lambda\right)\theta$ where $0<\lambda<1$. So that, the product of operator A is valued at θ and the product of operator B is valued at $\lambda\theta$. Let p_A and p_B be the prices set by the operators, the indifferent consumer between subscribing to A

and B, is given by

$$\theta^{AB} = \frac{p_A - p_B}{(1-\lambda)}$$

and the indifferent consumer between subscribing to B and not subscribing to any of them, is given by

$$\theta^{B0} = \frac{p_B}{\lambda}.$$

LEMMA 1 *Given p_A and p_B demand for operator A is given by $D_A = 1 - \theta^{AB}$ assuming the interval is positive; else, demand is zero. Demand for operator B is given by $D_B = \theta^{AB} - \theta^{B0}$ assuming $\theta^{AB} > \theta^{B0}$; else, demand is zero.*

To provide the service, operators need access to a network infrastructure that sets them an access fee per subscriber a. The network charges the fee in a non-discriminatory way. Consequently, the profits of the operators are given by

$$\pi_i = (p_i - a) D_i \quad i: \ A, B.$$

We assume that marginal cost of the network is zero, but there exists a fixed cost F to deploy the infrastructure. We assume that F is distributed according to $F \sim G(F)$. Penetration (demand) for the network is the sum of the demands for both operators. The profits (gross of F) of the network are

$$\Pi = a(D_A + D_B)$$

and we assume that the probability of deployment is measured by $G(\Pi)$.

The timing of the game is the following: in the first stage the network decides about deployment and sets a. In a second stage, operators compete in prices and consumers take subscription decisions. We solve the model by backward induction. Then, we start by characterizing the operators price equilibrium for a given price of the network's access fee.

2.1 Price services equilibrium

We look for the Nash equilibrium of the operators game taking a as given. We follow the same approach as Casadesus et al. (2010), and we consider that operator B is 'active' if the operator earns positive profits or is on the margin of earning positive profits. Being on the margin of earning profits arises when operator B is just pushed down to charging marginal cost (here a) and the lowest-value customer in the market is just indifferent between operators A and B. More formally, $p_B = a$ and $D_B = 0$, but $dD_B/dp_A > 0$, so that if operator A raises its price, operator B would have positive demand. In contrast, when operator B is not active, at $p_B = a$ all customers in the market strictly prefer operator A to B and thus, the operator market is a monopoly. In what follows we will say that the operators market is a competitive regime if operator B has a positive demand and we will say that it is a limit pricing regime whenever operator B is on the margin of earning profits. Finally, we will consider that this market is a monopoly regime as long as operator B is not active.

We find that the level of a determines the regime that prevails in the operators' market. As the following figure shows, if $a < \frac{\lambda}{2}$ there is a competitive regime, if $\frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda}$ there is a limit pricing regime and if $a > \frac{\lambda}{2-\lambda}$ there is a monopoly regime.

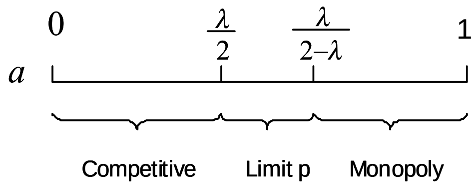

Figure 1

In the following lemma we present the prices that operators set in equilibrium, for a given access fee a.

Lemma 2 *Equilibrium prices are the following*

$$p_A(a) = \begin{cases} \frac{(3a+2(1-\lambda))}{4-\lambda} & a < \frac{\lambda}{2} \\ \frac{a}{\lambda} & \frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda} \\ \frac{1}{2}(1+a) & a > \frac{\lambda}{2-\lambda} \end{cases},$$

$$p_B(a) = \begin{cases} \frac{(a(2+\lambda)+\lambda(1-\lambda))}{4-\lambda} & a < \frac{\lambda}{2} \\ a & \frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda} \end{cases}.$$

The next figure illustrates the prices and the regimes (taken $\lambda = 0.7$).

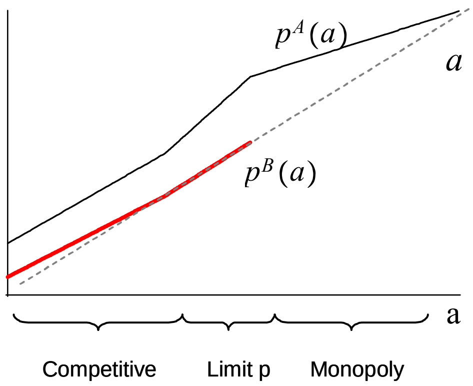

Figure 2

The access fee is the marginal cost of the firms. The equilibrium prices show us that an increase of the marginal cost leads to a larger comparative advantage of firm A. Taking λ as given, a low marginal cost allows for the presence of both operators. However, when the access fee is high, operator B is not able to compete in the market. The intuition behind this is that when a increases, the number of consumers with a willingness to pay greater than the cost of providing the service decreases. This demand reduction leads to a more homogenous set of consumers, limiting the possibilities of differentiation. Hence, the environment becomes more competitive which is bad news for B because it has an inferior service.

It is obvious that the profits of firm B decrease in the access price. However, the fact that the larger a is the larger the comparative advantage of firm A (and its market share) does not imply that the profits of firm A may increase in the access price. In particular, its profits given by

$$\pi_A(a) = \begin{cases} (1-\lambda)\frac{(2-a)^2}{(4-\lambda)^2} & a < \frac{\lambda}{2} \\ a(1-\lambda)\frac{\lambda-a}{\lambda^2} & \frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda} \\ \frac{1}{4}(1-a)^2 & a > \frac{\lambda}{2-\lambda} \end{cases}$$

are continuous and decreasing in a.

It is also evident that the prevalence of each regime is conditioned by λ. The next figure depicts the operator A's profits and shows how the ranges, under which each regime prevails, move when λ changes. The solid line shows us the profits of firm A when $\lambda = 0.45$ and the dashed line does when $\lambda = 0.7$.

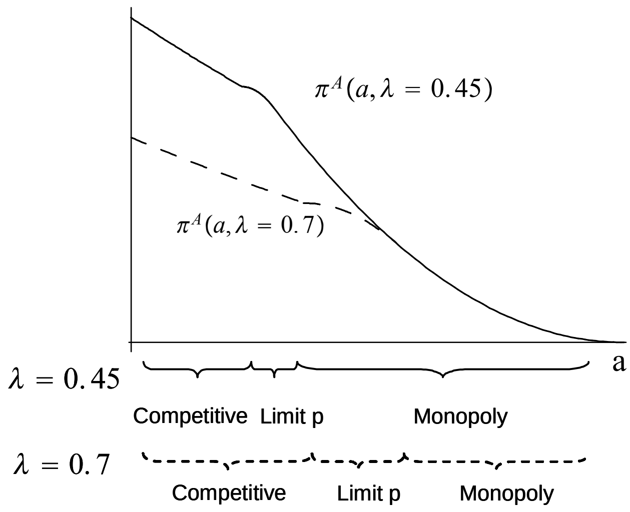

Figure 3

It is easy to see that both cut-off points, $\frac{\lambda}{2}$ and $\frac{\lambda}{2-\lambda}$, are increasing in λ. Moreover, the range under which a limit pricing regime occurs becomes wider as λ increases. If λ is high, such that $a < \frac{\lambda}{2}$, it is profitable for operator A to accept the presence of operator B, instead of pushing it out by lowering p_A. Consequently, the higher is λ, the higher is the probability of operator B of having a positive demand. As expected, a higher λ reduces also the probability of a monopoly regime to arise. If differentiation is low, it will be hard for operator A to charge the monopoly price without inducing entry by operator B.

2.2 The network problem (SPNE)

In the first stage the network decides about investment and optimally chooses the access fee to be charged to the operators. From the previous analysis we deduce that the level of competition in the retail market is decreasing in a as a higher a makes condition $\lambda > 2a$ less likely to hold and relaxes condition $\frac{2a}{1+a}$. Moreover, setting a creates a double marginalization problem which may be alleviated by impulsing competition between operators. Consequently, the network faces a trade-off: it may set a low fee to induce competition and large penetration or a high fee that will lead to a monopoly market. The following results show us that the network sets a fee such that the demand of operator B is zero for any λ. However, the operator B plays a role in equilibrium. If λ is high enough, the network will leave operator B active and taking advantage over its competitive pressure. The next lemma states the equilibrium access fee.

Lemma 3 *The network sets the following access fee*

$$a = \begin{cases} \frac{1}{2} & \lambda < \frac{1}{2} \\ \frac{1}{2}\lambda & \lambda \geq \frac{1}{2} \end{cases} . \quad (1)$$

If vertical differentiation between operators driven by contents is rather low (i.e.; $\lambda > \frac{1}{2}$), it is profitable for the network to boost penetration and to encourage competition (at least in the margin) by setting a low fee $\frac{1}{2}\lambda$. When operator B is active on the margin, it exerts a competitive pressure so that the operator A's margin ($p_A - a = \frac{1}{2}(1-\lambda)$) is lower than the margin when the comparative advantage of operator A due to contents is larger and operator B is not active ($p_A - a = \frac{1}{4}$). Thus, as expected, the double marginalization is decreasing in λ.[13]

2.3 Policy implications

Consider λ as a measure of the scope of exclusivity in the market of contents, so that a higher λ implies a less concentrated market. We may think that operator A has all the contents and operator B only a subset of these contents. Thus, a larger λ expands the subset of contents of operator B, and shrinks the set (value) of contents that operator A has in exclusivity.

Now we present the main result of this section that follows from observing the gross profits of the network, which are given by

$$\Pi = \begin{cases} \frac{1}{8} & \lambda < \frac{1}{2} \\ \frac{1}{4}\lambda & \lambda \geq \frac{1}{2} \end{cases} . \quad (2)$$

Proposition 1 *The probability of deployment (network profit) is weakly increasing in λ.*

This proposition shows that there is a strong relationship between the incentives to deploy the network and the structure of the market of contents. By simple computation it can also be shown that penetration, consumer surplus and total welfare are higher when operator B is active on the margin.

[13] A publicly owned network (something that is widely observed nowadays) may include in its objective function other elements in addition to the profits of the network (i.e., consumer surplus). In Appendix B, we solve the network problem when it maximizes jointly profits and consumer surplus. In this case, we show that this network would set a lower fee a but also that the structure of this fee looks like the one in our problem where the network only takes profits into account. The publicly owned network also sets a higher fee and induces a monopoly regime if λ is low enough.

Proposition 2 *Penetration, consumer surplus and total welfare are weakly increasing in λ.*

Last results stem from two effects: on the one hand an increase in λ mitigates double marginalization, as explained above. On the other hand, a higher λ implies that operator B offers a better product and that consumers have access to a larger subset of premium contents.

There can be different ways to relate a higher λ with lower concentration of the market of contents. In the current specification of the model a higher λ implies that the availability of contents increases as the operator B acquires some premium contents of operator A. This is, for example, the effect of a wholesale must-offer remedy imposed on the "strong" operator.[14] Alternatively, we can consider that a higher λ implies a redistribution of the contents, and that the ones acquired by operator B are lost by operator A. This way of reducing concentration is consistent with a regulatory remedy that forces content providers to sell their contents in exclusive packages of rights, splitting the contents among a number of different operators.[15] In Appendix C, we show that our results are also consistent with a model where a higher λ implies a redistribution of the contents.

Regarding the operators' surplus, we know from Lemma 2 and Lemma 3 that, independently of λ, operator B will not have a positive demand. In contrast, operator A does better if $\lambda \, \epsilon \left[\frac{1}{2}, \frac{3}{4}\right]$ than when $\lambda < \frac{1}{2}$ as the equilibrium profits expression shows

$$\pi_A = \begin{cases} \frac{1}{16} & \lambda < \frac{1}{2} \\ \frac{1}{4}(1-\lambda) & \lambda \geq \frac{1}{2} \end{cases} . \tag{3}$$

Proposition 3 *The operator A may be better off with an increase in λ.*

Thus, reducing the market concentration of contents may be profitable even for the operator that owns the exclusivity. The reason is that, as $\lambda < \frac{1}{2}$ the network sets a very high access fee which hurts operator's profits. However, as λ exceeds this threshold, the network changes its access price in a way that is beneficial to operator A.

[14]This kind of measure has been adopted by OFCOM in UK. For more details see footnote 10 in this paper.

[15]For instance, the broadcasting rights of the UEFA Champion's League are split into packages and sold separately to operators. Similarly, due to an intervention by the Office or Fair Trading, in the 2000 Premier League auctions the broadcasting rights were split into a package of pay-per-view rights and a package of non pay-per-view. No pay TV operator was allowed to win the auctions for both packages (Harbord and Szymanski, 2011).

3 Strategic content provider

In the baseline model we have implicitly assumed that operator A either owns the premium contents or has paid a fixed price for them. In this section, we extend the previous model by considering that the difference in the sets of premium contents between operators A and B is controlled by a content provider. In particular, operators can offer a basic service which is valued by consumer θ at $\lambda\theta$ and the content provider holds a premium content which is valued at $(1-\lambda)\theta$ by consumer θ. Notice that this model is equivalent to the previous one, in which one operator controls the premium content and a consumer θ values the bundle of basic service plus premium content at $\lambda\theta + (1-\lambda)\theta = \theta$.

As we explain in the Introduction, we argue that NGNs open the possibility for content providers to sell directly to consumers the premium contents. For example, using streaming, blockbuster movies can be offered to the network consumers at the same time as official opening. We will analyze what are the consequences of this possibility. We will assume that the provider can sell the content directly to consumers and we will see under what conditions the provider wants to engage in an exclusive contract with some operator.

The rest of the model is identical to the baseline model but there exists a stage, previous to the stated ones, where the owner of the premium content makes a take-it-or-leave-it offer to one operator, the operator A by default, or to both operators. This offer specifies a fixed fee paid by the operator for providing the premium content and the price c that subscribers have to pay for it. We are assuming that the content provider has all the bargaining power, and therefore he sets the fixed fee equal to $\pi_A - \pi_B$ which allows him to extract the additional surplus that the content confers to operator A under exclusivity.[16] Notice that with non-exclusivity the fixed fee is equal to zero and the content provider obtains all the revenues through c. This is the case because, as we explain below, with no exclusivity Bertrand competition takes place and, consequently, operators have no positive profits ($\pi_A - \pi_B = 0$).

The timing is as follows: first, the content provider decides about exclusivity and accordingly sets c and the fixed payment. Then, the network chooses the access fee a, and finally operators

[16] We think that this is a sensible assumption since content providers are selling to pre-existing networks in different markets and they can commit to international pricing policies.

compete in prices. We solve the model by backward induction.

We start analyzing the market outcome as long as there is no content exclusivity. Then, we determine the equilibria under exclusivity with operator A. Finally, we compare both solutions and we characterize the optimal strategy regarding exclusivity of the content provider.

3.1 The market outcome under non-exclusivity

Assume that the provider decides to offer its content in an "open" and non exclusive way to consumers. They will have to subscribe to some platform if they want to buy the premium content, but they are indifferent about which of them, e.g., the Hollywood creators design a web page and sell directly to consumers that have access to Internet.[17]

In this setting the operators are not differentiated and both offer the same basic service, Bertrand competition takes place in the operators market, and thus prices are given by $p_A^{NE} = p_B^{NE} = a^{NE}$. Consumers may subscribe to the basic service and some of them may also buy the content. It determines a premium demand D_{cp}^{NE}, and a basic demand D_{basic}^{NE}. The penetration of the network is given by $D_{penetration}^{NE} = D_{cp}^{NE} + D_{basic}^{NE}$.

Consumers of the premium content are those such that $\theta \geq a^{NE} + c^{NE}$, whereas consumers in the interval $\frac{a^{NE}}{\lambda} < \theta < a^{NE} + c^{NE}$ will only subscribe to the basic service. As $c^{NE}\frac{\lambda}{1-\lambda} < a^{NE}$ holds (the price of the content is sufficiently low and quality sufficiently high compared to the network fee), last set of consumers disappears and all the consumers that subscribe to the basic service also buy the premium content. Therefore,

$$D_{penetration}^{NE} = \begin{cases} 1 - \frac{a^{NE}}{\lambda} & a^{NE} < c^{NE}\frac{\lambda}{1-\lambda} \\ 1 - \left(a^{NE} + c^{NE}\right) & a^{NE} > c^{NE}\frac{\lambda}{1-\lambda} \end{cases}.$$

If a is low, penetration will be high and consumers with lower θ will not buy the premium content. In contrast, as long as a is high, penetration will be rather low and all the subscribers will also buy the content.

Lemma 4 *With no exclusivity the strategy of the network is the following*

$$a^{NE} = \begin{cases} \frac{1}{2}\left(1 - c^{NE}\right) & c^{NE} < 1 - \sqrt{\lambda} \\ \frac{1}{2}\lambda & c^{NE} > 1 - \sqrt{\lambda} \end{cases}.$$

[17] As members of *Ultraviolet (www.uvvu.com)* are going to do.

The network fee is non-increasing in c, as the following figure shows.

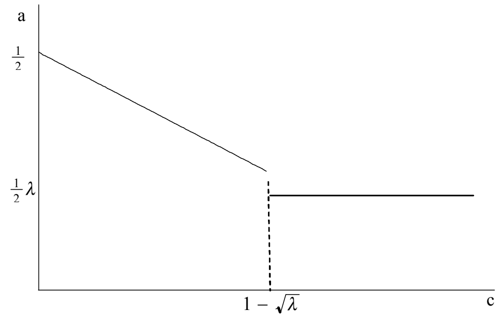

Figure 4

Notice that a and c are strategic substitutes, something which might be expected, given that the network and the content are complements. If c is rather low, the network sets a high fee which is strictly decreasing in c ($c < 1 - \sqrt{\lambda} \Rightarrow \frac{1}{2}(1-c) > \frac{1}{2}\lambda$). In such case, all subscribers buy the content and consequently c affects the marginal consumer of the basic service, the network penetration and the fee a. In contrast, if c is high, subscribers in the margin of penetration are only affected by a (since they do not buy the content). Thus, in this case, the optimal network fee should not depend locally on c.

Given the network reaction function, the content provider will set its fee depending on the value of λ. The provider will set a c such that all subscribers buy the content or will set a high c that leads some subscribers to only consume the basic service.

LEMMA 5 *With no exclusivity the strategy of the content provider is the following*

$$c^{NE} = \begin{cases} \frac{1}{2} & \lambda < \hat{\lambda} \\ 1 - \sqrt{\lambda} & \lambda > \hat{\lambda} \end{cases},$$

and it yields profits

$$\pi_{cp}^{NE} = \begin{cases} \frac{1}{8} & \lambda < \hat{\lambda} \\ \left(1 - \sqrt{\lambda}\right)\left(1 - \frac{(1-\sqrt{\lambda})}{(1-\lambda)}\right) & \lambda > \hat{\lambda} \end{cases},$$

where $\hat{\lambda}$ *is implicitly defined by* $\left(1 - \sqrt{\hat{\lambda}}\right)\left(1 - \frac{\left(1-\sqrt{\hat{\lambda}}\right)}{(1-\hat{\lambda})}\right) = \frac{1}{8} \Rightarrow \hat{\lambda} \simeq 0.03.$

As $\lambda < \hat{\lambda}$ the content is of a very high quality, and all the subscribers buy it. In contrast, as $\lambda > \hat{\lambda}$ there will be a group of subscribers that will not pay for the content. Notice that the price is not monotonic in the quality of the premium content. The price when $\lambda < \hat{\lambda}$ is lower than when $\lambda \in [\hat{\lambda}, \frac{1}{4}]$. This is because, in the first case, the content provider internalizes the effect of his price over penetration, while in the second case, the content provider sets a very high price which forces the network to focus on the basic service market, setting a low fee and obtaining the profits through a wider penetration.

3.2 Equilibria with exclusivity

Previous sections considered two situations: on the one hand, the baseline model is equivalent to assume that the provider charges $c = 0$ and a fixed payment to operator A for the content exclusivity. On the other hand, in Subsection 3.1, we have analyzed the case where the provider charges directly to consumers the variable price c for the content with no exclusivity. The interest of this section is to determine if there is any equilibrium under which the content provider sets $c \geq 0$ and prefers exclusivity (by a fixed payment) with operator A.[18]

We make an overview of the equilibrium analysis of subgame (the second and the third stages of the game) and we refer interested readers in the details to the technical Appendix. Under exclusivity with operator A, the outcome of the pricing game is very similar to pricing equilibrium described in Figure 1 and Lemma 2: given λ and c, the network access fee a determines the structure of the market in the following way.

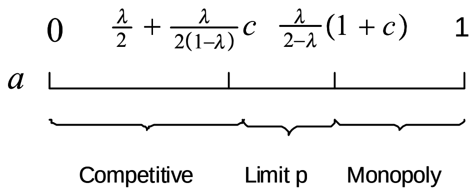

Figure 5

We want just to highlight that c reduces the comparative advantage of operator A and consequently expands the competitive regime to a larger set of parameters.

Regarding the network decision, taking as given the price of the premium content and λ, the network deals with the same trade-off between penetration and high margin that is present in the baseline model. The following lemma characterizes the network strategies:

[18]We are assuming that the price of the premium content must be weakly positive. We disregard negative prices, and this is an assumption, since theoretically there may be equilibria with high fixed payments and negative prices. We do not think that negative prices are realistic, for example, for competition policy considerations.

Lemma 6 *There are functions,* $c_1(\lambda)$ *and* $c_2(\lambda)$*, and* $c_3(\lambda)$ *decreasing in* λ*, and there exists* $\bar{\lambda}$ *where* $c_1(\bar{\lambda}) = c_2(\bar{\lambda}) = c_3(\bar{\lambda})$ *such that:*

i) take $\lambda > \bar{\lambda}$*: if* $c > c_1(\lambda)$ *the network induces a competitive regime, if* $c_2(\lambda) < c < c_1(\lambda)$ *the network induces a limit pricing regime and if* $c < c_2(\lambda)$ *the network induces a monopoly regime.*

ii) take $\lambda < \bar{\lambda}$*: if* $c > c_3(\lambda)$ *the network induces a competitive regime and if* $c < c_3(\lambda)$ *the network induces a monopoly regime.*

The intuition of the lemma becomes clear when we observe the next picture. There we find, for each pair of (λ, c), the strategy that the network will follow.

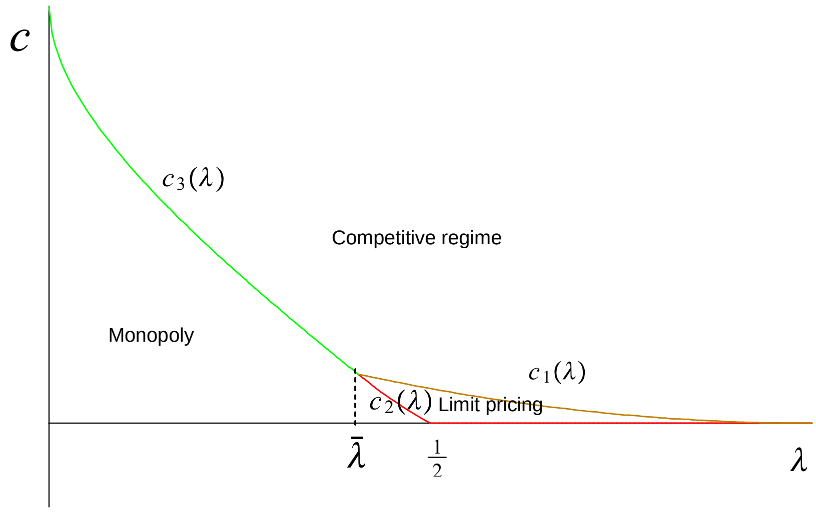

Figure 6

In particular, $c_1(\lambda)$ shows pairs (λ, c) under which the network is indifferent between profits in the competitive regime and profits in the limit pricing regime. For a given λ, a larger (lower) c makes the competitive (limit pricing) regime more attractive for the network given that the comparative advantage of operator A is lower (higher). Similarly, $c_2(\lambda)$ shows pairs (λ, c) under which the network is indifferent between profits in the limit pricing and the monopoly. Lower (larger) c makes the monopoly (limit pricing) regime more profitable for the network because a lower (larger) c leads to a larger (lower) comparative advantage of operator A and the network can extract a larger (lower) fee from the operator. Finally, $c_3(\lambda)$ shows pairs of (λ, c) under which the network is indifferent between profits in the competitive regime and profits in the monopoly regime. Larger (lower) c makes the competitive (monopoly) a better regime to be induced. Hence, these functions define binary orders among the regimes, in the Appendix it is shown how using transitivity we can characterize the optimal regime for every pair (λ, c). Notice that, when $c = 0$ we are in the baseline model where $\lambda = \frac{1}{2}$ is the threshold between the strategies that induce the monopoly and the limit pricing regime.

Finally, we focus on the decision of the content provider that determines the subgame perfect Nash equilibrium.

LEMMA 7 *There exist* $\lambda_1 \epsilon \left(0, \bar{\lambda}\right)$ *and* $\lambda_2 \epsilon \left(\frac{1}{2}, 1\right)$ *such that, as* $\lambda < \lambda_1$ *the content provider chooses a monopoly regime by setting* $c = \frac{1}{3}$ *and as* $\lambda \epsilon \left(\lambda_1, \bar{\lambda}\right)$*, the content provider chooses a competitive regime by setting* $c_3(\lambda)$*. As* $\lambda \epsilon \left(\bar{\lambda}, \lambda_2\right)$ *the provider sets* $c_2(\lambda)$ *and induces a limit pricing regime and as* $\lambda \epsilon (\lambda_2, 1)$ *the provider sets* $\bar{c}(\lambda)$ *(specified in the Appendix), where* $\bar{c}(\lambda) > c_1(\lambda)$ *and induces a competitive regime.*

Many forces and prices are involved behind the results in this lemma. In particular, coexistence of multiple effects creates a non-monotonic strategy by the content provider. Under the competitive and the monopoly regimes a and c are strategic substitutes and consequently when setting $c > 0$ the content provider disciplines the network. Therefore, in general $(\lambda \notin \left(\frac{1}{2}, \lambda_2\right))$ it is not optimal for the content provider to set $c = 0$ and to take all the revenues through the fixed payment. In contrast, under the limit pricing regime a and c are strategic complements and, therefore, it is profitable for the provider to set a low c. For the range $\lambda \epsilon \left(\bar{\lambda}, \frac{1}{2}\right)$, the content provider sets $c_2(\lambda)$, given that a lower c would induce a monopoly regime which is not optimal. There is only a range $(\lambda \in \left(\frac{1}{2}, \lambda_2\right))$ in which the optimal c is equal to 0 and this does not depend on our assumption of positive prices. Although we have considered that $c_2(\lambda)$ is constrained to be higher or equal than 0, $c = 0$ is also the best response of the content provider for all possible prices (including negative ones) in the range. In other words, our constraint was not binding in the optimal response as $\lambda \in \left(\frac{1}{2}, \lambda_2\right)$.

3.3 Exclusivity versus non-exclusivity

We have characterized the optimal strategy of the content provider in cases of exclusivity and non-exclusivity. Next proposition compares both and establishes the condition under which exclusivity is an equilibrium.

Proposition 4 *There exists* $\lambda^{*}\epsilon \left(\lambda_1, \bar{\lambda}\right)$ *such that, as* $\lambda < \lambda^{*}$ *there is no exclusivity, and as* $\lambda > \lambda^{*}$ *the provider signs an exclusive contract with operator A.*

Non-exclusivity allows the content provider to extract better the consumer surplus but it generates a double marginalization problem with the network. Under exclusivity, if $c > 0$, there is an additional marginalization as operators do not set their marginal cost prices. However counterintuitive, this "triple marginalization" may be more profitable than double marginalization for the content provider. The cost of exclusivity is that it makes it harder to extract consumer surplus. Therefore, when the premium content is highly valued by consumers ($\lambda < \lambda^{*}$), and thus it is more important to extract consumer surplus, non-exclusivity dominates. On the contrary, when the consumers' willingness to pay for the premium content is low ($\lambda > \lambda^{*}$), exclusivity is the equilibrium outcome.

4 Discussion and concluding remarks

This paper analyzes the interaction between the market of premium contents and the evolution of the next generation network industry. On one side, we have analyzed the impact of the exclusivity of premium contents over the incentives to deploy NGNs, the performance of the market of telecom operators, and welfare. On the other side, we have endogenized the structure of the market of contents given the presence of NGNs and analyzed what are the incentives of the providers of premium contents to offer exclusivity contracts. In particular, we have contributed in several ways to the new literature on NGNs.

As far as we know, this is the first paper in analyzing an NGNs setting under structural separation between the network and telecom service operators. Although there is regulatory uncertainty over NGNs, since most of the countries have not established yet clear market rules, we consider that structural separation is likely to be a leading regulatory framework. This is because most of the NGN initiatives have been partially or completely financed by public funds. Moreover, NGNs are a natural monopoly for the consumer (it is very unlikely that consumers may have access to several networks) therefore as the services of the NGN become more important for consumer's welfare (affecting, for example, education or health services) the network access regulation should become stricter.

In the baseline model, consistent with the literature of the market of premiums contents, we take exclusivity as given and analyze how the scope of such exclusivity affects the profitability of the network (and the incentives to deploy it) as well as consumer surplus. Our main message is that the lower the concentration in the market of contents, the larger the network profits, the incentives to invest and welfare.[19] Moreover, given the pricing game between the network and the operators, the profits of the operator holding the exclusivity of the premium content is not monotonic with respect to his comparative advantage in contents.

In the second part of the paper we introduce in the model a new player, the strategic content provider. The strategy of a content provider is driven by the fact that the NGN technology allows him to sell the content directly to consumers. The assumption that the content provider will be able to charge consumers directly (thanks to NGNs) changes completely the standard results regarding exclusivity. In the previous literature (see for example Armstrong (1999) and Weeds (2009)) the content provider does not have access to consumers and the best strategy is to make an auction among operators. Given that the monopolist's willingness to pay is larger than the oligopoly's aggregate willingness to pay, the auction leads to exclusivity.. In our framework, when the content provider does not sign any exclusivity contract and he may charge a price to consumers for the content, he is keeping the monopoly power. In fact, we show that non-exclusivity is the expected outcome when the premium content is highly valued by consumers.[20] Consequently, the deployment of NGNs and the wider access to these networks by population will imply that very good contents will not be sold in exclusivity, reducing current concerns about exclusivity of premium contents.[21]

[19] An important underlying assumption is the one related to the timing of the game. We think that it is natural to assume that the network operator sets prices before the service operators get into the game. However, it is likely that service operators were active in other markets and then they may have some capability to have general pricing policies. Consequently, it is important to check the robustness of our main result with respect to the timing and consider a setting where the network operator sets prices simultaneously with service operators. Motivated by the complementarity between operating systems and microprocessors, Casadesus et al. (2010) have solved this game and they reach a similar conclusion to ours.

[20] This result is similar to the one obtained by Hagiu and Lee (2009). This paper analyzes a model of content providers and content distributors, and it shows that propensity for exclusivity can be increasing, decreasing or even non-monotonic in content quality. In our model, with three layers in which exclusivity is determined by the interaction between access fee to the network, operators service prices and the price of the premium content, we obtain a decreasing relationship between exclusivity and the quality of the premium content.

[21] In the present paper, we take the quality of the premium content as given. An interesting line of future research will be to analyze the impact of the NGNs (and the resulting non exclusivity of contents) over the incentives of content providers to invest in quality. Stennek (2007) analyzes this problem in the Armstrong (1999) setting and concludes that exclusivity may lead to higher quality contents. We cannot translate directly this result to our framework since the content provider voluntarily chooses non exclusivity contracts and obtains higher profits with

There is another important implication of our analysis for the industry. As we have pointed out in the Introduction, NGNs imply a revolution for the industry and, as in every revolution there will be winners and losers. Our analysis implies that content providers are clear winners. On the other hand, as the content provider sets a positive price to the consumers ($c > 0$), profits of the network are lower than when this is zero.[22] Moreover, in our open neutral network setting, there are not obvious sources of profits for traditional telecom service operators, unless they find the way to offer a differentiated service. In other words, NGNs are challenging the traditional business model of telecoms.

this strategy.

[22]This statement follows from comparing the expression in (2) when $c = 0$ exogenously, and the profits that the network gets in equilibrium when the content provider is allowed to set $c > 0$.

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Appendix A

Proof of Lemma 2: When operator B is active, reaction functions are the following

$$\begin{aligned} p_A(p_B) &= \frac{1}{2}(a + p_B + (1-\lambda)), \\ p_B(p_A) &= \frac{1}{2}(a + p_A\lambda). \end{aligned} \tag{4}$$

Simultaneously solving reaction functions yields prices $p_A(a) = \frac{(3a+2(1-\lambda))}{4-\lambda}$ and $p_B(a) = \frac{(a(2+\lambda)+\lambda(1-\lambda))}{4-\lambda}$ such that the corresponding levels of penetration are given by $D_A(a) = \frac{(2-a)}{(4-\lambda)}$ and $D_B(a) = \frac{(\lambda-2a)}{\lambda(4-\lambda)}$. It follows that this is an equilibrium, where $D_B > 0$ and operators compete, as long as $a < \frac{\lambda}{2}$.

If $a > \frac{\lambda}{2}$ operator A will be alone in the service market, however setting the monopoly price $p_A(a) = \frac{1}{2}(1+a)$ will be an equilibrium if $a > \frac{\lambda}{2-\lambda}$, otherwise operator B would have room of making positive profits and would enter to the market. For the range $\frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda}$ operator A will set a limit price $p_A(a) = \frac{a}{\lambda}$ such that operator B will decide stay out of the market, although active on the margin, by setting $p_B = a$. ■.

Proof of Lemma 3: The network has to choose a to maximize

$$\Pi(a) = \begin{cases} a\left(\frac{(3\lambda - a(\lambda+2))}{\lambda(4-\lambda)}\right) & a < \frac{\lambda}{2} \\ a\left(1 - \frac{a}{\lambda}\right) & \frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda} \\ a\frac{1}{2}(1-a) & a > \frac{\lambda}{2-\lambda} \end{cases}.$$

If we solve for the first range when $a < \frac{\lambda}{2}$ and competitive regime prevails, we see that the value that maximizes expression $a\left(\frac{1}{\lambda(4-\lambda)}(3\lambda - a(\lambda+2))\right)$ is $a = \frac{3\lambda}{2\lambda+4}$. However, since $\frac{3\lambda}{2\lambda+4} > \frac{\lambda}{2}$ for any λ the network sets $a = \frac{1}{2}\lambda$ which determines $p_A = \frac{1}{2}$ and $p_B = \frac{1}{2}\lambda$. Moreover, it yields

$D_A = \frac{1}{2}$ and $D_B = 0$. For the second range of a, where there is a limit pricing regime, the solution is the same. This strategy generates the following profits for the network

$$\Pi^1(\lambda) = \frac{1}{4}\lambda.$$

The network may also set an access fee $a > \frac{\lambda}{2-\lambda}$ such that in the downstream market there is a monopoly regime. In this case the network chooses a to maximize

$$a\left(\frac{1}{2}(1-a)\right),$$

and then the network sets $a = \frac{1}{2}$, which yields price and demand in the retail market $p_A = \frac{3}{4}$ and $D_A = \frac{1}{4}$. With this strategy the network gets the following profits

$$\Pi^2(\lambda) = \frac{1}{8}.$$

If we compare profits that follow from each strategy we find that

$$\Pi^1(\lambda) \lesseqgtr \Pi^2(\lambda) \text{ as long as } \lambda \lesseqgtr \frac{1}{2},$$

and the statement in the Lemma follows. ■.

Proof of Lemma 4: Assuming non-exclusivity, we say that we are in the first regime if all subscribers buy the content, otherwise, we say that we are in the second regime. The problem of the network is to set a to maximize the following function:

$$\Pi(a) = \begin{cases} a\left(1-\frac{a}{\lambda}\right) & a < c\frac{\lambda}{1-\lambda} \\ a(1-(a+c)) & a > c\frac{\lambda}{1-\lambda} \end{cases}.$$

The expression $a = \frac{1}{2}(1-c)$ maximizes $a(1-(a+c))$, and it is the optimal strategy with profits $\left(\frac{1}{2}(1-c)\right)^2$ as $c < \frac{1-\lambda}{\lambda+1}$. The value $a = \frac{1}{2}\lambda$ maximizes $a\left(1-\frac{a}{\lambda}\right)$, and it is the optimal strategy with profits $\frac{1}{4}\lambda$ as $c > \frac{1-\lambda}{2}$. Otherwise the network should set $a = c\frac{\lambda}{1-\lambda}$ which yields profits $c\lambda\frac{1-c-\lambda}{(1-\lambda)^2}$. Thus, the profits of the network in the first regime (all the consumer buy the content) as a function of c and λ are

$$\Pi^3(\lambda, c) = \begin{cases} \left(\frac{1}{2}(1-c)\right)^2 & c < \frac{1-\lambda}{\lambda+1} \\ c\lambda\frac{1-c-\lambda}{(1-\lambda)^2} & c > \frac{1-\lambda}{\lambda+1} \end{cases},$$

and the profits of the network in the second regime (not all consumers buy the content) are

$$\Pi^4(\lambda, c) = \begin{cases} c\lambda\frac{1-c-\lambda}{(1-\lambda)^2} & c < \frac{1-\lambda}{2} \\ \frac{1}{4}\lambda & c > \frac{1-\lambda}{2} \end{cases}.$$

Thus, the solution of the content provider depends on the comparison between $\Pi^3(\lambda, c)$ and $\Pi^4(\lambda, c)$.

Note that $Max_c\, \Pi^3(\lambda, c) = \frac{1}{2}(1-\lambda)$ and $\Pi^3\left(\lambda, \frac{1}{2}(1-\lambda)\right) = \frac{1}{4}\lambda$ so that profits $\Pi^3(\lambda, c)$ when $c > \frac{1-\lambda}{\lambda+1} > \frac{1-\lambda}{2}$ are dominated by those of the strategy of setting $a = \frac{1}{2}\lambda$. Similarly, note that when $c < \frac{1-\lambda}{2} < \frac{1-\lambda}{\lambda+1}$, profits $\Pi^3\left(\lambda, \frac{1-\lambda}{2}\right) = \frac{1}{16}(\lambda+1)^2 > \Pi^3\left(\lambda, \frac{1}{2}(1-\lambda)\right) = \frac{1}{4}\lambda$. Consequently, the strategy of setting $a = c\frac{\lambda}{1-\lambda}$ is always dominated.

Finally, we compare profits $\Pi^3(\lambda, c)$ and $\Pi^4(\lambda, c)$ when $\frac{1-\lambda}{2} < c < \frac{1-\lambda}{\lambda+1}$, and it is very easy to show that $\Pi^3(\lambda, c) \gtrless \Pi^4(\lambda, c)$ if $c \lesseqgtr 1-\sqrt{\lambda}$. ■.

Proof of Lemma 5: If the content provider sets $c > 1-\sqrt{\lambda}$ there will be a positive set of consumers that will only buy the basic service, and those consumers such that $\theta(1-\lambda) \geq c$ holds, will buy the content. Therefore, the problem of the provider is to set c to maximize

$$\pi_{cp}(c) = \begin{cases} c\frac{1}{2}(1-c) & c < 1-\sqrt{\lambda} \\ c\left(1-\frac{c}{(1-\lambda)}\right) & c > 1-\sqrt{\lambda} \end{cases}.$$

The value $c = \frac{1}{2}$ maximizes $c\frac{1}{2}(1-c)$, yields profits $\frac{1}{8}$ and satisfies the constraint as $\lambda < \frac{1}{4}$. If $\lambda > \frac{1}{4}$, the $c = 1-\sqrt{\lambda}$ would yield profits $\frac{1}{2}\sqrt{\lambda}\left(1-\sqrt{\lambda}\right)$. If the content provider sets a c such that we are in the first regime (all consumers buy the content), it obtains:

$$\pi^1_{cp}(\lambda) = \begin{cases} \frac{1}{8} & \lambda < \frac{1}{4} \\ \frac{1}{2}\sqrt{\lambda}\left(1-\sqrt{\lambda}\right) & \lambda > \frac{1}{4} \end{cases}.$$

Now, consider that the content provider sets a c such that we are in the second regime (not all the consumers buy the content). The function $c\left(1-\frac{c}{(1-\lambda)}\right)$ is concave and it is maximized for $c = \frac{1-\lambda}{2}$. However, $\frac{1-\lambda}{2}$ is always lower than the constraint which implies that the constrained optimal is $c = 1-\sqrt{\lambda}$. Thus, the profits of the second regime as a function of λ are

$$\pi^2_{cp}(\lambda) = \left(1-\sqrt{\lambda}\right)\left(1-\frac{\left(1-\sqrt{\lambda}\right)}{(1-\lambda)}\right).$$

Hence, the solution of the content provider depends on the comparison between $\pi^1_{cp}(\lambda)$ and $\pi^2_{cp}(\lambda)$. It is easy to show that if $\lambda > \frac{1}{4}$ then $\pi^1_{cp}(\lambda) < \pi^2_{cp}(\lambda)$ and the second regime is optimal. If $\lambda < \frac{1}{4}$, then $\pi^1_{cp}(0) - \pi^2_{cp}(0) > 0$, $\pi^1_{cp}\left(\frac{1}{4}\right) - \pi^2_{cp}\left(\frac{1}{4}\right) < 0$ and $\pi^1_{cp}(\lambda) - \pi^2_{cp}(\lambda)$ is decreasing if $\lambda \in [0, \frac{1}{4}]$. Consequently, $\pi^1_{cp}(\lambda) - \pi^2_{cp}(\lambda) = 0$ has only one root if $\lambda \in [0, \frac{1}{4}]$. There is a $\widehat{\lambda}$ such that $\pi^1_{cp}\left(\widehat{\lambda}\right) - \pi^2_{cp}\left(\widehat{\lambda}\right) = 0 \Leftrightarrow \left(1-\sqrt{\widehat{\lambda}}\right)\left(1-\frac{\left(1-\sqrt{\widehat{\lambda}}\right)}{(1-\widehat{\lambda})}\right) = \frac{1}{8} \Rightarrow \widehat{\lambda} = \frac{33}{128} - \frac{7}{128}\sqrt{17}$. ■

Proof of Lemma 6: We start the proof with a Lemma that presents operators prices. Then we can solve the problem of the network.

Lemma 8 *When* $c > 0$, *equilibrium prices are the following*

$$p^A(a,c) = \begin{cases} \frac{(3a+2(1-\lambda)-2c)}{4-\lambda} + \frac{c\lambda}{4-\lambda} & a < \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \\ \frac{a}{\lambda} - c & \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \leq a \leq \frac{\lambda}{2-\lambda}(1+c) \\ \frac{1}{2}(1+a-c) & a > \frac{\lambda}{2-\lambda}(1+c) \end{cases},$$

$$p^B(a,c) = \begin{cases} \frac{(a(2+\lambda)+\lambda(1-\lambda))}{4-\lambda} + \frac{c\lambda}{4-\lambda} & a < \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \\ a & \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \leq a \leq \frac{\lambda}{2-\lambda}(1+c) \end{cases}.$$

Proof: If operator B has a positive demand, equilibrium outcome given a and c is the following

$$p_A = \frac{1}{4-\lambda}(3a + 2(1-\lambda) - 2c) + \frac{c\lambda}{4-\lambda},$$

$$p_B = \frac{(a(2+\lambda) + \lambda(1-\lambda))}{4-\lambda} + \frac{c\lambda}{4-\lambda},$$

and

$$D_A = \frac{(2-a)(1-\lambda) - c(2-\lambda)}{(1-\lambda)(4-\lambda)},$$

$$D_B = \left(\frac{(1-\lambda)(\lambda-2a) + \lambda c}{\lambda(1-\lambda)(4-\lambda)}\right).$$

Then, we use the same procedure that we follow in the proof of Lemma 2 to prove that the ranges of a are given by Figure 5. ■

The problem of the network is to choose, for a given λ and c, the fee, a, that maximizes the function:

$$\Pi(a,c) = \begin{cases} a\left(\frac{3\lambda-(a+c)\lambda-2a}{\lambda(4-\lambda)}\right) & a < \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \\ a\left(1-\frac{a}{\lambda}\right) & \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \leq a \leq \frac{\lambda}{2-\lambda}(1+c) \\ a\frac{1}{2}(1-a-c) & a > \frac{\lambda}{2-\lambda}(1+c) \end{cases}.$$

We have to solve the problem in two steps. Firstly, we have to analyze the network optimization problem for a given (c,λ) under the constraint that we are in a particular regime (competitive regime characterized by the first case ($a < \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c$), the limit pricing regime characterized by the second case ($\frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \leq a \leq \frac{\lambda}{2-\lambda}(1+c)$) and the monopoly regime characterized by the third case ($a > \frac{\lambda}{2-\lambda}(1+c)$)). Then, we will obtain the optimal strategy and profits for every regime. The next step is to analyze what is the optimal regime for a particular combination of (c,λ).

Consider the first constraint, $a < \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c$, the network sets $a = \frac{\lambda(3-c)}{2(\lambda+2)}$ as long as $c > \frac{1}{3}(1-\lambda)^2 = c_1(\lambda)$ which induces a competitive regime with

$$\begin{aligned} D_A &= \frac{1}{2}\frac{8(1-c) - 7\lambda + c\lambda - \lambda^2 + c\lambda^2}{(\lambda-1)(\lambda+2)(\lambda-4)} \\ D_B &= \frac{3c + 2\lambda - \left(1+\lambda^2\right)}{(1-\lambda)(\lambda+2)(4-\lambda)} \end{aligned}$$

and profits

$$\Pi^{cr}(c,\lambda) = \frac{\lambda}{4}\frac{(3-c)^2}{(\lambda+2)(4-\lambda)}.$$

If $c < c_1(\lambda)$, the unconstrained optimal fee is larger than the constraint, and the network sets the constraint (which is optimal given the concavity of the problem)

$$a = \frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \tag{5}$$

which induces a limit pricing regime with

$$D_A = \frac{1}{2}\left(\frac{1-c-\lambda}{1-\lambda}\right)$$

and profits

$$\Pi^{lp}(c,\lambda) = \frac{\lambda}{4}\left(1 - \frac{c^2}{(1-\lambda)^2}\right). \tag{6}$$

Along the second range $\frac{\lambda}{2} + \frac{\lambda}{2(1-\lambda)}c \leq a \leq \frac{\lambda}{2-\lambda}(1+c)$ the network sets (5) and profits are also (6). Notice that the unconstrained optimal will be $\frac{\lambda}{2}$, which jointly with the concavity implies that the optimal solution must be the lowest value of the feasible set. Finally, take the last range $a > \frac{\lambda}{2-\lambda}(1+c)$, the network sets $a = \frac{1}{2}(1-c)$, which yields

$$\begin{aligned} D_A &= \frac{1}{4}(1-c) \\ \Pi^m(c,\lambda) &= \frac{1}{8}(1-c)^2. \end{aligned}$$

This solution is valid only if the constraint is satisfied. Otherwise, if $c > \widehat{c}(\lambda) = \frac{1}{\lambda+2}(2-3\lambda)$ the network sets $a = \frac{1}{2-\lambda}\lambda(1+c)$, and demand is given by

$$D_A = \frac{1-c-\lambda}{2-\lambda},$$

and profits by this restricted monopoly case

$$\Pi^{rm}(c,\lambda) = \lambda(c+1)\frac{(1-c-\lambda)}{(2-\lambda)^2}. \tag{7}$$

Note that $\widehat{c}(\lambda)$ satisfies $\Pi^{m}\left(\widehat{c}(\lambda),\lambda\right)=\Pi^{rm}\left(\widehat{c}(\lambda),\lambda\right)$ and that $\Pi^{cr}\left(c_1(\lambda),\lambda\right)=\Pi^{lp}\left(c_1(\lambda),\lambda\right)$. The following function

$$c_{21}(\lambda)=\left(\sqrt{2}\right)(1-\lambda)^2\frac{\frac{1}{2}\sqrt{2}-\sqrt{\frac{\lambda^3}{(1-\lambda)^2}}}{\lambda^2+1}$$

satisfies, $\Pi^{lp}\left(c_{21}(\lambda),\lambda\right)=\Pi^{m}\left(c_{21}(\lambda),\lambda\right)$.

Since we restrict to $c\geq 0$ it follows that

$$c_2(\lambda)=\begin{cases} c_{21}(\lambda) & \lambda\leq\frac{1}{2} \\ 0 & \lambda>\frac{1}{2}\end{cases}.$$

Similarly, from $\Pi^{m}(c,\lambda)$ and $\Pi^{cr}(c,\lambda)$ we find

$$c_3(\lambda)=\frac{4\lambda+\lambda^2+\sqrt{2}\sqrt{\frac{\lambda}{(\lambda+2)^3(4-\lambda)}}\left(32-2\lambda^3+24\lambda\right)-8}{\left(\lambda-2\sqrt{2}\right)\left(\lambda+2\sqrt{2}\right)},$$

such that $\Pi^{m}\left(c_3(\lambda),\lambda\right)=\Pi^{cr}\left(c_3(\lambda),\lambda\right)$.

First, we show that there exists $\bar{\lambda}\in[0,\frac{1}{2}]$ ($\bar{\lambda}\simeq 0.4$) such that $c_1\left(\bar{\lambda}\right)=c_2\left(\bar{\lambda}\right)$ which follows from the fact that functions $c_1(\lambda)$ and $c_2(\lambda)$ are both decreasing in $\lambda\in\left[0,\frac{1}{2}\right]$, $c_2(0)>c_1(0)$, and $c_2\left(\frac{1}{2}\right)=0<c_1\left(\frac{1}{2}\right)$. It implies, that

$$\Pi^{cr}\left(c_1\left(\bar{\lambda}\right),\bar{\lambda}\right)=\Pi^{lp}\left(c_1\left(\bar{\lambda}\right),\bar{\lambda}\right)=\Pi^{lp}\left(c_2\left(\bar{\lambda}\right),\bar{\lambda}\right)=\Pi^{m}\left(c_2\left(\bar{\lambda}\right),\bar{\lambda}\right). \quad (8)$$

Given that $c_3(\lambda)$ gives us $\Pi^{m}\left(c_3(\lambda),\lambda\right)=\Pi^{cr}\left(c_3(\lambda),\lambda\right)$, then $\Pi^{m}\left(c_3\left(\bar{\lambda}\right),\bar{\lambda}\right)=\Pi^{cr}\left(c_3\left(\bar{\lambda}\right),\bar{\lambda}\right)$, and consequently, at $\bar{\lambda}$, the equality $c_1\left(\bar{\lambda}\right)=c_2\left(\bar{\lambda}\right)=c_3\left(\bar{\lambda}\right)$ is satisfied.

Now, we move to the second step and we analyze the optimal regimes for the network, given a pair (c,λ). Note that, as $\lambda<\bar{\lambda}$, $c_1(\lambda)<c_3(\lambda)<c_2(\lambda)<\widehat{c}(\lambda)$. Given that we know that for a larger c than $c_3(\lambda)$, the competitive regime dominates the monopoly regime, we can ignore $\widehat{c}(\lambda)$, that compares the profits of monopoly with constrained monopoly. This is because both regimes are dominated by the competitive regime for $c>c_3(\lambda)$. Using a similar argument, we can ignore $c_2(\lambda)$ if $\lambda<\bar{\lambda}$, since for $c>c_1(\lambda)$, competitive regime dominate the limit pricing regime, and as we said, for $c>c_3(\lambda)$, the competitive regime dominates the monopoly regime. Finally, for the same token we can ignore $c_1(\lambda)$ if $\lambda<\bar{\lambda}$. Because, for $c<c_2(\lambda)$, the monopoly regime dominates the limit pricing regime, and as we said, for $c<c_3(\lambda)$, competitive regime is dominated by the monopoly regime. Therefore, the only function that we have to consider when $\lambda<\bar{\lambda}$ is $c_3(\lambda)$, which tell us that for low values of c the optimal regime is the monopoly, and for large values of c the optimal regime is the competitive regime.

Consider the range such that $\lambda > \bar{\lambda}$. Along this range it holds that $c_3(\lambda) \leq c_2(\lambda) < c_1(\lambda)$. Hence, we can ignore $c_3(\lambda)$ if $\lambda > \bar{\lambda}$. Firstly, notice that if $c < c_1(\lambda)$ the competitive regime cannot be induced. Thus, if $c > c_1(\lambda)$, the competitive regime dominates the limit pricing regime and the monopoly regime (because for $c > c_2(\lambda)$ and the monopoly regime is dominated by the limit pricing regime). If $c_2(\lambda) < c < c_1(\lambda)$ the limit pricing regime dominates, since for $c_2(\lambda) < c$ limit pricing dominates monopoly. Finally, for $c < c_2(\lambda)$ the monopoly regime dominates for the definition of $c_2(\lambda)$ and the fact, that the competitive regime is not feasible. Finally, we can also ignore $\widehat{c}(\lambda)$ since it is always larger than $c_2(\lambda)$, and for $c > c_2(\lambda)$, the monopoly regime is dominated by the limit pricing regime. Therefore, $c_2(\lambda)$ and $c_1(\lambda)$ are enough to describe the network optimal regime strategies when $\lambda > \bar{\lambda}$. Consequently, the three regions in the Lemma are defined. ■

Proof of Lemma 7: Provider chooses c to maximize the expression

$$cD_A(c) + (p_A(c) - a(c)) D_A(c) - (p_B(c) - a(c)) D_B(c).$$

Consider $\lambda > \bar{\lambda}$. The content provider gets the higher profits that a competitive regime can generate by setting

$$\bar{c}(\lambda) = 9\lambda \frac{1-\lambda}{16 + 21\lambda - \lambda^3}$$

as long as $\bar{c}(\lambda)$ is higher than $c_1(\lambda)$ and it yields profits

$$\pi_{cp}^{cr}(\bar{c}(\lambda)) = \frac{1}{4}(\lambda - 1)\frac{-48\lambda - 9\lambda^2 + 4\lambda^3 - 64}{(\lambda - 4)(-21\lambda + \lambda^3 - 16)}.$$

Otherwise, the content provider may induce the limit pricing regime by setting $c_1(\lambda)$ which yields

$$\pi_{cp}^{lp}(c_1(\lambda)) = \frac{1}{36}(1-\lambda)(\lambda+2)(4-\lambda).$$

In particular, there exists $\bar{\lambda} < \lambda_0 < \frac{1}{2}$ such that $\bar{c}(\lambda_0) = c_1(\lambda_0)$. The content provider can also induce a limit pricing by setting $c_2(\lambda)$ which yields the higher profits that a limit pricing regime can generate:

$$\pi_{cp}^{lp}(c_2(\lambda)) = \begin{cases} \frac{1}{4}(1-\lambda)\frac{2\lambda + 2\sqrt{2}\sqrt{\frac{\lambda^3}{(\lambda-1)^2}} + \lambda^2 - 2\lambda^3 + \lambda^4 - 4\sqrt{2}\lambda\sqrt{\frac{\lambda^3}{(\lambda-1)^2}} + 2\sqrt{2}\lambda^2\sqrt{\frac{\lambda^3}{(\lambda-1)^2}}}{(\lambda^2+1)^2} & \lambda \leq \frac{1}{2} \\ \frac{1}{4}(1-\lambda) & \lambda > \frac{1}{2} \end{cases}.$$

Note that $\pi_{cp}^{lp}(c_2(\lambda)) \geq \pi_{cp}^{lp}(c_1(\lambda))$ along the relevant range $\lambda \epsilon \left(\bar{\lambda}, \lambda_0\right)$ and $\pi_{cp}^{lp}(c_2(\lambda)) > \pi_{cp}^{cr}(\bar{c}(\lambda))$ as $\lambda \epsilon \left(\lambda_0, \frac{1}{2}\right)$. Consequently, as $\lambda \epsilon \left(\bar{\lambda}, \frac{1}{2}\right)$ the provider will set $c_2(\lambda)$.

Now, notice that there exists $\lambda_2 \epsilon \left(\frac{1}{2}, 1\right)$ such that as $\lambda \epsilon \left(\frac{1}{2}, \lambda_2\right)$ then $\pi_{cp}^{lp}(c_2(\lambda)) - \pi_{cp}^{cr}(\bar{c}(\lambda)) > 0$ and as $\lambda \epsilon (\lambda_2, 1)$ then $\pi_{cp}^{lp}(c_2(\lambda)) - \pi_{cp}^{cr}(\bar{c}(\lambda)) < 0$. As $\lambda \epsilon \left(\frac{1}{2}, \lambda_2\right)$ the provider will set $c_2(\lambda) = 0$, and as $\lambda \epsilon (\lambda_2, 1)$ the provider will set $\bar{c}(\lambda)$. Note that $c_2(\lambda) = 0$ arises as the optimal strategy for the range $\lambda \epsilon \left(\frac{1}{2}, \lambda_2\right)$ and it is not a consequence of our assumption of positive prices (i.e., $\pi_{cp}^{lp}(c_{21}(\lambda)) < \pi_{cp}^{lp}(0)$ as $\lambda \epsilon \left(\frac{1}{2}, \lambda_2\right)$).

Finally, as $\lambda < \bar{\lambda}$, the content provider chooses a competitive regime by setting $c_3(\lambda)$ (strategies involving $c \gtrless c_3(\lambda)$ are dominated). This strategy generates

$$\begin{aligned}\pi_{cp}^{cr}(c_3(\lambda)) &= \frac{\lambda(\lambda(\lambda(\lambda(\lambda(\lambda+2)-7)-15)+44)+56)}{\left(2\sqrt{2}-\lambda\right)^2\left(\lambda+2\sqrt{2}\right)^2(\lambda+2)(\lambda-1)} + \\ &\quad \frac{(\lambda(\lambda(\lambda(\lambda(\lambda(3-\lambda)+30)+68)+24)-192)-256)\sqrt{2}\sqrt{\frac{\lambda}{(\lambda+2)^3(4-\lambda)}}}{\left(2\sqrt{2}-\lambda\right)^2\left(\lambda+2\sqrt{2}\right)^2(\lambda+2)(\lambda-1)}.\end{aligned}$$

Alternatively, the provider can set $c < c_3(\lambda)$, which induces a monopoly regime and yields profits $\pi_{cp}^{m}(c(\lambda)) = \frac{1}{16}(3c+1)(1-c)$. This expression is maximized at $c = \frac{1}{3}$ where $\pi_{cp}^{m}\left(\frac{1}{3}\right) = \frac{1}{12}$. Consequently, the provider will set $c = \frac{1}{3}$ as $\pi_{cp}^{cr}(c_3(\lambda)) < \pi_{cp}^{m}\left(\frac{1}{3}\right) = \frac{1}{12}$ provided that $c = \frac{1}{3} < c_3(\lambda)$. In particular, there exists $\lambda_1 \epsilon \left(0, \bar{\lambda}\right)$, $(\lambda_1 \simeq 0.038)$ such that as $\lambda \epsilon (0, \lambda_1)$ then $\pi_{cp}^{cr}(c_3(\lambda)) - \pi_{cp}^{m}\left(\frac{1}{3}\right) < 0$ and as $\lambda \epsilon \left(\lambda_1, \bar{\lambda}\right)$ then $\pi_{cp}^{cr}(c_3(\lambda)) - \pi_{cp}^{m}\left(\frac{1}{3}\right) > 0$. The condition $c = \frac{1}{3} < c_3(\lambda)$ is satisfied is the range where $\lambda \epsilon (0, \lambda_1)$.

Proof of Proposition 4:

Note that the inequality $\pi_{cp}^{cr}(\bar{c}(\lambda)) > \pi_{cp}^{NE}$ is satisfied for any λ, and that the inequality $\pi_{cp}^{lp}(c_2(\lambda)) > \pi_{cp}^{NE}$ is also satisfied for the relevant range $\lambda \epsilon \left(\bar{\lambda}, \lambda_2\right)$.

If $\lambda < \bar{\lambda}$, there is a λ^* such that $\pi_{cp}^{NE}(\lambda^*) - \pi_{cp}^{cr}(c_3(\lambda^*)) = 0 \Rightarrow \lambda^* \simeq 0.36$, $\pi_{cp}^{NE} - \pi_{cp}^{cr}(c_3(\lambda)) > 0$ as $\lambda < \lambda^*$ and $\pi_{cp}^{NE} - \pi_{cp}^{cr}(c_3(\lambda)) < 0$ as $\lambda > \lambda^*$. In particular, λ^* exists because $\pi_{cp}^{NE}(\lambda)$ and $\pi_{cp}^{cr}(c_3(\lambda))$ are concave, $\lambda^{*NE} = Max_\lambda\ \pi_{cp}^{NE}(\lambda) < \lambda^{*c_3} = Max_\lambda \pi_{cp}^{cr}(c_3(\lambda))$, $\pi_{cp}^{NE}\left(\lambda^{*NE}\right) > \pi_{cp}^{cr}(c_3(\lambda^{*c_3}))$, $\pi_{cp}^{NE}(\lambda) - \pi_{cp}^{cr}(c_3(\lambda)) > 0$ as $\lambda \epsilon \left(0, \lambda^{*NE}\right)$, $\pi_{cp}^{NE}(\lambda) - \pi_{cp}^{cr}(c_3(\lambda))$ increasing as $\lambda \epsilon \left(0, \lambda^{*NE}\right)$, and $\pi_{cp}^{NE}\left(\bar{\lambda}\right) - \pi_{cp}^{cr}\left(c_3\left(\bar{\lambda}\right)\right) < 0$. Therefore $\pi_{cp}^{NE}(\lambda) - \pi_{cp}^{cr}(c_3(\lambda)) = 0$ has only one root if $\lambda \in [0, \bar{\lambda}]$.

■

Appendix B

Consider a publicly owned network. Assume that the shadow price of public funds is zero and that the publicly owned network puts the same weight on consumer surplus and profits. Thus, it wants to maximize total surplus $TS(a) = CS(a) + \Pi(a)$ where $CS(a)$ is the consumer surplus given by

$$CS = \int_{\theta^{AB}}^{1} (t - p_A)\, dt + \int_{\theta^{B0}}^{\theta^{AB}} (\lambda t - p_B)\, dt.$$

Consequently, the publicly owned network has to choose a to maximize

$$TS(a) = \begin{cases} a\left(\frac{(3\lambda - a(\lambda+2))}{\lambda(4-\lambda)}\right) + \frac{1}{2}\left(\frac{\lambda - 6a\lambda + 2\lambda^2 + 3a^2}{\lambda(4-\lambda)}\right) & a < \frac{\lambda}{2} \\ a\left(1 - \frac{a}{\lambda}\right) + \frac{1}{2}\left(\frac{(a-\lambda)^2}{\lambda^2}\right) & \frac{\lambda}{2} \leq a \leq \frac{\lambda}{2-\lambda} \\ a\frac{1}{2}(1-a) + \frac{1}{8}(1-a)^2 & a > \frac{\lambda}{2-\lambda} \end{cases}.$$

Note that the expression $a\left(\frac{(3\lambda - a(\lambda+2))}{\lambda(4-\lambda)}\right) + \frac{1}{2}\left(\frac{\lambda - 6a\lambda + 2\lambda^2 + 3a^2}{\lambda(4-\lambda)}\right)$ is monotonically decreasing in a. Thus, for this range the owner of the network would set $a = 0$ which yields

$$TS^1(\lambda) = \frac{1}{2}\left(\frac{2\lambda + 1}{4 - \lambda}\right).$$

For the second range of a, where there is a limit pricing regime, the solution is $a = \lambda\frac{1-\lambda}{1-2\lambda}$. However, since $\lambda\frac{1-\lambda}{1-2\lambda} > \frac{\lambda}{2-\lambda}$ for any λ the network would set $a = \frac{\lambda}{2-\lambda}$ that generates

$$TS^2(\lambda) = \frac{1}{2}(1-\lambda)\frac{\lambda+1}{(2-\lambda)^2}.$$

The network may also set an access fee $a > \frac{\lambda}{2-\lambda}$ such that in the downstream market there is a monopoly regime. In this case the network chooses a to maximize $a\frac{1}{2}(1-a) + \frac{1}{8}(1-a)^2$, and then the network would set $a = \frac{1}{3}$, a strategy that yields

$$TS^3(\lambda) = \frac{1}{6}.$$

If we compare total surplus that follow from each strategy we find that $TS^2(\lambda) < \min\{TS^1(\lambda), TS^3(\lambda)\}$ and that

$$TS^1(\lambda) \lesseqgtr TS^3(\lambda) \text{ as long as } \lambda \lesseqgtr \frac{1}{7}.$$

Therefore, the publicly owned network sets the following fee

$$a = \begin{cases} \frac{1}{3} & \lambda < \frac{1}{7} \\ 0 & \lambda \geq \frac{1}{7} \end{cases}.$$

As $\lambda < \frac{1}{7}$ the monopoly regime prevails. In contrast, as $\lambda \geq \frac{1}{7}$ there is a competitive regime.

Appendix C

A model where a higher λ implies a redistribution of contents

Consider the following variant of our baseline model: the product of operator A is valued at $(1-\lambda)\theta$ and the product of operator B is valued at $\lambda\theta$ where $0<\lambda<\frac{1}{2}$. Let p_A and p_B be the prices set by the operators, the indifferent consumer between subscribing to A and B, is given by

$$\theta^{AB}=\frac{p_A-p_B}{(1-2\lambda)}$$

and the indifferent consumer between subscribing to B and not subscribing to any of them, is given by

$$\theta^{B0}=\frac{p_B}{\lambda}.$$

When operator B is active, reaction functions are the following

$$\begin{aligned} p_A(p_B) &= \frac{1}{2}(a+1-2\lambda+p_B), \\ p_B(p_A) &= \frac{1}{2(1-\lambda)}(a(1-\lambda)+\lambda p_A). \end{aligned}$$

Simultaneously solving reaction functions yields prices $p_A(a)=\frac{1}{4-5\lambda}(3a(1-\lambda)+2(1-2\lambda)(1-\lambda))$ and $p_B(a)=\frac{1}{4-5\lambda}(a(2-\lambda)+\lambda(1-2\lambda))$ such that the corresponding levels of penetration are given by $D_A(a)=\frac{2(1-\lambda)-a}{4-5\lambda}$ and $D_B(a)=(1-\lambda)\frac{(\lambda-2a)}{\lambda(4-5\lambda)}$. It follows that this is an equilibrium, where $D_B>0$ and operators compete, as long as $a<\frac{\lambda}{2}$. If $a>\frac{\lambda}{2}$ operator A will be alone in the service market, however setting the monopoly price $p_A(a)=\frac{1}{2}(1-\lambda+a)$ is an equilibrium as $a>\frac{\lambda}{2-3\lambda}(1-\lambda)$ otherwise operator B would have room of making positive profits and would enter to the market. For the range $\frac{\lambda}{2}\leq a\leq\frac{\lambda}{2-3\lambda}(1-\lambda)$ operator A will set a limit price $p_A(a)=a\left(\frac{1-\lambda}{\lambda}\right)$ such that operator B will decide stay out of the market, although active on the margin, by setting $p_B=a$.

The network chooses a to maximize the following function

$$\Pi(a)=\begin{cases} a\left(\frac{3\lambda(1-\lambda)-(2-\lambda)a}{\lambda(4-5\lambda)}\right) & a<\frac{\lambda}{2} \\ a\left(1-\frac{a}{\lambda}\right) & \frac{\lambda}{2}\leq a\leq\frac{\lambda}{2-3\lambda}(1-\lambda) \\ a\frac{1}{2}(1+\lambda-a) & a>\frac{\lambda}{2-3\lambda}(1-\lambda) \end{cases}.$$

If we solve for the first range when $a<\frac{\lambda}{2}$ and a competitive regime prevails, we see that the value that maximizes expression $a\left(\frac{3\lambda(1-\lambda)-(2-\lambda)a}{\lambda(4-5\lambda)}\right)$ is $a=\frac{3}{2}\lambda\left(\frac{1-\lambda}{2-\lambda}\right)$. However, since $\frac{3}{2}\lambda\left(\frac{1-\lambda}{2-\lambda}\right)>$

$\frac{\lambda}{2}$ for any λ the network sets $a = \frac{1}{2}\lambda$ which determines $p_A(a) = \frac{1}{2}(1-\lambda)$ and $p_B = \frac{1}{2}\lambda$. It yields $D_A = \frac{1}{2}$ and $D_B = 0$. For the second range of a, where there is a limit pricing regime, the solution is the same. This strategy generates the following profits for the network

$$\Pi^1(\lambda) = \frac{1}{4}\lambda.$$

The network may also set an access fee $a > \frac{\lambda}{2-3\lambda}(1-\lambda)$ such that in the downstream market there is a monopoly regime. In this case the network chooses a to maximize $a\frac{1}{2}(1+\lambda-a)$, and then the network sets $a = \frac{1}{2}(1+\lambda)$, which yields price and demand in the retail market $p_A = \frac{1}{4}(3-\lambda)$ and $D_A = \frac{1}{4}(1+\lambda)$. With this strategy the network gets the following profits

$$\Pi^2(\lambda) = \frac{1}{8}(1+\lambda)^2.$$

If we compare profits that follow from each strategy we find that

$$\Pi^1(\lambda) < \Pi^2(\lambda) \text{ for any } \lambda.$$

In equilibrium profits of the network are given by $\Pi^2(\lambda)$ that are increasing in λ and thus, the result in Proposition 1 remains.

Note that $p_A = \frac{1}{4}(3-\lambda)$ is decreasing in λ and that $D_A = \frac{1}{4}(1+\lambda)$ is increasing in λ, consequently, the consumers surplus is also increasing in λ. Profits of operator A $\frac{1}{16}(\lambda+1)(1-3\lambda)$ are decreasing in λ but total profits $\frac{1}{16}(\lambda+1)(1-3\lambda)+\frac{1}{8}(1+\lambda)^2$ are increasing. It follows that the results in Proposition 2 also remain unchanged.