DISCUSSION PAPER SERIES

No. 8399

ASYMMETRIC BROADBAND WHOLESALE REGULATION

Steffen Hoernig

INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP8399.asp**

ISSN 0265-8003

ASYMMETRIC BROADBAND WHOLESALE REGULATION

Steffen Hoernig, Nova SBE and CEPR

Discussion Paper No. 8399
May 2011

Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 8399

May 2011

ABSTRACT

Asymmetric Broadband Wholesale Regulation*

Due to technological convergence, multiple infrastructures can now offer broadband or triple-play services, while the existing access regulation is based on a single essential network. We show that continued asymmetric access regulation of one network does not control sufficiently for market power and benefits the unregulated network, and that symmetric regulation would lead to higher consumer surplus. Furthermore, the whole setup of access regulation may not be viable in the long run if regulatory constraints provide strong first-mover advantages to the unregulated network.

JEL Classification: L51 and L96
Keywords: access regulation, cable, convergence and copper

Steffen Hoernig
Faculdade de Economia
Universidade Nova de Lisboa
Campus de Campolide
P-1099-032 Lisboa
PORTUGAL

Email: shoernig@fe.unl.pt

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=147558

* We acknowledge financial support from Belgacom for a related study. All opinions and errors contained in this paper are our own.

Submitted 16 May 2011

1 Introduction

Wholesale access regulation and service-based competition. The standard approach to the introduction of competition into electronic communications markets has been to mandate access to existing infrastructure where duplication of the latter was not deemed feasible. This usually implied that the “incumbent” (the ex-monopolist) had to supply wholesale services such as resale of call minutes or unbundling of physical infrastructure at regulated prices to the access seekers or “entrants” which would appear (called “service-based competition”). These would then grow their own retail customer base and ideally at some point invest in own backhaul and even access facilities in order to become independent of the regulated wholesale offers and their limitations in terms service design. This process, commonly known as the ladder-of-investment theory (see Cave 2006), would then ideally lead to an end of service-based competition and to a full establishment of facility-based competition (based on parallel networks as in mobile telephony), including the demise of the regulations that had underpinned service-based competition.

The world is not that simple, though, and this process is unlikely to come to its planned conclusion for a variety of reasons. First, the entrants themselves follow different business models and entry strategies, and these are not geographically uniform. Some entrants in specific areas (mostly urban ones) focus their attention on growth and successive network investment, with a view to become facility-based competitors. Others, in the same urban and particularly in rural areas, have adopted business models which depend crucially on the continuation of wholesale access offers and do not imply the emergence of facility-based competition. These entrants will then evidently have a strong interest in lobbying the regulator for the continuation of favorable access regulation even in the presence of emerging facility-based competition.

A second challenge to the standard interpretation of the ladder-of-investment theory arises from technological convergence. While its point of departure has been a unique feasible infrastructure (and thus a unique technology for providing the services at hand), convergence between access platforms such as copper, fibre and (coaxial) cable implies that the same services, such as voice telephony, broadband internet and subscription TV, can be offered on all platforms, either separately or in ”triple-play” bundles. In particular, cable companies, while retaining most subscription TV customers, have managed to make large inroads into the broadband market, and telephony companies have launched their own IPTV (television over internet protocol) services. This surge of convergence-driven facility-based competition has completely side-stepped the ladder-of-investment process as envisaged.

The result in some countries in Europe is the coexistence of facility-based competition between cable and copper-based providers with continued wholesale access regulation on copper. This constellation is expected to carry over to the upgrade from copper- to fibre-based infrastructure.

To our knowledge, Belgium is the only country in Europe where the national communications regulator, together with the regional broadcast regulators (VRM for the Flemish-speaking, CSA for the French-speaking, and Medienrat for the German-speaking populations), has acknowledged this issue and set out regulatory proposals to address it going towards a more symmetric access regulation. In their respective decision projects of December 2010, the four regulators involved proposed on the one hand to maintain access obligations on the copper DSL network, while introducing access obligations for cable networks, with the aim of making it possible for entrants to provide triple-play services over both copper and cable networks.[1] These regulations are not fully symmetry, though, because on cable wholesale broadband access will be bundled with TV services and sold at a "retail-minus" rate, while on DSL broadband bitstream access is sold standalone at a cost-oriented rate.

The United States have taken a different tack. The national regulator FCC had imposed wide-ranging unbundling obligations on local copper incumbents following the 1996 Telecommunications Act. With initially successful take-up, these were revoked until 2005 after a series of setbacks in the courts and in the market.[2] The effect was a transition to local duopolies comprising copper and cable, with doubts remaining whether competition would be vigorous or become cosy (see Marcus 2005). Partial deregulation has also happened in Austria, Malta and the UK in regions that were considered competitive.

Even with competing infrastructures there is an easily understood rationale for access obligations. From the point of view of the effectiveness of competition and its beneficial effects on consumers, better market outcomes tend to be achieved with more rather than with fewer competitors, especially if some are "mavericks" that disturb potentially cosy market outcomes through their attempts to win over customers.

This argument remains incomplete, though, unless one considers whether these mavericks will be able to survive in the long run, and whether access being mandated to only one of the competing networks manages to achieve the aims of access obligations in the first place. The Belgian competition authority Conseil de la Concurrence (2011, p. 8), for its part, stated that DSL-based entrants have lost clients to competing cable operators and questions whether BIPT's approach to only consider DSL for the broadband wholesale market is the correct one. Thus a discussion seems to have begun about how wholesale markets should be analyzed and regulated in the face of technological convergence.

Contribution. Our paper attempts to contribute to this discussion by considering which form of access regulation is better suited to limit market power, and whether the resulting regulatory arrangements are viable in the long run.

We consider a setting with two *ex-ante* identical and independent network operators, who compete for customers, possibly alongside entrants. Depending on the type of regulation, the latter are housed on either one or both networks if access is given. We compare the effectiveness of competition and the resulting market outcomes under symmetric and asymmetric regulation, where the former means either access or no access obligation on both networks, and the latter implies an access obligation only on one network. An es-

[1] From a legal point of view, the approach of the Belgian regulators avoids having to invoke "joint dominance" of cable and copper in wholesale broadband access markets in order to impose access obligations. Findings of joint dominance are difficult to establish and more difficult to be upheld in the courts.

[2] See Hazlett (2005) and Crandall (2008) for descriptions of the exact order of events and the credo of the "deregulationists".

sential ingredient in the model is that some consumers are temporarily locked in with one type of infrastructure for historical reasons, for example because of terminal equipment or because of a belief that the platform they know provides superior service quality.[3] It is well-known that the introduction of service bundles is attractive for networks because it not only allows them to keep their existing customers while offering them more services, but also because usage of multiple services on the same platform creates a stronger lock-in (and thus less "churn"). Thus capturing lock-in in models of this market seems important and is borne out by the results below.

We find that in the short run, for a given (positive) number of locked-in consumers, imposing access on both networks leads to higher consumer surplus than asymmetric regulation. This effect is due to the creation of competition for cable customers and the accompanying reduction of local market power on the cable network. We even find that in our static model consumer surplus under asymmetric regulation may be below that resulting from not imposing access at all while symmetric regulation can be strictly better than the latter. This result is due to how lower prices reduce local market power. [4]

A related issue is that under asymmetric regulation the access provider's retail pricing freedom may be restricted due to concerns about a "price squeeze", i.e. an insufficient margin between the access provider's wholesale and retail prices. If the squeeze were to be prevented by imposing (explicitly or implicitly) a binding floor to the access provider's retail price, all equilibrium prices will increase. Not only will consumer surplus and welfare decrease in the short run, but the main beneficiary of this measure may not be access seekers but the competing infrastructure.

We also consider market development in the long run when access providers are subject to an obligation to communicate to the market the introduction of new upstream technology and / or retail services. This type of obligation is usually imposed so that access seekers can adapt their offerings to the new conditions and replicate the access provider's new offers. Under asymmetric regulation this type of obligation may create a first-mover advantage for the unregulated operator which is not compensated through competition by mavericks. On the contrary, as we show this first-mover advantage can lead to a lasting market share advantage of the unregulated operator, and can even provoke the exit of access seekers and the break-down of the access regulation model.

Related literature. There is by now a large literature on the relative merits of service- and facility-based competition, which we make no attempt to enumerate. Cave (2006) presents the main points relevant for this paper.

The issue of asymmetric versus symmetric (or no) regulation has been debated to some extent in the US, in the wake of various decisions by the FCC and resulting market developments. The available sources usually set out the case against unbundling and asymmetric regulation. Crandall *et al.* (2002) describe proposals to end asymmetric

[3] This is not to say that other consumers may not be eager to switch - they will do so in our model.

[4] A more complete comparison of symmetric and no access regulation would have to take into account how service quality evolves and assess whether two vertically integrated networks would compete effectively.

regulation of cable and copper in the US, which was still in force at the time. They state that "the social costs of asymmetric regulation are by now familiar" but do not explain what these costs are. Rather, they focus on showing that broadband services over copper and cable are in the same retail market. Hausman *et al.* (2001, p. 307) argue against asymmetric regulation and state (exceptionally) that cable companies in the US should be forced to give access to alternative internet providers. Hausman (2002) and Hazlett (2005) conclude that unbundling regulation in the US have led to the temporary existence of a series of economically inviable access seekers and a reduction of investment into broadband infrastructure. Crandall (2008) provides an overview over what has happened in this and other markets where in his opinion regulation has failed. Marcus (2005), on the other hand, lays out concerns about whether US broadband retail customers are really served well by an duopoly or whether a more "European" approach of access regulation would lead to better results.

In Europe the corresponding debate seems to have just begun. Pavón-Villamayor (2007) is inspired by several instances of asymmetric regulation that arose through convergence. He considers a model where horizontal differentiation between two asymmetrically regulated products disappears over time. Regulation is modeled as different degrees of welfare maximization objectives due to partial public ownership, and thus has no relation to the network access literature.

Directly relevant to our subject, Bouckaert *et al.* (2008) describe asymmetric regulation of cable and copper in Belgium and argue that it has slowed down broadband penetration.

Finally, our modeling of competition with locked-in consumers is based on existing ideas in the literature on competition with switching costs, as summarized by Farrell and Klemperer (2007).

Overview. Section 2 sets out the basic model, and Section 3 analyzes how regulation affects market power. Section 4 considers long-run dynamics, while Section 5 concludes. Omitted proofs are contained in an Appendix.

2 Modeling Firms and Consumers

There are two firms, called incumbents 1 and 2, which operate (essentially) identical independent communications networks that both cover the whole country. These firms both offer retail broadband access and can give wholesale access to two entrant firms 3 and 4, which do not own a local access network. Access to either network involves a cost-based per-subscriber fee a.[5] We assume that each entrant asks for access from at most one network, where (without loss of generality) entrant 3 always locates on the network 2. Entrant 4 is on network 2 under asymmetric regulation and on network 1 under symmetric regulation.[6] All firms sell "broadband subscriptions" (which may be triple play bundles)

[5] "Cost-based" access prices are one of the mainstays of present access regulation. We interpret this wholesale price level as implying zero wholesale profits. Our results would not be qualitatively different with wholesale prices somewhat above cost.

[6] It is easily seen that this would be an outcome of a game of network choice by entrants.

to retail customers and compete in subscription prices.

We consider imperfect competition between these four firms, in the presence of network-based (local) market power. This is captured in a generalized Hotelling model of horizontal differentiation and customer lock-in. There are three types of consumers, who differ in their past choices and how these affect their future ones. We will first take these past choices as given in Section 3, and consider the dynamics of subscriber numbers in Section 4. Thus at the beginning of the period under consideration there are N "mobile" consumers who will make a choice between all four firms, and two groups of size M of "captive" consumers who only consider buying services on one platform.[7] It is the latter who are locked in to one platform due to switching costs which arise for example from broadband offers being bundled with TV or telephony services, or because consumers have developed trust into a specific platform. Define $m = M/N$ as the relative size of the captive groups.

In each consumer group's preference space, the available retail offers are located at n different "nodes" linked pairwise by "segments" where individual consumers are located, similar to Von Ungern-Sternberg (1991) and Hoernig (2010). Each single consumer's ideal choice corresponds to a point on one of the $n(n-1)/2$ segments of equal length l linking each pair of nodes. All segments in the same group contain the same number of consumers, and each consumer is assumed to make a first choice between the two retail offers corresponding to the two firms at the endpoints of his segment before considering the others.[8] In the group of mobile consumers, lines are normalized to length $l = 1$, and four firms compete against each other for customers on six segments. In the captive groups there will be three segments of length $l = 1/3$ if there are three firms, and two segments of length $l = 1/2$ with two firms or only one firm.[9] We will assume that under asymmetric regulation an equilibrium exists where the unregulated firm serves all its captive consumers. This implies that we are considering a "best-case scenario" for asymmetric regulation in terms of consumer surplus and welfare.

The match between consumers' ideal products and firms' offers is not perfect, thus a consumer at distance d from the product that he buys has utility loss (or "transport cost") of td, where $t > 0$ denotes the degree of horizontal differentiation between retail products (higher t means more differentiation).

Subscribing to firm i yields a gross surplus S_i. We assume that subscribing to incumbents leads to $S_1 = S_2 = S$, while subscribing to an entrant leads to the lower surplus $S_3 = S_4 = S - E$, where $E > 0$ is the difference in surplus due to differences in service quality, brand image, and consumer perceptions about entrants' long-term viability; let $\varepsilon = E/t$ and $s = S/t$. The parameters (m, ε, s) need to be in a certain range so that both under symmetric and asymmetric regulation full-coverage equilibria exist. As analyzed in

[7] For simplicity, for now we assume that both groups of captive consumers have the same size. Our results below would be even more in favour of symmetric regulation if we were to allow a larger number of locked-in consumers on the unregulated platform. In Section 4 we endogenize the numbers of captive consumers.

[8] In order to complete the preferences, as in the spokes model of Chen and Riordan (2007), we assume that consumers drop out of the market if their two preferred choices are not available.

[9] In other words, captive consumers are distributed around two Salop circles of size 1, with firms located at equal distances.

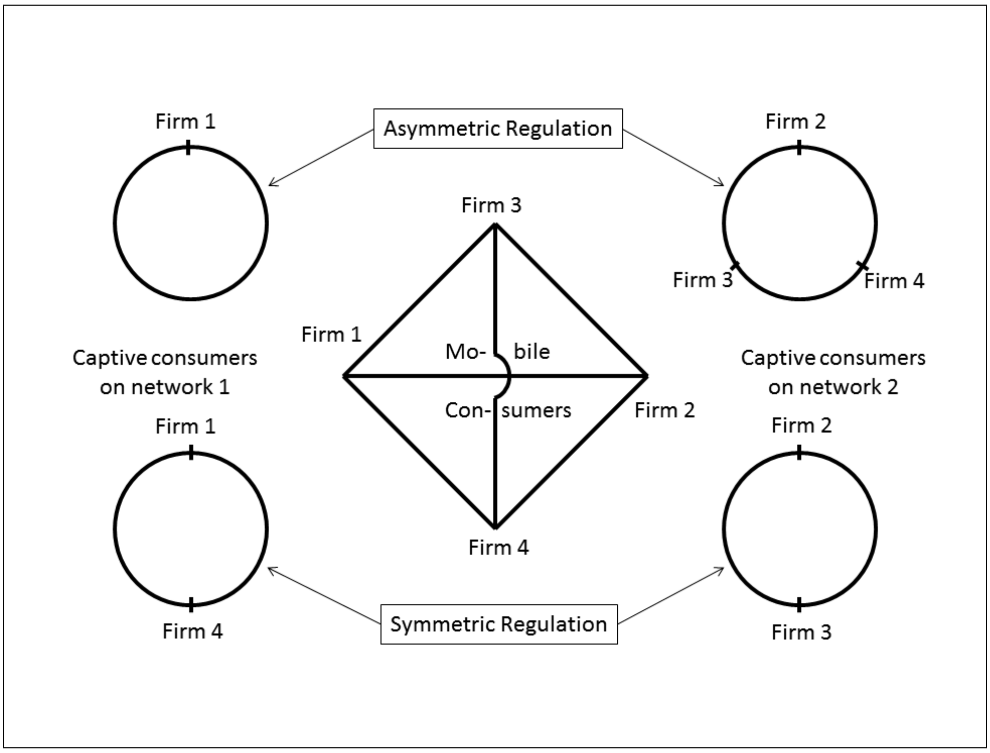


Figure 1: Preference spaces of "mobile" consumers and of captive consumers on networks 1 and 2.

more detail in the Appendix, this range is given by

$$\Phi = \left\{ (m, \varepsilon, s) \geq 0 \;\middle|\; \begin{array}{c} -\frac{(30m+7)\left(7+4m-48m^2\right)}{12m(4m+1)} \leq \varepsilon \leq \frac{30m+7}{36m+9}, \\ \phi(\varepsilon, m) \leq s - \frac{1}{2} \leq \frac{1}{4m}\phi^2(\varepsilon, m) \end{array} \right\}, \tag{1}$$

where $\phi(\varepsilon, m) = \frac{7+32m+48m^2+2\varepsilon(4m+1)}{(24m+7)}$. The parameter range Φ consists of a square set of values (ε, m) of roughly $0 \leq \varepsilon < 0.8$ and $0 \leq m < 0.4$, with the surplus s restricted to intermediate values. The latter are high enough so that all consumers participate but low enough so that no monopoly pricing of captive consumers occurs.

If firms i and j charge retail prices p_i and p_j, a consumer at location Y_{ij} on the corresponding segment of length l is indifferent between the two offers if

$$S_i - p_i - tY_{ij} = S_j - p_j - t(l - Y_{ij}),$$

which implies that is location is

$$Y_{ij} = \frac{l}{2} + \frac{1}{2t}(S_i - S_j + p_j - p_i).$$

Denote the indifferent consumers in the mobile group as y_{ij}, and those captive on networks 1 and 2 as x_{ij} and z_{ij}, respectively, with the convention that they are equal to zero for a firm i that is not present on the respective network.

Firm i's subscriber numbers in the mobile group are

$$\alpha_i = \frac{N}{6} \sum_{j \neq i} y_{ij} = \frac{N}{4} + \sigma \sum_{j \neq i} (S_i - S_j + p_j - p_i),$$

where we have defined $\sigma = N/(12t)$. Its captive subscribers are $\beta_i = M$ if it is a monopoly, and

$$\beta_i = 2Mx_{ij} = \frac{M}{2} + 2\tau (S_i - S_j + p_j - p_i)$$

with a duopoly on network 1 (similar for network 2), or

$$\beta_i = M (z_{ij} + z_{ik}) = \frac{M}{3} + \tau (2S_i - S_j - S_k + p_j + p_k - 2p_i),$$

with three firms on network 2, where $\tau = M/(2t)$.

In the following we have normalized firms' marginal production cost to zero, which simplifies the exposition but does not qualitatively affect the results. The aggregate transport for consumers on some interval $[0, y]$ is given by $\int_0^y txdx = ty^2/2$.

Consumer surplus, including transport cost, is given by

$$CS = \sum_{i=1}^{4} (\alpha_i + \beta_i)(S_i - p_i) - \frac{Nt}{2} \sum_{i;\ j \neq i} y_{ij}^2 - T_1 - T_2,$$

where T_1 and T_2 are the transport cost of captive consumers on networks 1 and 2. For a monopoly on network $i = 1, 2$ we obtain

$$T_i = \frac{Mt}{2} \left(\left(\frac{1}{2}\right)^2 + \left(\frac{1}{2}\right)^2 \right) = \frac{Mt}{4}.$$

Under asymmetric regulation, i.e. with three firms on network 2, we have

$$T_2 = \frac{Mt}{2} \sum_{i,j \geq 2;\ j \neq i} z_{ij}^2,$$

while under symmetric regulation we obtain

$$T_1 + T_2 = Mt \left(x_{14}^2 + x_{41}^2 + z_{23}^2 + z_{32}^2 \right).$$

Total welfare is the sum of consumer surplus and profits,

$$W = CS + \sum_{i=1}^{4} \pi_i.$$

3 The Short-Run Effects of Asymmetric Regulation

In this section we will consider a static setting where both networks are *ex-ante* identical and possess the same number of locked-in consumers. Our focus is on how local market power is affected by regulation and how it is checked by the resulting competition. First we neglect price squeeze issues and let the access provider set retail tariffs freely. In a second step we investigate the effects of a retail price floor.

3.1 Regulation and Market Power

We now will consider market outcomes in three scenarios: i) no access or pure infrastructure duopoly; ii) Asymmetric regulation with access only on network 2; and iii) symmetric regulation with access on both networks. The case without access, while being of interest in its own right, also serves a simple guide through the structure of the model. The derivations of equilibrium outcomes have been relegated to the Appendix.

No infrastructure access. As a benchmark, we first consider the case where no network gives access because no access regulation has been imposed.[10] In this case there are no entrants and the shares of mobile consumers are ($i = 1, 2$ and $j \neq i$)

$$\alpha_i = \frac{5N}{12} + 3\sigma \left(S - S + p_j - p_i\right),$$

where $\partial\alpha_i/\partial p_i = -3\sigma$ as in the case with four firms, with consumers who only consider entrants dropping out of the market.

Network owner i has profits derived from selling to M captive and α_i mobile consumers:

$$\pi_i = (M + \alpha_i)\, p_i.$$

Firm i's necessary first-order condition for an interior profit maximum is

$$M + \alpha_i - 3\sigma p_i = 0.$$

The equilibrium candidate will be symmetric with $\alpha_i = 5N/12$ and

$$p_1 = p_2 = 4t\left(\frac{5}{12} + m\right).$$

Thus the equilibrium retail price increases with the level of differentiation t and the size of the captive consumer groups m. The resulting consumer surplus including transport cost is

$$CS^{na} = N\left(\frac{5}{6} + 2m\right)S - 2Nt\left(\frac{5}{6} + 2m\right)^2 - \frac{Mt}{2},$$

and profits are

$$\pi_1 = \pi_2 = Nt\left(\frac{5}{6} + 2m\right)^2.$$

Total welfare is given by the sum of consumer surplus and profits:

$$W^{na} = N\left(\frac{5}{6} + 2m\right)S - \frac{Mt}{2}.$$

After checking whether any network would prefer to give up competing for mobile customers and deviate to monopoly pricing on its captive consumers, we find the following:

[10] Conseil de la Concurrence (2011, p. 9) states that neither DSL nor cable operators with a large client base would find it profitable to give voluntary access to their networks.

Lemma 1 *Without access, there is a unique full-coverage Nash equilibrium in the two incumbents' prices if* $(\varepsilon, m, s) \in \Phi$ *and* $s \geq 4m + 8/3$*, with consumer surplus and welfare as indicated above.*

Note that "full coverage" here refers to participating consumers only. For lower values of s even some participating consumers do not buy and / or the equilibrium involves mixed strategies. Since the no-access scenario is not the focus of the paper for simplicity we only consider the case of full coverage of participating consumers.

Asymmetric Regulation. Assume now that network 1 does not give access, while network 2 is obliged to give access to any entrant who requests access. As a result, both entrants 3 and 4 will be hosted on firm 2's network and compete for mobile and network 2's captive consumers.

For network 1, we thus have $\beta_1 = M$ and

$$\alpha_1 = \frac{N}{4} + \sigma\left(p_2 + p_3 + p_4 - 3p_1 + 2E\right),$$

with profits

$$\pi_1 = (\alpha_1 + M)\, p_1.$$

Network 2 has subscriber shares

$$\begin{aligned} \beta_2 &= \frac{M}{3} + \tau\left(p_3 + p_4 - 2p_2 + 2E\right), \\ \alpha_2 &= \frac{N}{4} + \sigma\left(p_1 + p_3 + p_4 - 3p_2 + 2E\right), \end{aligned}$$

and profits

$$\pi_2 = (\alpha_2 + \beta_2)\, p_2.$$

Note that since access is cost-based ($a = 0$ since we have normalized cost to zero) wholesale profits are zero.

Finally, entrants $i = 3, 4$ have subscriber shares (with $j = 3, 4, \neq i$)

$$\begin{aligned} \beta_i &= \frac{M}{3} + \tau\left(p_2 + p_j - 2p_i - E\right), \\ \alpha_i &= \frac{N}{4} + \sigma\left(p_1 + p_2 + p_j - 3p_i - 2E\right), \end{aligned}$$

and profits

$$\pi_i = (\alpha_i + \beta_i)\, p_i.$$

The expressions characterizing the equilibrium, including consumer surplus and welfare, are complex and are therefore listed in the Appendix. For now we give a qualitative description of the equilibrium:

Lemma 2 *Under asymmetric regulation, if* $(\varepsilon, m, s) \in \Phi$ *there is a unique full-coverage Nash equilibrium in the four firms' prices. We have*

$$p_1^* > p_2^* > p_3^* = p_4^*.$$

Thus we see that network 1's local market power over its captive consumers, coupled with the absence of direct competition for the latter, leads to higher prices. Entrants on the other hand make up for their surplus disadvantage through lower prices.

Symmetric Regulation. Now assume that entrant 4 is hosted on network 1, and that entrant 3 remains on network 2. Profits of network $i = 1, 2$ are

$$\pi_i = (\alpha_i + \beta_i)\, p_i,$$

with subscriber shares α_i as above and ($j = 4, 3$ respectively)

$$\beta_i = \frac{M}{2} + 2\tau\,(p_j - p_i + E)\,.$$

The profits and subscriber shares of entrants $i = 4, 3$ are α_i as above and ($j = 1, 2$ respectively)

$$\begin{aligned} \pi_i &= (\alpha_i + \beta_i)\, p_i, \\ \beta_i &= \frac{M}{2} + 2\tau\,(p_j - p_i - E)\,. \end{aligned}$$

The resulting market outcome is symmetric between networks (but not between entrants and access providers).

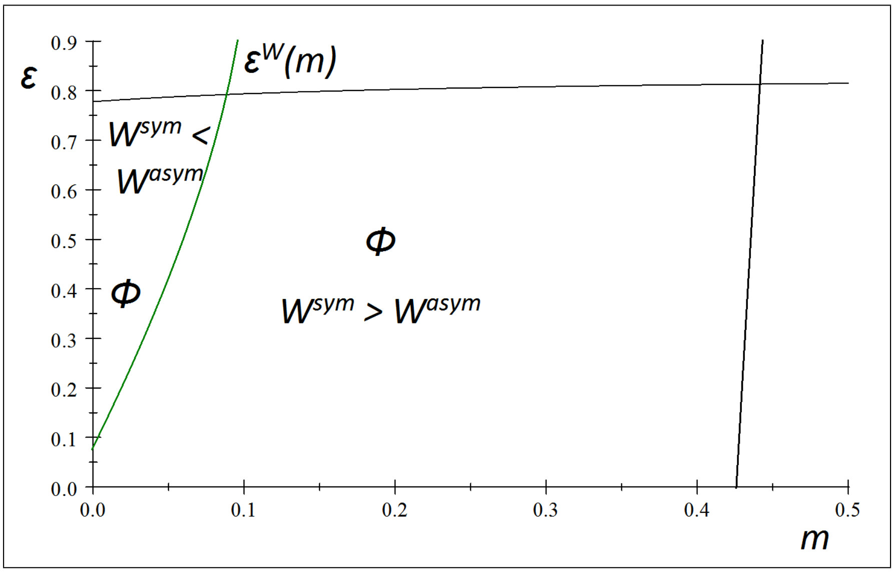
Lemma 3 *Under symmetric regulation, if* $(\varepsilon, m, s) \in \Phi$ *there is a unique full-coverage Nash equilibrium in the four firms' prices. We have*

$$p_1^* = p_2^* > p_3^* = p_4^*.$$

Comparison of Symmetric and Asymmetric Regulation. We will now compare consumer surplus and welfare under the regulatory regimes considered above. The following main result obtains:

Proposition 1

1. *Static consumer surplus is higher under symmetric than under asymmetric regulation for all* $(\varepsilon, m, s) \in \Phi$.
2. *Total welfare is higher for all* $(\varepsilon, m, s) \in \Phi$ *such that* $\varepsilon \leq \varepsilon^W(m)$, *as depicted in the following figure:*



Total welfare increases with a move to symmetric regulation unless there are only few captive consumers.

Under the assumptions of our present model, symmetric and asymmetric regulation only lead to the same outcome for consumer surplus and welfare if there are no captive consumers. When there are no captive consumers and wholesale prices are cost-based then it is not relevant for market outcomes on which network entrants is based.

This outcome changes drastically if networks have local market power. Both consumer surplus and welfare tend to be higher under symmetric regulation because the captive consumers on both networks are subject to local market power. The latter is checked by competition from the entrants on the regulated network but not on the unregulated network. In our modeling of symmetric regulation, one entrant is moved from the previously regulated to the previously unregulated network. This reduces competitiveness on one network and increases it on the other, and in the ensuing trade-off the latter effect is stronger. The only exception occurs when total transport cost increases in the move to symmetric regulation, which is happens when the number of captive consumers is small and the surplus disadvantage of entrants is large, i.e. $\varepsilon > \varepsilon^W(m)$. In this case consumer surplus still increases with the move to symmetric regulation, by total welfare decreases.[11]

Given that symmetric regulation dominates the asymmetric kind, one might want to ask whether the latter is at least better than no regulation at all. As mentioned above, the "deregulationist" debate in the US concentrated on the idea that broadband investment would be higher without any regulation, but this facet is absent in our model. Still, even ignoring investment issues there are instances where no regulation leads to higher consumer surplus than asymmetric regulation. This is remarkable especially given that in our model some mobile consumers will not buy if no entrants are present.

[11] Our assumption that symmetric regulation leads to a market structure with one entrant on each network, rather than allowing for additional entry, can be seen as conservative. With the possibility of additional entry the above trade-off is no longer present and the positive effects of symmetric regulation would be even more pronounced.

Proposition 2 *There are $(\varepsilon, m, s) \in \Phi$ such that symmetric regulation leads to higher consumer surplus than no access, while asymmetric regulation leads to lower consumer surplus than no access.*

The intuition behind this result is as follows: Very low-quality entrants (high ε) are too weak to increase consumer surplus much, thus for high ε no access is optimal even compared to symmetric regulation. On the other hand, high-quality entrants (small ε) make both types of regulation perform better than no access. There is an intermediate range where symmetric regulation performs better than no access, while asymmetric regulation actually reduces consumer surplus as compared to no access. The reason for the latter is that at an intermediate quality level the entrant that is moved to the previously unregulated network still exerts enough competitive pressure on network 1 to raise consumer surplus, while having both entrants on network 2 does not compensate for the overall reduction in surplus.

Thus summing up we find that from the point of view of static market power symmetric regulation performs better than asymmetric regulation, while not imposing access may be best if entrants do not bring additional surplus to the market.

3.2 Restrictions to Retail Pricing Freedom

The regulator or the competition authority may consider that in the above equilibrium the retail price of the access-providing firm is too low as compared to the access price a, i.e. that the possibility of a margin squeeze exists. This is particularly likely under asymmetric regulation since the presence of more entrants makes the network concerned compete harder on price. Thus in practice the access provider may not be able to choose retail prices below a certain price floor which is strictly above the Nash equilibrium level, say $\overline{p}_2 > p_2^*$. For our argument it is not relevant whether this price floor is explicitly announced or can be derived implicitly due to the threat of litigation. In either case, the access provider's retail price is kept artificially high and will in equilibrium be set at $\overline{p}_2$.

As concerns equilibrium outcomes if network 2 is bound by a price floor, we obtain the following result:

Proposition 3 *Under asymmetric regulation, a binding floor on the retail price of the access provider increases all equilibrium retail prices and reduces consumer surplus. Furthermore, it shifts subscribers from the access provider to his access seekers and to the unregulated network.*

It is not surprising that equilibrium prices increase in response to imposing a price floor on one competitor since firms' prices are strategic complements. As shown in the proof, the price floor leads entrants to increase their prices more than the unregulated network. Nevertheless, all three competitors benefit not only from higher prices but also from an increase in subscriber numbers. This increase occurs because price are raised by less than the price floor.

The prime beneficiaries of the price floor are the entrants, but also the unregulated network stands to gain. While the entrants' consumers benefit in the long run from a smaller probability of their provider's exit, both they and the unregulated networks' clients will be subject to permanently higher retail prices.

4 Dynamic Effects and Time-To-Market

In this section we consider how market shares evolve over time under asymmetric and symmetric regulation, respectively, if access obligations affect the timing of the introduction of new services and technologies. In order to analyze this question we now endogenize the numbers of captive and mobile consumers. Essentially, we assume that some consumers of each firm get locked in to the corresponding network for the next period, while they can still switch supplier on the same network as in Section 3.

Assume that in period t networks 1 and 2 inherit a stock of captive consumers M_1^t and M_2^t from the previous period, i.e. consumers who in period t will not switch networks. There will also be a pool of N^t mobile consumers which all firms on both networks compete for. This pool includes N_0 consumers who are new to the market and other consumers who were already in the market and are in a position to reconsider their network choice. We will describe below in detail how these subscriber groups evolve over time. The main assumption is that at the end of each period a share $\lambda \in (0, 1)$ of subscribers is locked in to their chosen network during the next period. A share μ of subscribers exits the market, while a share of $(1 - \mu - \lambda)$ rejoins the pool of mobile consumers. Note that we allow for market participation to grow over time.

Assume now, for simplicity and in order to demonstrate the ensuing market dynamics, that every period an innovation becomes viable (and known to all networks) which would increase gross surplus of every consumer by $\Delta > 0$ (and let $\delta = \Delta/t$). An unregulated network can immediately implement the innovation at retail level. The regulated one will have to wait until the next period, due to access-related obligations such advance notification to access seekers.[12]

For simplicity, we now assume that retail prices are identical and equal to p. The full dynamic equilibrium analysis would lead to much more complex expressions but similar qualitative conclusions. Subscriber shares are given by the same expressions as above, where now N, M_1 and M_2 vary over time. In the following analysis, we set up the dynamics of subscriber numbers and determine the market steady state under both asymmetric and symmetric regulation.

4.1 Asymmetric Regulation

Assume as above that network 1 is not regulated, but that network 2 is regulated and gives access to entrants 3 and 4. Since network 1 can implement each innovation one period earlier, there will be a permanent difference in gross surplus, $S_1 - S_i = \Delta$ for $i = 2, 3, 4$. Under the assumption of equal prices, network 1's subscriber numbers in period t are

[12] This setup can also be interpreted as innovations arising privately at network level, but since the regulated network must announce its plans of implementation to the market in advance, the unregulated network obtains this information one period before it will be implemented.

given by its share of mobile consumers plus its captive ones,

$$s_1^t = \alpha_1^t + M_1^t = \frac{N^t}{4}\left(1 + \delta + \frac{2}{3}\varepsilon\right) + M_1^t.$$

The regulated network and entrants $i = 3, 4$ share mobile and captive consumers and have subscriber numbers

$$\begin{aligned} s_2^t = \alpha_2^t + \beta_2^t &= \frac{N^t}{4}\left(1 - \frac{1}{3}\delta + \frac{2}{3}\varepsilon\right) + M_2^t\left(\frac{1}{3} + \varepsilon\right), \\ s_i^t = \alpha_i^t + \beta_i^t &= \frac{N^t}{4}\left(1 - \frac{1}{3}\delta - \frac{2}{3}\varepsilon\right) + M_2^t\left(\frac{1}{3} - \frac{1}{2}\varepsilon\right). \end{aligned}$$

Of these, the following will be captive to networks in the following period:

$$\begin{aligned} M_1^{t+1} &= \lambda s_1^t = \lambda\left[\frac{N^t}{4}\left(1 + \delta + \frac{2}{3}\varepsilon\right) + M_1^t\right], \\ M_2^{t+1} &= \lambda\sum_{i=2}^{4} s_i^t = \lambda\left[\frac{N^t}{4}\left(3 - \delta - \frac{2}{3}\varepsilon\right) + M_2^t\right]. \end{aligned}$$

Next period's mobile consumers will be sum of new consumers and those consumers who neither exited nor became captive:

$$N^{t+1} = N_0 + (1 - \lambda - \mu)\sum_{i=1}^{4} s_i^t = N_0 + (1 - \lambda - \mu)\left(N^t + M_1^t + M_2^t\right).$$

The unique (stable) steady state, i.e. long-run outcome, can be found from the last three expressions by setting $M_i^t = M_i$ and $N^t = N$ for t. Entry and exit of consumers compensate each other, therefore subscriber numbers stabilize at a total number of $\bar{N} = N_0/\mu$. The long-run captive and mobile consumers are

$$\begin{aligned} M_1 &= \lambda\left(\frac{1}{4} + \frac{\delta}{4} + \frac{\varepsilon}{6}\right)\bar{N}, \\ M_2 &= \lambda\left(\frac{3}{4} - \frac{\delta}{4} - \frac{\varepsilon}{6}\right)\bar{N}, \\ N &= (1 - \lambda)\,\bar{N}, \end{aligned}$$

and firms' long-run subscriber numbers are

$$\begin{aligned} s_1 &= \left(\frac{1}{4} + \frac{\delta}{4} + \frac{\varepsilon}{6}\right)\bar{N}, \\ s_2 &= \left(\frac{1}{4} + \frac{19}{36}\lambda\varepsilon - (1 + 3\lambda\varepsilon)\frac{\delta}{12} + (1 - \lambda\varepsilon)\frac{\varepsilon}{6}\right)\bar{N}, \\ s_3 = s_4 &= \left(\frac{1}{4} - \frac{19}{72}\lambda\varepsilon - (2 - 3\lambda\varepsilon)\frac{\delta}{24} - (2 - \lambda\varepsilon)\frac{\varepsilon}{12}\right)\bar{N}. \end{aligned}$$

We then obtain the following result:

Proposition 4 *In the long run, the unregulated network has more customers than all firms on the regulated network together if* $\delta \geq 1 - \frac{2}{3}\varepsilon$*. The market structure under regulation is not viable in the long run if* $\delta > 3 - \frac{2}{3}\varepsilon$*.*

Proof. We have $s_1 > s_2 + s_3 + s_4$ iff $\delta \geq 1 - \frac{2}{3}\varepsilon$. Furthermore, a necessary condition for the steady state with four firms to exist is $M_2 > 0$, or $\delta > 3 - \frac{2}{3}\varepsilon$. ■

Thus we find that a shorter time-to-market for the unregulated network can benefit the latter by allowing it to gain and keep more consumers over time. The very regulation that is meant to protect entrants has the effect of shifting potential customers onto the rival network. This effect may become so strong as to invalidate the service- and access-based competition model: If the unregulated network's artificial first-mover advantage (or the lag involved) is large then the market might tip in the sense that either the regulated access provider or its entrants lose economic viability. As the first-mover-advantage becomes large all firms on the regulated network would lose their customers.

Finally, under symmetric regulation, innovations will be implemented on both networks one period later, and long-run market shares of both networks will be symmetric, i.e. $s_1 + s_4 = s_2 + s_3 = \bar{N}/2$. Thus the effect we have just identified is due exclusively to asymmetric regulation and not to regulation as such, even though service innovation will be slowed down in either case.

5 Conclusions

In this paper we have considered some potential effects of asymmetric regulation in markets where multiple networks can provide the same services, such as broadband access or triple-play services. For historical reasons, in these markets often only one network is subject to access regulation, while the other network is left unregulated. We have shown that if the latter is a significant player in the market then symmetric regulation (access obligations on both networks) reigns in local market power more effectively than the asymmetric kind. Furthermore, we have shown that regulation-induced first-mover advantages of the unregulated network may invalidate the model of service-based competition by itself.

Thus our results imply that in the presence of multiple and competitive infrastructures the existing access regulation models may need to be reconsidered. While the presence of additional providers avoids the market from becoming "too cosy", if access regulation cannot guarantee that both entrants and their host network remain forceful competitors then it defeats its own purpose. Thus apart from technical issues, the resulting choice between either regulating both networks or regulating none is far from clear. The latter choice should depend on an assessment of whether two competing infrastructures lead to sufficiently competitive outcomes in terms of price and service quality.

Appendix: Omitted proofs

Proof of Lemma 1:

Proof. Under a deviation to monopoly pricing on its captive consumers, a firm either opts for full coverage or restricts sales to its closest customers. In the first case, profits are maximized if the farthest customer (at a distance of $1/2$) obtains zero surplus, i.e. the monopoly price is $p^m = S - t/2$, with profits $Mt\,(s - 1/2)$. In the second case, the indifferent consumers $y \leq 1/2$ are given by $S - p^m - ty = 0$, which leads to profits $2M\,(S - ty)\,y$. The latter are maximized at $y = s/2$ with value $Mts^2/2$. Thus monopoly profits are

$$\pi^m = Mt \begin{cases} s^2/2 & if \quad s \leq 1 \\ s - 1/2 & if \quad s > 1 \end{cases} .$$

No incumbent will deviate from the interior equilibrium candidate to monopoly pricing if $\pi^m \leq Nt\,(1+2m)^2$, or $s \leq \frac{1}{2} + \frac{(1+2m)^2}{m}$. The latter is larger than $\overline{s}\,(m,\varepsilon)$ defined below thus is redundant given $(\varepsilon, m, s) \in \Phi$.

For full coverage to obtain, the farthest participating mobile consumer has non-negative surplus, or $S - p - t \geq 0$ or $s \geq 1 + 4\left(\frac{5}{12} + m\right) = 4m + \frac{8}{3}$. The latter condition eliminates low values of s from Φ. ■

Proof of Lemma 2

Proof. The necessary first-order conditions for a profit maximum with covered markets are

$$\begin{aligned} (\alpha_1 + M) - 3\sigma p_1 &= 0, \\ (\alpha_i + \beta_i) - (2\tau + 3\sigma)\,p_i &= 0, \; i = 2,3,4. \end{aligned}$$

Substituting the expressions for market shares and solving for the candidate equilibrium prices, we obtain

$$\begin{aligned} p_1^* &= t\frac{32m + 48m^2 + 7}{24m + 7} + E\frac{8m + 2}{24m + 7}, \\ p_2^* &= t\frac{12m + 7}{24m + 7} + E\frac{(8m + 2)(36m + 7)}{(24m + 7)(30m + 7)}, \\ p_3^* = p_4^* &= t\frac{12m + 7}{24m + 7} - E\frac{144m^2 + 94m + 14}{(24m + 7)(30m + 7)}. \end{aligned}$$

It can be shown that $p_1^* > p_2^* > p_3^* = p_4^*$ for all t, m, E.

Networks' equilibrium subscriber numbers are

$$\begin{aligned} \alpha_1 &= N\left(\frac{1}{4} - \frac{12m^2 + 5m}{24m + 7} + \varepsilon\frac{4m + 1}{48m + 14}\right), \\ \alpha_2 &= N\left(\frac{1}{4} + \frac{12m^2 + 5m}{72m + 21} + \varepsilon\frac{(22m + 7)(4m + 1)}{(48m + 14)(30m + 7)}\right), \\ \beta_2 &= N\left(\frac{m}{3} + \varepsilon\frac{12m^2 + 3m}{30m + 7}\right), \end{aligned}$$

and the entrants' are

$$\begin{aligned} \alpha_3 = \alpha_4 &= N\left(\frac{1}{4} + \frac{12m^2 + 5m}{72m + 21} - \varepsilon\frac{(26m + 7)(4m + 1)}{(48m + 14)(30m + 7)}\right), \\ \beta_3 = \beta_4 &= N\left(\frac{m}{3} - \varepsilon\frac{12m^2 + 3m}{60m + 14}\right). \end{aligned}$$

Consumer surplus (including transport cost) can be found as

$$\begin{aligned} CS^{asym} &= (N+2M)\,S - tN\tfrac{5432m+13\,872m^2+16\,992m^3+13\,824m^4+735}{6(24m+7)^2} \\ &\quad -Nt\varepsilon\tfrac{(4m+1)^2}{(24m+7)^2}\left(\tfrac{172m+96m^2+49}{2(4m+1)}+3\varepsilon\tfrac{1309m+1728m^2-1728m^3+196}{2(30m+7)^2}\right) \end{aligned}$$

Firms' profits are

$$\begin{aligned} \pi_1 &= tN\frac{\left(7+32m+48m^2+2\varepsilon\,(4m+1)\right)^2}{4\,(24m+7)^2}, \\ \pi_2 &= tN\frac{4m+1}{4\,(24m+7)^2}\left(12m+7+2\varepsilon\frac{(4m+1)\,(36m+7)}{30m+7}\right)^2, \\ \pi_3=\pi_4 &= tN\frac{4m+1}{4\,(24m+7)^2}\left(12m+7-2\varepsilon\frac{47m+72m^2+7}{30m+7}\right)^2. \end{aligned}$$

Finally, total welfare is

$$\begin{aligned} W^{asym} &= (N+2M)\,S - tN\tfrac{3122m+7656m^2+9792m^3+10\,368m^4+441}{6(24m+7)^2} \\ &\quad -tN\varepsilon\tfrac{4m+1}{(24m+7)^2}\left(\tfrac{132m+49}{2}+\varepsilon\tfrac{623m-82\,944m^4-55\,584m^3-9360m^2+196}{2(30m+7)^2}\right). \end{aligned}$$

We will now consider the restrictions on the parameters ε, m and s which are necessary and sufficient for the asymmetric regulation equilibrium with full coverage to exist. First of all, in equilibrium, all indifferent consumers must lie between their segment boundaries, for which it is necessary and sufficient that $z_{32}\geq 0$ (the entrant's indifferent consumer on the shortest segment with the lowest-priced incumbent), or

$$\varepsilon\leq\overline{\varepsilon}\,(m)=\frac{30m+7}{36m+9},$$

and $y_{12}\geq 0$ (the unregulated network has some mobile customers which would otherwise choose the regulated incumbent) or

$$\varepsilon\geq\underline{\varepsilon}\,(m)=-\frac{(30m+7)\,(7+4m-48m^2)}{12m\,(4m+1)}.$$

The former always holds for $\varepsilon\leq 7/9\approx 0.78$, and the latter for $m\leq\overline{m}=\left(1+\sqrt{85}\right)/24\approx 0.43$.

Incumbent 1 will not abandon the segment of mobile consumers in order to derive monopoly profits from its captive consumers if $\pi_1\geq\pi^m$, or

$$s\leq\overline{s}\,(m,\varepsilon)=\frac{1}{2}+\frac{1}{4m}\phi^2\,(\varepsilon,m)\,,$$

where $\phi\,(\varepsilon,m)=\frac{7+32m+48m^2+2\varepsilon(4m+1)}{24m+7}$. On the other hand, the surplus of indifferent consumers must be non-negative. The lowest surplus will be obtain by the captive ones of the unregulated incumbent, i.e. under full coverage we must have $S-p_1-t/2\geq 0$, or

$$s\geq\underline{s}\,(m,\varepsilon)=\frac{1}{2}+\phi\,(\varepsilon,m)\,.$$

The parameter set Φ is thus given by the conditions $m, \varepsilon, s \geq 0$, $\underline{\varepsilon}(m) \leq \varepsilon \leq \overline{\varepsilon}(m)$ and $\underline{s}(m, \varepsilon) \leq s \leq \overline{s}(m, \varepsilon)$. ■

Proof of Lemma 3:
Proof. The necessary first-order conditions for profit maximization with full coverage are:

$$(\alpha_i + \beta_i) - (3\sigma + 2\tau) p_i = 0, \; i = 1, ..., 4.$$

Candidates for equilibrium prices are

$$\begin{aligned} p_1^* = p_2^* &= t\frac{2m+1}{4m+1} + E\frac{12m+2}{36m+7}, \\ p_3^* = p_4^* &= t\frac{2m+1}{4m+1} - E\frac{12m+2}{36m+7}, \end{aligned}$$

and subscribers shares are

$$\begin{aligned} \alpha_1 = \alpha_2 &= N\left(\frac{1}{4} + \varepsilon\frac{4m+1}{72m+14}\right), \\ \beta_1 = \beta_2 &= N\left(\frac{m}{2} + \varepsilon\frac{12m^2+3m}{36m+7}\right), \\ \alpha_3 = \alpha_4 &= N\left(\frac{1}{4} - \varepsilon\frac{4m+1}{72m+14}\right), \\ \beta_3 = \beta_4 &= N\left(\frac{m}{2} - \varepsilon\frac{12m^2+3m}{36m+7}\right). \end{aligned}$$

Consumer surplus under symmetric regulation, including transport cost, is

$$CS^{sym} = (N + 2M) S - tN\tfrac{20m^2+41m+10}{16m+4} - tN\varepsilon\left(m + \tfrac{1}{2} + 3\varepsilon\tfrac{(4m+1)^2(2-3m)}{(36m+7)^2}\right).$$

Firms' profits are

$$\begin{aligned} \pi_1 = \pi_2 &= Nt\left(\frac{1}{4} + m\right)\left(\frac{2m+1}{4m+1} + \varepsilon\frac{12m+2}{36m+7}\right)^2, \\ \pi_3 = \pi_4 &= Nt\left(\frac{1}{4} + m\right)\left(\frac{2m+1}{4m+1} - \varepsilon\frac{12m+2}{36m+7}\right)^2. \end{aligned}$$

Total welfare is

$$W^{sym} = (N + 2M) S - tN\tfrac{m+6}{4} - tN\varepsilon\left(m + \tfrac{1}{2} + \varepsilon\tfrac{(4m+1)\left(2-180m^2-33m\right)}{(36m+7)^2}\right).$$

For the above equilibrium candidate to be valid we must have $z_{32} \geq 0$, which holds if

$$\varepsilon \leq \overline{\varepsilon}^{sym}(m) = \frac{36m+7}{24m+6}.$$

The surplus of indifferent consumers at the equilibrium prices must be non-negative, in particular that of the indifferent captive consumers. Their surplus can be shown to be non-negative if $S - p_2 - tz_{23} \geq 0$, or

$$s \geq \underline{s}^{sym}(m, \varepsilon) = \frac{12m + 2\varepsilon + 8m\varepsilon + 5}{16m + 4}.$$

Note that $\overline{\varepsilon}^{sym}(m) > \overline{\varepsilon}(m)$ and $\underline{s}^{sym}(m, \varepsilon) < \underline{s}(m, \varepsilon)$, so that both constraints are redundant for $(\varepsilon, m, s) \in \Phi$. ■

Proof of Proposition 1:
Proof. Consumer surplus under symmetric regulation is higher if $CS^{sym} \geq CS^{asym}$, which can be shown to hold for all $(\varepsilon, m, s) \in \Phi$. Let $\varepsilon^W(m)$ be defined by $W^{sym} = W^{asym}$. Then it can be shown that $W^{sym} \geq W^{asym}$ for $(\varepsilon, m, s) \in \Phi$ and $\varepsilon \leq \varepsilon^W(m)$, the latter of which is not binding if $m > 0.08843$.[13] ■

Proof of Proposition 2:
Proof. Consumer surplus under no access is higher than under asymmetric regulation if $CS^{na} > CS^{asym}$, which can be shown to hold for $(\varepsilon, m, s) \in \Phi$ such that $m < \overline{m}(\varepsilon)$ for some function $\overline{m}(\varepsilon)$ and s sufficiently close to its lower limit for no access of $4m + 8/3$. A similar result holds for symmetric regulation if m is smaller than some function $\underline{m}(\varepsilon) < \overline{m}(\varepsilon)$. Thus there are $(\varepsilon, m, s) \in \Phi$ with $\underline{m}(\varepsilon) < m < \overline{m}(\varepsilon)$ and $CS^{sym} > CS^{na} > CS^{asym}$.[14] ■

Proof of Proposition 3:
Proof. Given $\overline{p}_2$, the other firms' equilibrium prices can be found from the first-order conditions as above, resulting in

$$\begin{aligned} p_1 &= ... + \frac{7 + 30m}{28 + 108m}\overline{p}_2, \\ p_3 = p_4 &= ... + \frac{7 + 36m}{28 + 108m}\overline{p}_2. \end{aligned}$$

These prices are increasing in the level of the price floor, but slower than the price floor itself. Equilibrium subscriber numbers are

$$\begin{aligned} M + \alpha_1 &= ... + N\frac{7 + 30m}{16t(7 + 27m)}\overline{p}_2, \\ \alpha_2 + \beta_2 &= ... - N\frac{21 + 158m + 288m^2}{16t(7 + 27m)}\overline{p}_2, \\ \alpha_3 + \beta_3 = \alpha_4 + \beta_4 &= ... + N\frac{(4m + 1)(7 + 36m)}{16t(7 + 27m)}\overline{p}_2. \end{aligned}$$

Those of the entrants and network 1 are increasing in $\overline{p}_2$, while those of network 2 are decreasing. ■

[13] Details on the corresponding calculations are available from the author.
[14] Details on the corresponding calculations are available from the author.

References

[1] BIPT (2010). Press Release, "L'IBPT, le CSA, le Medienrat et le VRM proposent l'ouverture du câble au travers d'une collaboration historique", December 20th, available at http://www.bipt.be.

[2] Bouckaert, J., T. van Dijk and F. Verboven (2008). "Regulation and broadband penetration – What is required to regain speed in Belgium?", mimeo, available at http://www.econ.kuleuven.be/public/ndbad83/frank/policyReports/Bouckaert,%20 van%20Dijk%20&%20Verboven,%202008.pdf (accessed April 12th, 2011).

[3] Cave, M. (2006). "Encouraging infrastructure competition via the ladder of investment", Telecommunications Policy, 30, pp. 223-237.

[4] Chen, Yongmin and Riordan, Michael H. (2007). "Price and Variety in the Spokes Model". Economic Journal, 117:897—921.

[5] Conseil de la Concurrence (2011). Avis 2011-A/A-01, "Avis du Conseil de la concurrence du 21 février 2011 relatif au projet de décision du Conseil de l'IBPT concernant l'analyse des marchés large bande", available at http://www.bipt.be.

[6] Crandall, R.W. (2008). "Letting go? The Federal Communications Commission in the Era of Deregulation", Review of Network Economics, 7(4), pp. 481-508.

[7] Crandall, R.W., J.G. Sidak and H.J. Singer (2002). "The Empirical Case against Asymmetric Regulation of Broadband Internet Access", Berkeley Technology Law Journal, 17(3), available at http://www.law.berkeley.edu/journals/btlj/articles/vol17/CRANDALL_et_al.pdf (accessed April 11th, 2011).

[8] Farrell J., and P. Klemperer (2007). "Coordination and Lock-In: Competition with Switching Costs and Network Effects", Handbook of Industrial Organization, volume 3.

[9] Hausman, J. (2002). "Internet-Related Services: The Results of Asymmetric Regulation", in R.W. Crandall and J.H. Alleman (eds), Broadband: Should We Regulate High-Speed Internet Access?, AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.

[10] Hausman, J., J.G. Sidak and H.J. Singer (2001). "Cable Modems and DSL: Broadband Internet Access for Residential Customers", American Economic Review, Papers and Proceedings, 91(2), pp. 302-307.

[11] Hazlett, T.W. (2005). "Rivalrous Telecommunications Networks With and Without Mandatory Sharing", AEI-Brookings Joint Center for Regulatory Studies Working Paper 05-07.

[12] Hoernig, S. (2010). "Competition between multiple asymmetric networks: theory and applications", CEPR Discussion Paper 8060, October.

[13] Markus, S. (2005). "Is the U.S. dancing to a different Drummer?", Communications & Strategies, 60(4), pp.39-58.

[14] Pavón-Villamayor, V. (2007). "La convergencia y el principio de la neutralidad tecnológica," El Trimestre Económico, Fondo de Cultura Económica, vol. 74(4), pages 845-883. English translation available at ftp://ftp.zew.de/pub/zew-docs/sw_2007/papers/Pavon-Villamayor.pdf (consulted on 12 May 2011).

[15] Von Ungern-Sternberg, T. (1991). "Monopolistic Competition on the Pyramid", Journal of Industrial Economics, 39(4), pp. 355-369.