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Open Access and Content Competition

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Abstract

Broadband "open access" regulation mandates openness of conduits (e.g. upgraded cable television) to service providers (e.g. America Online), but policy discussion often suggests that the ultimate goal is openness to advanced content (streaming video, interactive e-commerce, etc.). We define two forms of regulation, open access and common carriage, and discuss when they are equivalent. We argue that they are quite different in local access broadband. We develop a systems model with free entry and competition in all three industry segments (conduits, service providers, and content) and examine how open access regulation affects the number of firms in each. We confirm the view that an open access requirement can reduce entry of physical conduits, and more surprising we also describe conditions under which it can reduce the amount of content available to consumers.

JEL classification: L1, L5, L9; keywords: open access, broadband

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1 Introduction

May the owners of communications infrastructure choose who accesses that infrastructure? Frequently this question is cast in terms of content and conduit. Owners of cable television conduits do choose which channels to carry. Owners of telephone conduits are common carriers and may not discriminate among callers who produce telephone "content." That much is clear, but the picture is clouded when intermediary firms are added between the conduit and content. That is the situation today with regard to Internet access, and in this paper we provide a framework for thinking rigorously about openness with intermediaries.

The Telecommunications Act of 1996 introduced resellers between the local telephone conduit and the caller/consumer. Then broadband Internet put telephone and cable companies into competition for the first time. By law, telephone companies had to open their conduits to intermediaries, first to dial-up Internet Service Providers (ISPs), and then to broadband Competitive Local Exchange Carriers (CLECs). Cable companies had no such regulation, and they successfully fought off "open access" requirements at the local and national level. But mergers in the cable industry led to a series of consent decrees that did provide for intermediaries between cable companies and consumers. Opinion then turned against these open access requirements, which have been blamed for the slow deployment of advanced telecoms services in the United States (Hausman 2002).[2]

Part of the cause of this controversy is that two regulatory traditions are clashing. More important, technological change has created a new class of intermediaries, variously called Internet Service Providers, portals, virtual conduit operators, or content aggregators. We discuss the functions of these firms below, but for now let us refer to them as service providers. Like telephone resellers, service providers

[2]Strong arguments for and against open access respectively are Lemley and Lessig (2001) and Hazlett and Bittlingmayer (2003).

are the middlemen between the conduit and the content, but unlike in telephone, they are *not* common carriers. This means that openness of the conduit to service providers is not equivalent to openness to content.

No clear principle has been developed as to which type of openness is more desirable. Telephone common carrier regulation favored openness to content, but that rule was laid down long before there was a distinction between telephone company and service provider. The first service providers were the dial-up ISPs. These were initially a perfectly competitive industry of small firms, and they behaved like common-carriers even without regulation. Indeed, the technology of the Internet made it difficult for these ISPs to control web page content in any way. Now service providers are becoming larger, more technologically diverse, and less competitive, but still regulation focuses on the conduit, not the service provider.

This paper provides a framework for analyzing open access regulation that forces conduits to sell access to multiple service providers. The central decision in the model concerns a service provider (SP) that sells subscriptions to consumers and also sells access to content providers. This means the SP is a two-sided network (Rochet and Tirole 2004) that must determine a "price structure," i.e. whether to favor the consumer or the content side of the market. Here we focus on the content side, where the SP has conflicting incentives: to offer a large amount of content in order to attract subscribers or to limit content competition in order to create rents which it can expropriate.

Our model addresses the same general question as Gehrig (1998), namely whether the owner of a marketplace gains or loses from hosting more firms. As in his paper, we find that with sufficient differentiation between markets (here SPs), there is an interior equilibrium in which the SP owners will balance the conflicting incentives of variety for consumers versus rent extraction from producers. This result echoes the systems model of Church and Gandal (1992) who also find interior equilibria when software firms choose which of two incompatible computer platforms to develop for.

Rubinfeld and Singer (2001) consider vertical integration and vertical foreclosure in broadband, but the setting and results are not the same. They examine the incentives of broadband providers to foreclose content that they themselves own. They argue that a firm like Time Warner might have an incentive to exclude content on its America Online service that competes with content produced by Time Warner. Church and Gandal (2000) show a similar result in a hardware-software system. Chipty (2001) empirically finds that vertical integration does cause foreclosure in cable television. The results of these papers have parallels in our model, but in our case "vertical integration" occurs between two downstream segments, the service provider and the conduit. Content, in our model, is always independent.

Our paper offers three contributions. First, it includes three industry segments – conduits, service providers, and content providers – and allows for free entry in each segment; previous papers generally consider only two conduits or SPs. Second, we do not assume that service providers are open to all content; instead they choose how much content to offer endogenously. Third, we examine the effect of open access regulation on this choice. Under open access, an SP only sells one service to the consumer, whereas under closed access the integrated conduit/SP provides SP functionality, local access infrastructure, and other services like cable television or telephone.[3] Thus, the stand-alone SP has less incentive to sign up an additional subscriber, which means that open access regulation could tip the tradeoff more in the direction of content restrictions and reduced openness of SPs to content. This means that open access does not necessarily improve consumer welfare.

In the next section we discuss the role of the service provider. In Section 3 we present a model of competition with "closed access," i.e. one service provider per conduit, and then extend the model to open access. In Section 4 we compare the

[3] Hazlett and Bittlingmayer (2003) discuss multi-service offerings of cable television companies.

two regimes to each other and to the dial-up-based Internet. We present extensions to the model and conclusions in section 5.

2 Service Providers and Open Access

Communications networks consist of numerous layers. For example, the cable television supply chain consists of initial inputs produced by studios, aggregation by program services (channels), and distribution by cable operators (Chipty 2001). The supply chain for broadband Internet is even more complex, consisting of a large number of "platforms" (Greenstein 2000). Most of the platforms are competitive markets, but Greenstein notes that continued competition is not assured. For purposes of analysis, we consider three layers, "conduits," "service providers," and "content firms."[4]

Content Firms. The meaning of "content" has expanded relative to traditional media like television. While movies and TV-type programming are among the categories of broadband Internet content, online retail stores, mapping services, instant messaging, and so forth also provide content.[5]

While the initial business model for Internet content involved free, advertising-supported content, financial difficulties have led to a refocus on content paid for at least partially by the consumer. E-commerce is also content paid for by the consumer. For these reasons and for simplicity, we do not discuss advertising here.

[4] Wireless data, such as NTT DoCoMo's iMode service, has a similar structure, although for now the service provider and conduit functions are usually integrated within the same company. We think it is likely that calls for open access will develop in wireless, and we believe our model translates directly to that setting.

[5] Communications networks also allow users to communicate with one another and host their own personal content. Coffman and Odlyzko (2002) argue that two-way peer-to-peer communications are the most important Internet service, which would make other regulatory issues subordinate. But even these peer-to-peer activities are usually facilitated by upstream firms, which we will lump together with other types of content firms.

Service Providers. The next stage in the supply chain is the service provider. The pioneers in this field were the dial-up Internet Service Providers (ISPs) that provided a simple, leased connection to the Internet backbone. ISPs have no editing capability and behave like common carriers, but this is a market outcome rather than a regulatory one.[6]

The service provider industry has grown more diverse and less competitive. The most prominent service provider is America Online (AOL), which engages in extensive content aggregation and presentation activities. AOL explicitly charges access fees to content firms that want to be hosted on their service. Major SPs Earthlink and Microsoft Network (MSN) also do this, but not as actively. SPs also can discriminate on quality through the use of preferential caching services. These were pioneered by firms like Akamai, but are now integrated into the functionality of many SPs.[7] We therefore model content firms that pay an access fee in order to be available to an SP's subscribers.[8]

Conduits. The final link in the supply chain is the conduit, the cable or wireless connection between the SP and the subscriber's home.[9] Building conduits involves large fixed and sunk costs, so there is naturally concern with a lack of competition in this layer. Faulhaber and Hogendorn (2000) find that multiple wired conduits are

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[6]Many ISPs offer some filtering of content to prevent children from accessing adult sites or employees from accessing entertainment sites. ISPs also provide *de facto* content discrimination by promoting certain web sites on the web browser start-up screen.

[7]Rubinfeld and Singer (2001) discuss the increasing ability of SPs to practice what they call "content discrimination."

[8]NRC (2002) discusses discrimination in favor of certain content and a "walled garden" approach in which access to the general Internet is difficult or even unavailable. They note that just because a garden is walled does not mean it is small, so it is not clear that consumers would be made worse off. In our approach, consumers perceive content firms that pay access fees as markedly better; we do not require that the general Internet be outright disconnected.

[9]There may be economies of scope if the service provider and conduit are integrated. The degree to which it is possible or desirable to have separate service providers and conduits is a contentious issue. In this paper we assume there are no economies of scope as a benchmark case.

likely to enter in most urban and suburban areas, provided that there are no regulatory barriers. Wireless competitors may also arise. Still, the number of conduits is small, so market power is an issue.

Because of this potential for market power in the conduit layer, mergers involving telephone or cable television firms have led to calls for regulation. The late 1990s mergers of AT&T with TCI and MediaOne led Portland, Oregon and other cities to call for a choice of SPs on these conduits rather than a single vertically integrated SP (FCC 1999). AT&T and its allies maintained that open access amounts to giving away their expensive infrastructure investment, while the cable boards and several SPs argued from a common-carrier analogy. The arguments only concerned whether the conduit should offer open access to SPs, not whether the SP(s) should offer open access to content firms. Thus, the debate was not about true common carriage. In March 2002, the FCC concluded that cable broadband is an "information service" and not subject to any open access requirements (FCC 2002). It also expressed concern that open access regulation would threaten facilities-based conduit competition. The court found likewise, paving the way for asymmetric regulation of cable television and telephone with regard to Internet access.

Open access quickly reappeared when the FTC took up the review of the AOL Time Warner merger. In its consent decree, the FTC forced AOL to allow other SPs access to the Time Warner cable conduit before it could offer its own service.[10] However, this decree was much less strict than what telephone carriers were subject to under the Telecoms Act.[11]

With the 2001 downturn in the telecoms sector, deployment of new technologies

[10]Ironically, AOL's inability to gain access to non-Time Warner cable systems is a threat to the company and may reduce concentration in the SP industry. See "AOL Rethinks its Game Plan on Internet Access," *Wall Street Journal*, April 19, 2002, pg. A3.

[11]Julia Angwin, "'Open Access' Isn't So Open at Time Warner," *Wall Street Journal*, May 6, 2002, pg. B1 describes how "Cable companies can hand pick a few competitors that agree to their stringent terms."

slowed, prompting concern from governments that viewed these technologies as engines of economic growth. The open access regulations have come in for criticism as inhibitors to deployment of broadband. The model we present below suggests that these criticisms may be correct, and that open access regulation may reduce conduit deployment and (more surprisingly) content competition.

3 The Model

Our model focuses on competition among content firms and how it interacts with the number of SPs. We believe the focus on content is a useful addition to the open access debate because broadband content is very innovative industry with potential to affect the overall economy while the SP industry is much more specialized.

3.1 The Game

There are M online households which value content, SP, and conduit services. Any number of conduits may serve these households by building infrastructure. Under closed access, each conduit operates one vertically integrated SP. A large number of content firms may buy access to one or more of these conduit/SPs.

The firms compete in a three-stage game: (i) conduits enter the market; (ii) conduits negotiate alliances with content firms; (iii) consumers subscribe to one conduit and purchase content. Consumers can only purchase content available through their chosen conduit.

Stage 1: Conduits Enter. Let the number of conduits that enter be K. For these vertically integrated firms, the fixed cost of entry is F, which includes the capital cost of the conduit and the setup costs of the integrated SP. We assume this cost is identical for each potential entrant.

Stage 2: Conduits Negotiate Alliances with Content Firms. Let there be a large pool of potential content firms, and those which enter become monopolistic competitors. We interpret this to mean that each content firm offers roughly the same type of content (e.g. multiple music servers) but with some horizontal product differentiation. Of course there are in fact many types of content, but our "representative type" approach is equivalent to having many different types, provided the cross-elasticities between types are low so they do not compete with one another.

Each conduit chooses to negotiate an alliance with some of these content firms. In exchange for hosting its product, the content firm pays an access fee equal to a share of its profits. The outcome of this bargaining is that content firms pay a share $\alpha(K)$ of their profits, where $\alpha'(K) < 0$ to reflect a decrease in conduit bargaining power when there are more conduits competing.

Conduit k choooses to host n_k content firms. This choice will affect the content firms' profits, so we denote the profits of a typical content firm on conduit k by $\pi(n_k)$. The profile $\mathbf{n} = (n_1, \ldots, n_K)$ describes the number of content firms available on all K conduits.

We assume any costs of hosting content are constant, and without loss of generality let them be zero. We also assume that there are no fixed costs of entry for content firms. This assumption allows us to focus on the number of content firms without concern for the identity of each firm.[12]

Stage 3: Consumers Subscribe to Conduits and Consume Content. Each consumer purchases a subscription to one, and only one, conduit. Consumer utility has three components: utility from access to broadband content firms (more is better), utility from other conduit services like cable TV and/or telephone service, and idiosyncratic utility for each conduit based on marketing, conduit technology, the user interface, etc.:

$$u_k = v(n_k) + t + \epsilon$$

[12]Adding fixed costs is not a problem as long as $\alpha(K)$ is low enough that content firms have sufficient operating profits to cover the fixed costs.

We model consumer choice using multinomial logit demand, with $v(n_k) + t$ the systematic utility attributable to observable characteristics of the conduit and ϵ the unsystematic utility with a type 1 extreme value distribution. Conduits can obtain revenue from subscribers through a combination of monthly subscription fees, service charges, and indirectly through advertising. Thus, the conduit captures a share $\beta(K)$ of the systematic utility.[13]

Since consumers buy content only through their conduit, content competition takes place separately on each conduit. We model this competition using a reduced form of monopolistic competition. Spence (1976, pg. 410) argues that "The entry of an additional product has several effects. It increases the surplus from the new product, but lowers the demand for existing products and causes them to contract output. In terms of the surplus, there are gains and losses." This suggests that $\pi(n_k)$ is decreasing and that $v(n_k)$ is increasing and concave. The total surplus (per subscriber) from content production and consumption on conduit k is

$$n_k \pi(n_k) + v(n_k) + t$$

In most monopolistic competition models, the total surplus is increasing in the number of firms, provided that consumers value variety enough (Mankiw and Whinston 1986). But what matters for the conduit's choice of the amount of content to offer is the portion of total surplus it can appropriate to itself. Here that is:

$$s(n_k, K, t) = \alpha(K) n_k \pi(n_k) + \beta(K)(v(n_k) + t)$$

[13] It would be preferable to model the subscription price-setting subgame explicitly. However, games in which firms noncooperatively set quality and then price are analytically difficult even when limited to duopoly (see Shaked and Sutton (1982) for pure vertical differentiation, Ferreira and Thisse (1996) for Hotelling horizontal differentiation with quality choice, and Rhee (1996) for the multinomial logit with quality choice). Using a duopoly model to study broadband open access would assume away one of the goals of the policy, namely entry of additional SPs into the market. We believe our approach, where the conduits retain shares α and β of producer and consumer surplus, captures the important intuition behind the quality/price choice while allowing us to consider entry of any number of firms.

The behavior of this appropriable surplus function $s(\cdot,\cdot,\cdot)$ is crucial to the outcome of the model. If s is increasing in n, then even a monopoly conduit would want to offer as much content as possible. If, on the other hand, the following property holds, then even a monopoly conduit would choose an interior profit maximizing number of content firms:

Decreasing Surplus Property (DSP):[14]

$$s_{nn}(n_k, K, t) \leq 0 \text{ and } \exists \hat{n} \geq 1 \text{ s.t. } s_n(n_k, K, t) < 0 \text{ , } \forall n_k > \hat{n}$$

Are we in fact in an environment where DSP holds? One reason to think so is empirical: AOL, MSN and the like do in fact sell special arrangements to a select few content firms. A second reason is theoretical and is based on price discrimination. It is fairly easy to bargain with firms over profit-sharing in alliances, with each firm thus paying a different "price." Identifying different types of consumers and charging them different prices is likely to be much more difficult. This suggests that $\alpha(K) > \beta(K)$, perhaps much greater, and that therefore DSP is likely to hold. Evans (2003, pg. 337) provides a useful table showing that charges are lower to the consumer side of the market is many two-sided platform industries.

3.2 Equilibrium

Stage 3. We solve the game backwards to find a subgame perfect Nash equilibrium. At the final stage, consumers choose conduits according to the multinomial logit model. The strength of the unsystematic utility is parameterized by the variance of ϵ, which we denote σ. The larger is σ, the stronger are the tastes of each consumer for his or her preferred vertically integrated conduit, regardless of the number of content firms available on other conduits.

The outcome of the stage 3 subscription decision is a market function, which gives the probability that a consumer chooses conduit k given the profile of content

[14] Subscripts denote derivatives.

firms available on all the conduits:

$$\Phi_k(\mathbf{n}) = \frac{\exp\left(\dfrac{(1-\beta(K))(v(n_k)+t)}{\sigma}\right)}{\sum_{j=1}^{K}\exp\left(\dfrac{(1-\beta(K))(v(n_j)+t)}{\sigma}\right)} \tag{1}$$

Market share Φ_k increases in the number of content firms on conduit k and decreases in the number of content firms on conduits other than k. Since the total number of consumers is M, the number of subscribers to conduit k is $\Phi_k(\mathbf{n})M$.

Stage 2. In stage 2, the conduits noncooperatively choose the number of content firms. For any n_k, the conduit receives $\alpha(K)\pi(n_k)$ per subscriber from each of the n_k content firms. The total profit of conduit k, including revenue from both content firms and subscribers, is

$$s(n_k, K, t)\Phi_k(\mathbf{n})M \tag{2}$$

In equilibrium, all conduits simultaneously maximize (2), and we have the following result:

Proposition 1 *For sufficiently large σ, there is a symmetric Nash equilibrium in which all conduits host n^* content firms and have equal market shares $\Phi_k(\mathbf{n}^*) = 1/K$.*[15] *If DSP does not hold, each conduit hosts every possible content firm, while if DSP holds,*[16] *n^* is an interior solution to*

$$s_n(n^*, K, t)\Phi_k(\mathbf{n}^*) + s(n^*, K, t)\frac{d\Phi_k(\mathbf{n}^*)}{dn_k} = 0 \tag{3}$$

The first term in (3) indicates that a portion of the surplus in the content market becomes profit to the conduit. Under DSP, the conduit cannot capture as much of this surplus when it hosts more content firms. Working against this effect, the second term in (3) shows that hosting more content firms increases the market share of a conduit. But this market share effect diminishes in n, so under DSP there is an

[15] Proofs are in the appendix. For low σ, there may be a vertically differentiated, asymmetric equilibrium as in Shaked and Sutton (1982), but this can only be found numerically.

[16] Actually DSP is sufficient but not necessary; as long as s is decreasing in n and not too convex, the interior equilibrium exists.

interior optimum number of content firms. Thus, common carrier behavior is not necessarily an equilibrium in this model.

Denote the stage 2 equilibrium total surplus that solves (3) by $S(K,t) = s(n^*, K, t)$. Total surplus responds to changes in t and K as follows

Corollary 1 $\dfrac{\partial n^*}{\partial K} > 0 \qquad S_K = \dfrac{\partial S}{\partial K} < 0$

When conduit competition increases (K rises), each conduit's market share falls, which lowers the marginal profit from hosting more content. At the same time, the conduits lose negotiating power and the consumers retain more of their surplus, which strengthens the marginal increase in demand from hosting more content. For both reasons, conduit competition increases the number of content firms hosted on each conduit. In turn this reduces the conduit's surplus. The strength of this response is given by S_K.

Corollary 2 $\dfrac{\partial n^*}{\partial t} > 0 \qquad \beta - 1 < S_t = \dfrac{\partial S}{\partial t} < \beta$

When utility from non-content related services, t, increases (e.g. when a conduit begins offering telephone service), the direct effect is to raise the conduit's surplus by β. But there is more incentive to host content because customer market share is worth more, so n increases. This effect works to decrease S, and the final result is that a \$1 increase in t causes a less than β increase in S; indeed if competitive forces are strong enough, a higher t could actually lower the conduits' surplus. The strength of this response is given by S_t.

Stage 1. Assuming that the conduits are sufficiently differentiated to achieve a symmetric equilibrium, they enter the market until

$$S(K,t)\frac{M}{K} = F \qquad (4)$$

There must be a solution to (4) as long as *Decreasing Surplus* holds.

4 Comparison of the Policies

In this section we use our model to compare open to closed access, emphasizing the number of content firms available under each regime. We apply the model to the current Internet and discuss the changes that are occurring in the parameters.

4.1 Conduits

Under open access, the conduit and SP are not integrated, so consumers choose a conduit and an SP in "mix-and-match" fashion - any SP can be used along with any conduit. We assume that consumers pay the conduit directly for its service, and SPs do not pay the conduit anything.[17]

This form of open access separates the conduits from decisions regarding content. All conduits offer the same services that give utility t, so they have equal market shares.[18] If the number of conduits that enter is J, each conduit has bargaining power $\beta(J)$ with consumers. Let each conduit have a fixed entry cost G; then conduits enter until

$$\beta(J)t\frac{M}{J} = G$$

In principle, the change in the number of conduits under open access is ambiguous, since we would expect $G < F$ (though perhaps not by much). However, we can show that open access increases the number of conduits only under implausible conditions, and therefore we conclude that the number of conduits stays the same or decreases with open access regulation.

Proposition 2 *Suppose there are 2 or more conduits under closed access earning*

[17] It seems natural to assume that a component of open access regulation would be explicit or implicit limits on any fees charged by conduits to SPs (as indeed is the case for telephone companies under the Telecommunications Act of 1996). Therefore we believe they would not constitute a strategic variable.

[18] Conduits do differ in service quality, uptime, tech support, etc., but strategic choice of these variables is beyond the scope of this model.

operating profit $S(K,t)$ per subscriber. Then the number of conduits will increase under open access only if this operating profit is more than three times the fixed cost per home passed, G/M, of building a conduit.

4.2 Service Providers

Under open access, SPs negotiate alliances with content firms and host content. With the mix-and-match assumption, their situation is identical to the conduits described in section 3; only the parameters change. There are two important differences in the competitive situation of the SPs versus integrated conduits (i) SPs do not have to build physical infrastructure, so their fixed cost of entry is lower (possibly much lower) than for an integrated conduit. (ii) The SPs do not offer the non-content related services that give consumers utility t. As a result the SPs retain surplus $S(K,0)$, which is always less than the surplus retained by the *same number* of integrated conduits.

These conflicting effects make the comparison of closed to open access ambiguous. Totally differentiating (4), we find that the change in the number of SPs is:

$$dK = \frac{M\frac{\partial S}{\partial t}dt - KdF}{F - \frac{\partial S}{\partial K}M} \tag{5}$$

The denominator is positive, so equation (5) indicates that the free entry number of SPs responds positively to the decline in the fixed cost and negatively to the decline in service offerings represented by t.

We can put this comparison in terms of easily measured changes according to the following proposition:

Proposition 3 *The number of service providers increases under open access if and only if the percentage reduction in fixed costs is greater in absolute value than some fraction of the percentage change in surplus due to reduced service offerings:*

$$\text{sign}[dK] = \text{sign}\left[|\%\Delta F| - S_t\left|\frac{t}{S}\right|\right]$$

As we discuss below, one cannot rule out $dK < 0$ by appealing to "reasonable" values of the relevant changes.

4.3 Content

The sufficient condition for content to increase under open access is that the SPs' retained surplus decreases even after netting out the effect of the change in t:

$$dn > 0 \quad \text{iff} \quad (S_t - \beta)\frac{dt}{S} + \frac{S_K}{S}dK < 0 \tag{6}$$

From Corollary 2, the term in brackets is negative, i.e. the total effect of the fall in t is a fall in surplus. Thus the first term in (6) is positive and we conclude:

Proposition 4 *The number of content firms on a typical SP will rise under open access only if open access causes sufficient entry of additional SPs:*

$$\exists \delta \geq 1 \quad \text{s.t.} \quad dn > 0 \quad \text{iff} \quad dK \geq \delta$$

Open access can only lead to more content being offered if it results in positive entry of SPs into the market. If it fails to produce such entry, then it would reduce the amount of content available to the consumer.

4.4 Parameterization

The dial-up-based Internet is similar to the open access model because many SPs are available over the telephone conduit. Given the small scale of many dial-up SPs, it appears that the fixed costs are very low. The low price of dial-up SP service relative to local telephone service suggests that t is large relative to S. Currently the low fixed costs outweigh the high value of t, so there are large numbers of dial-up SPs in the market.

For some time now, SPs have been introducing advanced technologies and services that create higher fixed costs and more product differentiation (Greenstein, 2000). The trend toward product differentiation is illustrated by the increased dominance of America Online, a company that was initially expected to lose market share relative to smaller, lower-priced rivals. The advent of broadband local access is bringing more changes as SPs adapt to increasingly demanding content.

All indications are that there will be fewer, more differentiated SPs. In the model, we showed that an increase in SP horizontal differentiation reduces the number of content firms. This leads to an important conclusion: even if consumers continued to access the Internet using the telephone, there would likely be changes in Internet market structure. SP industry consolidation and evolution would reduce the amount of content competition even without broadband.

Using our model results, we discuss four stylized scenarios for the future of the SP industry. We do not present these scenarios as definitive predictions, but merely as examples showing that our model is plausibly consistent with either success or failure of open access from a policy perspective.

In all four scenarios, we assume that under closed access, SP service would be provided by cable TV and telephone companies that sold other high-value services to their customers. This implies a high t, and thus a large loss in surplus from removing that t. Based on the fact that broadband SP service generally costs a bit less than either telephone or cable TV service, we use a working assumption that $t/S = 70\%$. That is, SP service produces a bit less than one-third the total value of a combined broadband/telephone/TV service offering. We also let $S_t = 30\%$ and $\beta = 50\%$, meaning that every \$1 increase in t causes a potential 50 cent increase in retained surplus, but that 20 cents of this is lost due to increased competition between the SPs.

Scenario 1: The Dial-Up Internet. The "classic" Internet industry is characterized by very low fixed costs and near-perfect competition between SPs (ignoring AOL), as opposed to much higher costs for conduits. Thus, $dF/F \approx -100\%$, which means $dK > 0$. In such a competitive environment, entry of a third or fourth SP reduces total surplus considerably, say $S_K/S = -50\%$. Plugging these values into (6) gives

$$(0.80 - 1)(-0.70) - 0.50dK < 0 \quad \text{if} \quad dK > 0.28 \tag{7}$$

Thus any entry at all will increase content in this scenario.

Scenario 2: Main Street. Suppose that SP competition is becoming less intense (as suggested by AOL's high share of the dial-up market) but that it remains inexpensive to set up an SP. Then we still have $dF/F \approx -100\%$, but now perhaps $S_K/S = -10\%$. Then,

$$(0.80 - 1)(-0.70) - 0.10dK < 0 \quad \text{if} \quad dK > 1.4 \tag{8}$$

Now it becomes crucial that a more substantial amount of entry occur, although indeed this is still reasonably likely.

Scenario 3: The Airlines. If scale and technology are the major drivers of change in the SP industry, then SPs will become larger and will have higher fixed costs. Then dF/F will be smaller, and if $dF/F < 56\%$, dK will actually be negative. If SPs nevertheless compete vigorously, added content would still require $dK > 0.28$ as in scenario 1, but now that would be less likely to occur.

This tradeoff has some similarities to airline deregulation. Under regulation, airlines were tied to certain airports and/or certain routes, with the resulting profits supporting a large number of airlines. Deregulation led to falling profit margins and fewer, larger-scale airlines. "Content" variety fell, since the number of cities with jet service and the number of city-pairs with non-stop service fell.

Another lesson from the airlines is that firms will try to find unforeseen ways to control infrastructure. Since deregulation, the primary airline competitive strategy has been avoiding "open access" to airports by creating hub-and-spoke networks.

Scenario 4: IBM and Microsoft. The worst case scenario for open access is that fixed costs are rising in the SP industry, *and* competition is growing less intense. This makes $dK \leq 0$ likely, even though as in scenario 2, $dK > 1.4$ is required for content to increase. Open access would actually reduce the number of SPs and the amount of content. Thus, open access is not really the main issue for competition policy in this scenario; the main issue is the intrinsic uncompetitiveness of the SP industry.

This scenario has similarities to the rise of Microsoft. For years antitrust policy focused on IBM's supposed control of computer infrastructure, and no one expected that the real market power lay in the operating system.

The Internet emerged to prominence in scenario 1, and in that scenario open access is very positive for content competition. Decision-makers in the open access debate should be mindful that the SP industry may be moving away from scenario 1. In general, the direction of movement seems to be toward scenarios 3 or 4, since scale is increasing and competitive intensity may or may not be diminishing. In both scenarios 3 and 4, the effect of open access is not obviously beneficial: it produces less conduit competition in exchange for ambiguous changes in content competition.

5 Conclusion

5.1 Extensions

The model we have presented is flexible to a variety of situations that may be important as broadband Internet (and wireless) evolves. The following are some possible extensions and suggestions for future research.

The Online Population. Throughout the model, the number of consumers, M, is assumed constant. Once demand for broadband has reached a saturation level, this assumption will be justified. During the industry's growth phase, the number of online consumers is growing as the value of buying broadband access increases.

The effect on content of introducing an endogenous M would be to strengthen the demand effect: more content would bring more people online. The probable result would be greater content competition in equilibrium (under either closed or open access).

Geographical Footprints. In this model, the conduits and SPs are assumed to cover the same geographic area, so that both types of firms compete for the same number of households, M. Currently the geographical size of both conduits and SPs is in flux. Many cable television systems, for example, remain confined to a small geographical area but contract with a nationwide SP (for the time being, closed access is the rule).

If this pattern continues, the SPs may have a larger geographic footprint than the conduits. This suggests that the SPs would be very large scale, creating an even more decisive movement to scenarios 3 or 4. A full analysis would include a bargaining decision as independent conduits formed alliances with national SPs.

Partial Vertical Integration: Conduits Own One SP. Open access does not include full "unbundling," in which the conduits are prevented from owning their own SPs. Therefore, it is likely that one of the SPs on each open access conduit would actually be owned by the conduit. This has two implications for the model.

First, assuming these conduit-owned SPs continued to be proprietary, the mix-and-match assumption would be partially violated. It would not be possible to access, for example, Comcast's SP over Verizon's broadband conduit. If each of the conduits' proprietary SPs were equally "good," this would cause no change in the model. But if one conduit had an especially attractive SP, it would skew consumers' conduit subscription choices.

Second, because the conduit would have some stake in the SP industry (and, through access fees, in the content industry), its behavior would be changed. The conduit-owned SP would have a greater incentive to provide content than the nonconduit owned SPs, because more content would bring in more subscribers to the conduit as well as the SP. The conduit would also have an incentive to discriminate in favor of its proprietary SP in terms of quality of transmission (Economides, 1998).

5.2 The Course of the Open Access Debate

The open access debate has proceeded under the assumption that conduits have very high fixed costs and are not very competitive with one another, while SPs have very low fixed costs and are very competitive with one another. The model developed in this paper has shown that under these assumptions, open access produces much greater competition in the content industry, though probably with the tradeoff that there are fewer conduits built. If the current assumptions do not hold in the future, then open access has much less positive effects on content competition, and can even lead to a less competitive content industry.

The SP industry is changing rapidly as the Internet develops. This makes it difficult to determine exactly what the future market structure of a stand-alone SP industry will be, but the success or failure of open access regulation depends on that hypothetical market structure. In 2002, the FCC tilted away from open access for cable (FCC, 2002) and began an inquiry into a similar move for telephone. This culminated in February 2003 with a celebrated rupture between Commissioners Powell and Martin over the proper way to relax open access rules on incumbent telephone companies.[19] Though the rules were relaxed, a greater role for the states means that open access remains an important political issue.

We have emphasized that openness of the conduit to SPs is not equivalent to openness of SPs to content. The first is a regulatory decision, the second has so far been left to the market. We saw in the model that consolidation in the SP industry

[19] A nice description with an amusing title is "The FCC Presses Auto-Destruct," *The Economist,* February 27, 2003.

can lead to less content availability regardless of whether there is open or closed access. If the primary policy goal is to preserve access to content, it may be more effective to consider some type of openness requirement for the SPs themselves, rather than the current focus on regulation of the conduit.

Appendix

Proof of Proposition 1 We begin by determining what values of n_k are candidates for equilibrium. We then prove that the profit function is everywhere concave for these values.

The derivative of (1) is

$$\frac{d\Phi_k(\mathbf{n})}{dn_k} = (1-\beta(K))v_n(n_k)\frac{\Phi_k(1-\Phi_k)}{\sigma}$$

Thus, the first order condition (3) can be written

$$s_n(n_k, K)\Phi_k + s(n_k, K)(1-\beta(K))v_n(n_k)\frac{\Phi_k(1-\Phi_k)}{\sigma} = 0 \tag{9}$$

The first term of (9) is negative by DSP; the second term is always positive.

The second order condition is

$$\begin{aligned}&s_{nn}(n_k, K)\Phi_k + 2s_n(n_k, K)(1-\beta(K))v_n(n_k)\frac{\Phi_k(1-\Phi_k)}{\sigma} + \\ &s(n_k, K)(1-\beta(K))v_{nn}(n_k)\frac{\Phi_k(1-\Phi_k)}{\sigma} + \\ &s(n_k, K)(1-\beta(K))^2(v_n(n_k))^2\frac{(1-\Phi_k)(1-2\Phi_k)}{(\sigma)^2} < 0\end{aligned}$$

The first and second terms are negative by DSP. The third term is negative for concave v. The fourth term is nonpositive for the case of $\Phi_k \geq \frac{1}{2}$. For the case of $\Phi_k < \frac{1}{2}$, we note that if the sum of the third and fourth terms is negative, the entire second derivative is negative. Thus a sufficient condition for the SOC to hold is

$$s(n_k, K)(1-\beta(K))\frac{1-\Phi_k}{\sigma}\left[v_{nn}(n_k)\Phi_k + (1-\beta(K))(v_n(n_k))^2\frac{1-2\Phi_k}{\sigma}\right] < 0 \tag{10}$$

The first terms of (10) are positive, so the inequality holds if the bracketed term is negative. Rearranging that term gives

$$\frac{1}{\sigma} + \left(\frac{v_{nn}(n_k)}{(1-\beta(K))(v_n(n_k))^2} - \frac{2}{\sigma}\right)\Phi_k \leq 0 \tag{11}$$

If σ is sufficiently large, then (11) holds because the positive first term approaches 0.

Proof of Corollary 1: From (9), n^* is the solution to

$$s_n(n_k, K, t) + (s(n_k, K, t)(1-\beta(K))v_n(n_k)\frac{1-\Phi_k}{\sigma} = 0 \tag{12}$$

The derivative (12) with respect to K is:

$$\begin{aligned}
&s_n + s_{nn}\frac{dn}{dK} + s(1-\beta)v_n\sigma^{-1}\left(-\frac{d\Phi}{dK}\right) \\
&+s(-\beta_K)v_n\sigma^{-1}(1-\Phi) + s(1-\beta)v_{nn}\frac{dn}{dK}\sigma^{-1}(1-\Phi) \\
&+s_n\frac{dn}{dK}(1-\beta)v_n\sigma^{-1}(1-\Phi) = 0
\end{aligned}$$

Solving for dn/dK gives

$$\frac{dn}{dK} = \frac{-s_n + sv_n\sigma^{-1}\left((1-\beta)\frac{d\Phi}{dK} + \beta_K(1-\Phi)\right)}{s_{nn} + (1-\beta)\sigma^{-1}(1-\Phi)\left(sv_{nn} + s_n v_n\right)} \tag{13}$$

All terms in both the numerator and denominator are negative, so we have shown that $\frac{dn}{dK} > 0$. It then follows immediately that

$$\frac{dS}{dK} = s_n\frac{dn}{dK} < 0.$$

Proof of Corollary 2: The derivative (12) with respect to t is:

$$\begin{aligned}
&s_{nn}\frac{dn}{dt} + s(1-\beta)v_n\sigma^{-1}\left(-\frac{d\Phi}{dt}\right) + \left(s(1-\beta)v_{nn}\frac{dn}{dt}\sigma^{-1}(1-\Phi)\right) \\
&+\left(s_n\frac{dn}{dt}(1-\beta)v_n\sigma^{-1}(1-\Phi)\right) + \left((1-\beta)v_n\sigma^{-1}(1-\Phi)\right)
\end{aligned}$$

There is no change in Φ when t changes (unless t changes so much that the equilibrium number of firms changes), so the second term drops out. Solving for dn/dt gives

$$\frac{dn}{dt} = \frac{-v_n}{\frac{s_{nn}\sigma}{(1-\beta)(1-\Phi)} + sv_{nn} + s_n v_n} \tag{14}$$

All terms in both the numerator and denominator are negative, so $\frac{dn}{dt} > 0$.

Since $S_t = \frac{dS}{dt} = s_n\frac{dn}{dt} + \beta$ and s_n is negative, it is clear that S_t is bounded above by β. To show that is is bounded below by $\beta - 1$, we need to show that $s_n\frac{dn}{dt} > -1$. We can rearrange this expression to

$$\frac{s_{nn}\sigma}{(1-\beta)(1-\Phi)} + sv_{nn} < 0$$

Since both terms are negative, this must be true.

Proof of Proposition 2: The conduit generates surplus t only. So for 3 or more conduits to enter, it must be that

$$\beta(3)tM \geq 3G \tag{15}$$

Since $S(2,t) \geq \beta(3)t$ by definition, (15) cannot hold unless $S(2,t) \geq \frac{3G}{M}$.

Proof of Proposition 3: We saw in (5) that

$$\text{sign}[dK] = \text{sign}\left[M\frac{\partial S}{\partial t}dt - KdF\right]$$

In free entry equilibrium, (4) requires that $S(K,t) = \frac{KF}{M}$, so multiplying the first term on the right hand side by $\frac{S}{S}$ gives

$$\text{sign}[dK] = \text{sign}\left[\frac{KF}{MS(K,t)}M\frac{\partial S}{\partial t}dt - KdF\right]$$

Now cancel terms and multiply the entire right hand side by $\frac{1}{KF}$:

$$\text{sign}[dK] = \text{sign}\left[\frac{\frac{\partial S}{\partial t}dt}{S(K,t)} - \frac{dF}{F}\right]$$

Substituting $dt = -t$ and $\frac{dF}{F} = \%\Delta F$ and rearranging gives the desired expression.

Proof of Proposition 4: The first term in (6) is positive and the fraction in the second term is negative. The proposition then follows immediately.

References

Chipty, T., "Vertical Integration, Market Foreclosure, and Consumer Welfare in the Cable Television Industry," *American Economic Review* vol. 91, no. 3, 2001, pp. 428-453.

Church, J. and Gandal N., "Network Effects, Software Provision, and Standardization," *Journal of Industrial Economics,* vol. 40, no. 1., 1992, pp. 85-103.

Church, J. and Gandal N., "Systems Competition, Vertical Merger and Foreclosure," *Journal of Economics and Management Strategy,* vol. 9, no. 1, 2000, pp. 25-51.

Coffman, K. G. and Odlyzko, A. M., "Internet Growth: Is there a 'Moore's Law' for Data Traffic?" in Abello, J., Pardalos, P. M. and Resende, M. G. C., eds., *Handbook of Massive Data Sets,* Kluwer, 2002, pp. 47-93.

Economides, N., "The Incentive for Non-Price Discrimination by an Input Monopolist," *International Journal of Industrial Organization,* vol. 16, pp. 271-284.

Evans, D., "The Antitrust Economics of Multi-Sided Platform Markets," *Yale Journal on Regulation,* vol.20, no.2, 2003, pp. 325-381.

Faulhaber, G. and Hogendorn, C., "The Market Structure of Broadband Telecommunications," *Journal of Industrial Economics,* vol. 48, no. 3, 2000, pp. 305-329.

FCC, *Broadband today,* Cable Services Bureau, 1999.

FCC, "In the matter of inquiry concerning high-speed access to the internet over cable and other facilities," FCC No. 02-77, 2002.

Ferreira, R. D. S., and Thisse, J.-F., "Horizontal and Vertical Differentiation: The Launhardt Model," *International Journal of Industrial Organization,* vol. 14, 1996, pp. 485-506.

Gehrig, Thomas, "Competing Markets," *European Economic Review,* vol. 42, 1998, pp. 277-310.

Greenstein, S., "The Evolving Structure of Commercial Internet Markets," in Brynjolfsson, E. and Kahin, B., eds., *Understanding the Digital Economy: Data, tools, and Research,* Cambridge and London: MIT Press, 2000, pp. 151-184.

Hausman, J., "Internet-Related Services: The Results of Asymmetric Regulation," in Crandall, R. and Alleman, J., eds., *Broadband,* Washington: Brookings Institution Press, 2002, pp. 129-156.

Hazlett, T. and Bittlingmayer, G., "The Political Economy of Cable 'Open Access.'" *Stanford Technology Law Review,* vol. 4, 2003.

Lemley, M. and Lessig, L., "The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era," *UCLA Law Review,* vol. 48, no. 4, 2001.

Mankiw, N. G., and Whinston, M., "Free Entry and Social Inefficiency," *RAND Journal of Economics,* vol. 17, no. 1., 1986, pp. 48-58.

National Research Council (NRC), *Broadband: Bringing Home the Bits*, National Academy Press, Washington, DC, 2002.

Rhee, B.-D., "Consumer Heterogeneity and Strategic Quality Decisions," *Management Science,* vol. 42, no. 2, 1996, pp. 157-172.

Rochet, J.-C. and Tirole, J., "Two-Sided Markets: an Overview," working paper, 2004.

Rubinfeld, D. and Singer, H., "Vertical Foreclosure in Broadband Access," *Journal of Industrial Economics,* vol. 49, no. 3, 2001, pp. 299-318.

Shaked, A. and Sutton, J., "Relaxing Price Competition through Product Differentiation," *Review of Economic Studies,* vol. 49, 1982.