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SHOCKS TO THE BROADBAND ECOSYSTEM: IMPLICATIONS FOR COMPETITION AND MARKET STRUCTURE

Abstract: In this POLICY BULLETIN, we evaluate the consequences to broadband service providers ("BSPs") from the tremendous innovation in Internet applications and devices. Our findings reveal that as consumers continue to flock to network-agnostic devices and over-the-top services, they are less wedded to any particular broadband service provider. The problem appears particularly acute for mobile wireless networks where much of the innovation is directed. As a result of this "commoditization" of broadband services, network operators are likely to intensify price competition with each other to the benefit of consumers. However, given the high fixed and sunk costs required to build and operate broadband networks, increasing the intensity of price competition could also result in lower profit margins, thus potentially shrinking the equilibrium number of firms that could profitably serve the market. This possible result is of interest for policymakers because it could mean that in an inter-related broadband ecosystem, prices fall even as markets become more concentrated. These complex responses also suggest that if the ecosystem analogy is appropriate for the broadband marketplace, then public policy must contemplate the full and wide-ranging effects of structural changes across the entire ecosystem, particularly if such changes are driven, in part or whole, by regulatory intervention. A disturbance to one part of an ecosystem, whether of natural or of contrived origins, inevitably flows to other parts of the system and may, in some cases, threaten the overall health and sustainability of the broadband sector. Understanding, and perhaps quantifying, the flow of costs and benefits across the ecosystem is essential to sound policymaking.

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I. Introduction

In the modern communications policy lexicon, the "Broadband Ecosystem" is an expression describing the interdependence of broadband networks, devices, and content.[1] Frequently, the term is intended to suggest some sort of uniqueness inherent to high-speed Internet services, implying that society will need a distinct and perhaps new set of regulatory and competitive tools with which to manage the Internet sector. In fact, though, economic ecosystems in this sense are everywhere.[2] An economic ecosystem is, after all, a collection of goods and services that are inter-related in either demand (i.e., substitutes and complements) or in production (i.e., inputs and outputs). Networks, devices and content make up the Broadband Ecosystem; automobiles; tires and fuel make up the motor vehicle ecosystem. Every good or service is an element of an ecosystem of some sort.

While economic ecosystems are ubiquitous, the concept of an ecosystem need not be vacuous. Indeed, the nature and strength of interrelationships among goods, and the character of the institutions within which they are exchanged, may strongly influence business strategy, public policy and economic outcomes.[3] Accordingly, if one chooses to invoke an "ecosystem" view of communications markets, then it is essential to establish the exact nature of the interrelationships that establish the ecosystem, and then formally model their implications for economic activity and public policy intervention. Certainly, invoking the term ecosystem is not

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[1] CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN, Federal Communications Commission (March 16, 2010) (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296935A1.pdf) (hereinafter the *National Broadband Plan*) at pp. 15-16.

[2] *See, e.g.,* J. Moore, *Predators and Prey: A New Ecology of Competition*, 71 HARVARD BUSINESS REVIEW 75-86 (May/June 1993).

[3] Research and experience indicates that, in an economic ecosystem, behaviors that are colorably anti-competitive or anti-consumer may very well be efficient and welfare-enhancing, and regulatory interventions that are arguably pro-consumer may actually reduce consumer well being. For example, once the strong complementarity between subscription multichannel video services and set-top boxes is considered, there are no apparent gains from a regulatory-mandated retail market for such devices, as encouraged by Section 629 of the Telecommunications Act. T. R. Beard, G.S. Ford, L.J. Spiwak, and M. Stern, *Wobbling Back to the Fire: Economic Efficiency and the Creation of a Retail Market for Set-Top Boxes,* PHOENIX CENTER POLICY PAPER NO. 41 (December 2010) (available at: http://www.phoenix-center.org/pcpp/PCPP41Final.pdf). Likewise, given the strong complementarity between mobile communications services and handset equipment, a regulatory prohibition on certain industry practices—such as term contracts, early termination fees, and handset certification—could lead to higher prices for consumers, an unintended and undesirable consequence of a policy with purportedly pro-consumer intent. *See, e.g.,* G.S. Ford, T.M. Koutsky and L.J. Spiwak, *Consumers and Wireless Carterfone: An Economic Perspective*, PHOENIX CENTER POLICY BULLETIN NO. 21 (September 2008) (available at: http://www.phoenix-center.org/PolicyBulletin/PCPB21Final.pdf); G.S. Ford, T.M. Koutsky, & L.J. Spiwak, *A Policy And Economic Exploration of Wireless Carterfone Regulation*, 25 SANTA CLARA COMPUTER & HIGH TECH. L.J. 647 (2009).

a green light for ignoring the underlying economic realities, nor an excuse for abandoning economic analysis due to some alleged technological watershed. Indeed, as noted economists Carl Shapiro and Hal Varian observe: "Technology changes. Economic laws do not."[4] Fortunately, the economic forces that bind elements into an economic ecosystem are familiar, and their implications can often be modeled using standard, widely-accepted techniques under relevant and plausible assumptions.

In this POLICY BULLETIN, we contemplate the economic effects on broadband service providers ("BSPs") of perhaps the most important trend in modern communications markets: the increase in the use of network-agnostic services facilitated by rapid innovation in both devices and applications. We characterize this trend as attenuating the attachment of consumers to particular broadband service providers, thereby lessening consumers' perceived quality differentiation between broadband networks. Indeed, it appears that the customers of modern multifunction devices and network-agnostic applications increasingly lack much attachment to any particular service provider.[5] The result is stronger price competition. As economic theory suggests, such changes will result in highly competitive market outcomes even when the market contains only a "few sellers."[6] In such circumstances, therefore, while there

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4 C. Shapiro and H.R. Varian, INFORMATION RULES (Harvard Business School Press 1999) at pp. 1-2.

5 S. Wilson, *The Democratization of Wireless: Assessing the Impact of Open Mobile Survey*, DELOITTE RESEARCH TECHNOLOGY, MEDIA & TELECOMMUNICATIONS STUDY (2009) at 2 ("Most respondents believe that the carrier business models of today will no longer be in-use three years from now, and the threat of commoditization looms large") (available at: http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/TMT/tmt_OpenMobileSurvey.pdf); J. Evans, *FaceTime Shows Apple's Network Future*, COMPUTERWORLD (September 13, 2010)("Ultimately the carrier networks will wake up to discover they have become nothing more than mobile ISP's charged with keeping the network alive")(available at: http://blogs.computerworld.com/16935/facetime_shows_apples_network_future); J. Hanson and K. Collins, *Innovative Approaches to Win the US Bundled Pricing Game*, ACCENTURE WORKING PAPER (2008) (available at: http://www.accenture.com/SiteCollectionDocuments/PDF/BundledPricingFINALREV331.pdf); P. Bedell, WIRELESS CRASH COURSE, at 423 (at Ch. 18.5, *The Commoditization of Wireless*); S. Schechner and J.E. Vascellaro, *TV Porn Doesn't Sell Like It Used To*, WALL STREET JOURNAL (Aug. 5, 2011) (reporting that consumers are switching away from MVPD provided on-demand options in favor of Internet available content) (available at: http://online.wsj.com/article_email/SB10001424053111903885604576488540447354036-lMyQjAxMTAxMDAwNTEwNDUyWj.html?mod=wsj_share_email_bot).

6 G.S. Ford, T.M. Koutsky and L.J. Spiwak, *Competition After Unbundling: Entry, Industry Structure and Convergence*, 59 FEDERAL COMMUNICATIONS LAW JOURNAL 331 (2007) (available at: http://www.phoenix-center.org/FCLJCompetitionAfterUnbundling.pdf); T. R. Beard, G. S. Ford, T.M. Koutsky, & L.J. Spiwak, *Network Neutrality and Industry Structure*, 29 HASTINGS COMMUNICATIONS AND ENTERTAINMENT LAW JOURNAL 149 (2007) (previously published as PHOENIX CENTER POLICY PAPER NO. 24 (April 2006) (available at: http://www.phoenix-center.org/CommEntNetworkNeutrality.pdf); *see also National Broadband Plan, supra* n. 1 at p. 37 ("modern analysis find that markets with a small number of participants can perform competitively").

may be "few" providers, the market is performing well and thus the case for additional regulation is weak.

Falling prices and shrinking margins are typically viewed in a favorable light among policymakers, and rightly so. That said, lower profits may have important implications for market structure, innovation and broadband policy over the long-run.[7] In markets with high fixed and sunk costs, shrinking profits may lead to an increase in equilibrium industry concentration among broadband service providers, a result many using traditional antitrust-style market metrics would likely find objectionable.[8] Here, however, we find that prices are lower even when concentration is higher. Moreover, the shrinking profits for network providers may lower welfare in the long-run as firms abandon markets and curb investments, threatening the overall health of the Broadband Ecosystem.[9] Investments are made to reap a financial return. The increased intensity of price competition for Internet connectivity may be expected to reduce returns, and consequently to reduce long-term investments requiring significant sunk expenditures (other things constant).[10] Given the Federal Communication Commission's ("FCC") stated concerns about both the increasing industry concentration[11] and the "affordability" of broadband services[12], our analysis indicates that market evolution is

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7 *Network Neutrality and Industry Structure*, *id.*

8 *National Broadband Plan*, *supra* n. 1 at p. 37 ("Given that approximately 96% of the population has at most two wireline providers, there are reasons to be concerned about wireline broadband competition in the United States"); *In re Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services,* FCC 11-103, __ FCC Rcd __, FIFTEENTH REPORT (rel. June 27, 2011) *passim*.

9 Testimony of Anna-Maria Kovacs before the Committee on Energy and Commerce Subcommittee on Communications and Technology, United States House of Representatives (March 9, 2011) (available at: http://republicans.energycommerce.house.gov/Media/file/Hearings/Telecom/030911/Kovacs.pdf) at 4 ("forcing carriers to raise broadband access prices, cut capital investment, or both").

10 *C.f. National Broadband Plan, supra* n. 1 at p. 42 ("if "expected returns … do not justify [network] upgrades, then users may face higher prices, fewer choices and less innovation.")

11 *See, e.g., In the Matter of Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993 Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services,* FIFTEENTH REPORT, FCC 11-103, __ FCC Rcd __ (rel. June 27, 2011) (available at: http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf); *see also National Broadband Plan*, *supra* n. 1, at pp. 36-7.

12 *See, e.g.,* J. Horrigan, *Broadband Adoption and Use in America,* OBI WORKING PAPER SERIES NO. 1 (February 2010) at p. 5 (available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296442A1.pdf).

contributing to higher industry concentration because some developments are shifting profits away from the core networks and into the application layer.[13]

On the flip side, since these new services require an Internet connection, increases in the number of applications and devices *may* increase the demand for Internet connections, thereby growing the market for connectivity and, perhaps, increasing service provider margins.[14] This latter effect explains, in part, the significant efforts by broadband providers to serve customers by increasing network quality relative to rivals, offering interesting and specialized combinations of services and equipment, and encouraging, both directly and indirectly, innovation in devices, applications and content.[15] Notably, however, our model is limited to the analysis of prices and margins for broadband service; we do not address the service provider's choice of the level of quality or the nature of product offerings, but recognize that quality competition is, today, a primary mode by which service providers attract patrons.

This POLICY BULLETIN is outlined as follows. In Section II, we lay out the structure of a model of competition among broadband service providers. In Section III, we discuss the price-reducing effect from a weakening of consumer-attachment to particular broadband networks resulting from the introduction of new applications and content.[16] Yet, these same applications that weaken attachment also may increase the overall demand for network services, and this higher demand tends to drive up the profits at the network stage.[17] Obviously, these two effects work in opposite directions on the profits of broadband providers. In Section IV, we consider equilibrium industry structure. Concluding comments are provided in the final section.

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13 *C.f., Network Neutrality and Industry Structure, supra* n. 6.

14 R. Webber, *Mixed Views Over Impact of iPad on Mobile Operators,* BROADBAND EXPERT (May 4, 2010) (available at: http://www.broadband-expert.co.uk/blog/mobile-broadband-news/mixed-views-over-impact-of-ipad-on-mobile-operators/778263).

15 *See* G.S. Ford and M. Stern, PHOENIX CENTER PERSPECTIVE NO. 10-07: *Endogenous Sunk Costs, Quality Competition and Welfare: A Technical Note* (December 16, 2010) (available at: http://www.phoenix-center.org/perspectives/Perspective10-07Final.pdf)

16 T. R. Beard, G.S. Ford, T.M. Koutsky and L.J. Spiwak, *Network Neutrality and Foreclosing Market Exchange*, 1 INT. J. MANAGEMENT AND NETWORK ECONOMICS 160 (2009).

17 This effect is akin to the "virtuous cycle" argument made by the FCC in its *Open Internet Order*, but as we show, this cycle is only one of many potential effects of the regulatory intervention. *See In re Preserving the Open Internet, Broadband Industry Practices,* FCC 10-201, REPORT AND ORDER, __ FCC Rcd __ (rel. Dec. 23, 2010) at ¶ 14.

II. Background and Theoretical Setup

We begin with the simplifying assumption that the Internet access service market is served by two symmetric BSPs that engage in product differentiated price competition.[18] We divide the consumers of each BSP into two types. First, some of the customers have a strong attachment to a particular BSP, perhaps due to use of the specialized services of that BSP. Alternately, some customers have a weak (or no) attachment to a given BSP, since these customers use devices or applications that simply require a generic broadband connection and can therefore be used with any BSP's Internet service. As we see it, the trends in technology are increasing the proportion of consumers with a weak, rather than strong, attachment to particular BSPs.

As an example, consider the case of over-the-top video services. Today, many customers purchase both Internet and multichannel video services from a single BSP. Such a customer may have a strong preference for the Internet services of the BSP, since Internet and video services are often bundled in attractively priced packages. Over-the-top video, however, requires only the broadband connection and may serve for some customers as a substitute for traditional multichannel video services. Evidence supports the substitutability of these services.[19] A recent survey by one over-the-top video vendor found that 30% of its customers cancel cable service after using its service, suggesting a contemporaneous decline in specialized services as unspecialized services grow.[20] Likewise, a number of cable operators have reported subscriber loss and partly blame the increased use of over-the-top video services.[21] If the customer no longer subscribes to the pay video services of the BSP but requires only a broadband connection, then that customer's attachment to any given provider is weakened.

Attachment to a specific BSP is also weakened by other marketplace developments. For example, Amazon's Kindle offers a "3G" connection but the customer plays no role in acquiring such service; mobile broadband is bundled with the device. Similarly, Apple is considering becoming a mobile virtual network operator ("MVNO") in an attempt to create its own roaming network, a strategy intended to bundle connectivity with its devices and minimize connectivity

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18 *See, e.g.*, M. Waterson, ECONOMIC THEORY OF THE INDUSTRY (1984), Ch. 6.

19 *See* Schechner and Vascellaro, *supra* n. 5.

20 R. Lawler, *30% of PlayOn Users Cut the Cord,* GIGAOM (October 15, 2010) (available at: http://gigaom.com/video/30-of-playon-users-cut-the-cord).

21 J. Orlin, *Comcast Reports Drop in Cable Subscribers; Blames Economy*, TECHCRUNCH (October 27, 2010) (available at: http://techcrunch.com/2010/10/27/comcast-reports-drop-in-cable-subscribers-blames-economy/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Techcrunch+%28TechCrunch%29); T. Seals, *Can Cable Tackle the Video Cord-Cutting Crisis?*, VISION2MOBILE (March 10, 2011) (available at: http://www.vision2mobile.com/articles/2011/03/can-cable-tackle-the-video-cord-cutting-crisis.aspx).

rates for its data-hungry devices.[22] If successful, Apple will be the seller of both the device and the necessary network connectivity, extracting the consumer from the market for Internet service.

Given this scenario, a service provider's demand consists of two parts representing these consumer groups, given simply here as:

$$q_S = a - \theta_S(P - P') \tag{1a}$$

$$q_W = a - \theta_W(P - P') \tag{1b}$$

where q indicates quantity of broadband services demanded *per representative customer*, P and P' are the own and cross prices of the two BSPs, the subscript "S" indicates demand by users with a strong attachment and "W" indicates demand by users with a weak attachment to a given BSP, a is a willingness-to-pay (for service) parameter, and θ_S and θ_W are the product differentiation parameters. In general, we assume $0 < \theta < 1$. A larger value of θ implies greater substitution between services (i.e., less product differentiation); that is, the difference is prices (P - P') has a larger effect on q when θ is larger. Since the services suitable for any broadband connection do not require attachment to any particular BSP, we assume that $\theta_W > \theta_S$. In other words, price differences are more important to users with weaker attachment to a given BSP.

The q in Equations (1a) and (1b) are unit demands (representing a "connection" necessary to use the relevant device), so that total market demand Q for a firm is given by,

$$Q = n_S q_S + n_W q_W \,, \tag{2}$$

where n_S is the number of customers with a strong attachment and n_W is the number of customers with a weak attachment to a particular BSP. As noted above, each firm has these two sorts of customers, a group that has a strong attachment to a given BSP ($n_S q_S$) and another group

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[22] An MVNO provider purchases bulk capacity from facilities-based mobile communications carriers, which it can then use to support its own customer base. J. Ong, *Apple granted patent where carriers bid to provide service to iPhones*, APPLE INSIDER (February 9, 2011) (available at: http://www.appleinsider.com/articles/11/02/09/apple_granted_patent_where_carriers_bid_for_iphone_service.html); D. Coldewey, *Apple Wants To Be It's Own Carrier; MVNO Patent Application Extended*, TECHCRUNCH (June 2, 2011)(available at: http://techcrunch.com/2011/06/02/apple-wants-to-be-its-own-carrier-mvno-patent-application-extended); M. Mansell, *MVNO: The Future of the iPhone?*, BESTTECHIE (February 9, 2011) ("Apple has been granted a patent for MVNO (Mobile Virtual Network Operator) technology that would allow Apple themselves to act as a "carrier" for the iPhone without needing to invest in the infrastructure or back-ends that they would need if they were setting up a network from scratch") (available at: http://www.besttechie.net/2011/02/09/mvno-the-future-of-the-iphone).

($n_U q_W$) that is relatively more price sensitive (since they can switch between networks without loss of device functionality).

The service provider, therefore, faces the problem of pricing the contract it offers when its customer base includes users of potentially quite different price sensitivities. Under the simplifying assumptions used here, such as linear demands and a uniform price, this problem devolves to one of setting prices to take account of the "average" sensitivity of buyers, and this average depends on both the numbers of customers in each class, and the degree to which they differ in viewing the rival BSP services as good substitutes.[23]

Calculating the average sensitivity to price differentials, we obtain the weighted differentiation parameter:

$$\bar{\theta} = \frac{n_S \theta_S + n_W \theta_W}{n_S + n_W}, \tag{3}$$

which is the customer weighted-average of the two differentiation parameters from Equations (1a) and (1b). Again, linearity allows us to write the firm's total demand as,

$$Q = (n_S + n_W)[a - \bar{\theta}(P - P')]. \tag{4}$$

In the next section, we proceed by describing and solving for the conventional Bertrand differentiated goods pricing game, in which the two downstream firms simultaneously and non-cooperatively select their service contract prices P and P' in order to maximize their own profits.

III. Equilibrium Price

The firm chooses its price (P) to maximize its profits given the other firm's price (P'),

$$\max_P \{(P - c)Q\}. \tag{5}$$

The game described by the payoffs of the form given in (5) is well-behaved and the solution is both unique and intuitively plausible. We restrict attention to symmetric solutions.

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[23] The idea is similar to that in T. R. Beard, R. Saba, G. Ford & R.C. Hill, *Fragmented Duopoly: A Conceptual and Empirical Investigation*, 78 JOURNAL OF BUSINESS 2377-2396 (2005).

A symmetric Nash equilibrium results in the following equilibrium market price(s):

$$P^* = c + \frac{a}{\overline{\theta}} \tag{6}$$

In Equation (6), we see that prices (charged by both providers) are equal to marginal costs (c) *plus* a mark-up $(a/\overline{\theta})$, where the mark-up reflects the degree of product differentiation and the level of willingness to pay for the service. This expression for price allows us to reach several conclusions. First, price is higher when willingness to pay, measured by a, is higher. That is, as "cool" new services usable on any BSP's broadband connection are introduced (e.g., video, games, texting, and so forth), the willingness to pay for connectivity may rise, thereby pushing up prices and price-cost margins.

Second, reductions in average product differentiation (an increase in $\overline{\theta}$) will cause prices to become closer to variable costs (c). Thus, the components that make up the parameter $\overline{\theta}$, such as the numbers of buyers in the strongly and weakly attached categories (see Eq. 3), will affect the mark-up in equilibrium. For example, if services unspecialized to a network grow at the expense of specialized services (i.e., reducing n_S and increasing n_W), then $\overline{\theta}$ increases (see Eq. 3), and consequently price falls; or, if the unspecialized service just brings in new consumers (i.e., increases n_W, n_S constant), then $\overline{\theta}$ also increases (see Eq. 3), and price falls. In other words, the migration of customers to services that do not require a particular BSP's services reduces the effective degree of differentiation between BSPs, thereby increasing the intensity of competition and reducing margins on Internet connections. On balance, the effect of services that weaken attachment is to increase the competition between providers regardless of the initial market structure, and this increase in competition may be expected to result in lower mark-ups.

The analysis above illustrates some of the competitive consequences of the increasing sophistication and capabilities of devices and applications in the Broadband Ecosystem. Although the network service providers are not directly involved in the creation or pricing of a new device or application that eases the use of unspecialized services, they are materially affected by its introduction. That is, devices, applications and networks *are* part of an ecosystem. These material effects, though, are not solely destructive of the firms' bottom lines: if new customers, who previously did not buy any service, are drawn into the market by the opportunities presented by a novel application, then the BSPs can benefit. Using the solutions to the model and defining the firms' profit functions in equilibrium, the profit of a firm can be written as:

$$\pi^* = \left(\frac{a}{M}\right)^2 \frac{(n_S - n_W)^2}{n_S\theta_S + n_W\theta_W} \tag{7}$$

Equation 7 illustrates the potentially important effect of increases in total customer numbers arising from an increase in the numbers of customers with weak attachments. Profit of the firm is necessarily rising as n_W rises whenever, for example, $\theta_S > \theta_W/2$. In other words, the firm enjoys increased profits from the introduction of a device that draws only weakly attached customers even though it increases the level of price competition, at least whenever the price sensitivity of strongly-attached customers is sufficiently high to begin with.[24] Thus, BSPs may favor the launching of new, unspecialized services even though they know the price consequences may be unfavorable for them. (Consumers, on the other hand, enjoy at least short run gains from the new device or application regardless of the effects on service providers).

Hence, the introduction of new, high-value Internet-dependent devices and services can represent a case in which the interests of most or even all of the relevant participants align—a "virtuous cycle" in the lingo of the *National Broadband Plan*.[25] The device maker or seller of the unspecialized service, of course, benefits from sales to the public. The customers enjoy (at least) two sources of benefit: lower prices for service contracts due to increased price competition among broadband providers, and gains arising from new market participants attracted by the device's or application's potential. (A third sort of benefit, not modeled here, presumably attaches to customers who switch from specialized to unspecialized services.) Even the service providers, who will certainly experience more price competition and lower margins as a result of the new service or device introduction, can benefit from the introduction if it is truly significant or revolutionary, so that it induces sufficient inflows of new customers to the marketplace. The opportunities to serve those customers can blunt the less appealing consequences of more intense price competition. As discussed below, however, this cycle may not always be so virtuous. Over the long-run, a rise in the intensity of price competition among broadband networks potentially has consequences of a less favorable sort.

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[24] *See, e.g.*, M. Reardon, *Modern Power Moms Flock to Smartphones*, CNET.COM (August 17, 2009) (available at: http://news.cnet.com/8301-1035_3-10310523-94.html); *A New Wave of Smartphone Platforms Attracts New Corporate Users—and IT Concerns*, EWEEK.COM (July 1 2009) (available at: http://mobile.eweek.com/c/a/Mobile-and-Wireless/A-New-Wave-of-Smartphone-Platforms-Attracts-New-Corporate-Usersand-IT-Concerns-835324); F. Sideco, *Smartphones to Account for Majority of Cellphone Shipments by 2015,* ISUPPLI.COM (August 25, 2011) (available at: http://www.isuppli.com/Mobile-and-Wireless-Communications/News/Pages/Smartphones-to-Account-for-Majority-of-Cellphone-Shipments-by-2015.aspx).

[25] *National Broadband Plan*, *supra* n. 1 at p. 15 ("Networks, devices and applications drive each other in a virtuous cycle. If networks are fast, reliable and widely available, companies produce more powerful, more capable devices to connect to those networks. These devices, in turn, encourage innovators and entrepreneurs to develop exciting applications and content. These new applications draw interest among end users, bring new users online and increase use among those who already subscribe to broadband services"); *see also Open Internet Order*, *supra* n. 17 at ¶ 14.

IV. Industry Structure

In earlier research, we have demonstrated that the regulation of broadband services aimed to curbing the innovative-freedom of broadband providers may lead to increases in industry concentration.[26] The same is true for the increased intensity of price competition resulting from a weakening of consumer attachment to networks, which may follow the introduction of certain applications. To demonstrate, let the number of service providers be endogenous in the long-run. Moreover, assume a long-run "saturation" of the market so that $n_S + n_W = N$ is fixed. (We are therefore imaging that point in the future where broadband access is in fact universal.) Let δ_W denote the fraction of the consumers with weak attachment. Hence, $n_W = \delta_W N$ and $n_S = (1 - \delta_W)N$. In this situation, the equilibrium profits of data services firm are given as,

$$\pi_{LR} = \left(\frac{a}{M}\right)^2 \frac{N}{\theta_S + \delta_W(\theta_W - \theta_S)}, \tag{8}$$

where M is the number of the BSPs in the market. If we let the fixed costs of a data services firm be denoted by F, then a long-run zero profit condition yields the following number of BSPs:

$$M_{LR} = \frac{a}{\sqrt{F}} \sqrt{\frac{N}{\theta_S + \delta_W(\theta_W - \theta_S)}}. \tag{9}$$

As shown in Equation (9), an increase in the proportion of consumers with weaker attachment, as indicated by an increase in δ_W, reduces the equilibrium number of firms serving the market (M). Thus, the systematic weakening of attachment—whether driven by devices, applications or regulation—results in a *decrease* in the long-run number of firms and, consequently, an increase in market concentration.[27] In the political environment of communications regulation, this rise in concentration might well create some anxiety, especially since the broadband marketplace is sometimes characterized as relatively concentrated.[28] But, in this simple model, the long-run price of data services still *declines* despite the rise in concentration. The long-run equilibrium price can be written as,

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[26] *Network Neutrality and Industry Structure*, *supra* n. 6.

[27] *National Broadband Plan*, *supra* n. 1, at p. 62 ("The key insight is that in such industries the total number of firms is likely to be limited and may even shrink as the market grows."); J. B. Baker, *Competitive Price Discrimination: The Exercise of Market Power without Anticompetitive Effects*, 70 ANTITRUST LAW JOURNAL 643-654 (2003) at p. 645 ("it may be necessary for sellers to charge at least some customers prices in excess of marginal cost in order to make it profitable for firms to enter the market (by covering fixed costs) or stay there (to the extent the fixed costs are not sunk).")

[28] *National Broadband Plan, supra* n. 1, at § 4.1.

$$P_{LR} = \sqrt{\frac{F}{N[\theta_S + \delta_W(\theta_W - \theta_S)]}}, \quad (10)$$

where a rise in δ_W leads to a decline in P_{LR}. This result is of interest for policy makers, since it demonstrates that price is not always positively related to market concentration, but may exhibit a *seemingly* perverse relationship in which prices are seen to fall even as markets become more concentrated. In other words, a strict adherence to the price-concentration relationship implied by the traditional Structure-Conduct-Performance Paradigm, where prices rise with increase in market concentration, is invalid.[29] As we have shown before, in markets with large fixed and sunk costs, the simplistic notion that price and concentration are always positively related is invalid.[30] Indeed, falling prices may drive higher concentration.[31] This particular result is opposite that of our earlier work on *regulation-induced* increases in concentration where we found that higher concentration led to lower consumer and economic welfare.[32]

A. *Revenue from Specialized Services*

This inverse relationship between prices and concentration need not hold, however, in more complex settings. For example, in some cases, the BSPs derive profits from specialized services that may raise the level of customer attachment to a network. Multichannel video service is one example. Let us denote this profit by $\pi_A(\delta_W)$. This profit will inevitably be a decreasing function of the fraction of the market with weak attachment, δ_W. This can be incorporated into the expressions given above for the long-run number of firms and the price of data services by simply subtracting $\pi_A(\delta_W)$ from F. In other words, the smaller the profits from the sale of specialized services in addition to Internet connections, the more the firm's fixed costs that will have to be covered by profits from the sale of data services alone. The equilibrium number of firms is then just

$$M_{LR} = \frac{a}{\sqrt{F - \pi_A(\delta_W)}} \sqrt{\frac{N}{\theta_S + \delta_W(\theta_W - \theta_S)}}, \quad (11)$$

and the equilibrium price is

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29 S. Martin, ADVANCED INDUSTRIAL ECONOMICS (1993) at pp. 5-7.

30 *Competition After Unbundling*, *supra* n. 6.

31 *Id*.

32 *Network Neutrality and Industry Structure*, *supra* n. 6.

$$P_{LR} = \sqrt{\frac{F - \pi_A(\delta_U)}{N[\theta_S + \delta_W(\theta_W - \theta_S)]}}. \quad (12)$$

From Equations (11) and (12) we see that if π_A decreases sufficiently due to the increase in δ_W, then the long-run number of firms could fall sufficiently to cause an increase in the long-run price of Internet connectivity. This result is plausible, but is merely one of several credible possibilities.

B. *Other Long Run Implications*

We could, of course, add more complexity to our analysis, perhaps considering the BSPs incentives to invest in network quality, capacity or innovation. In the long-run, these incentives, and their evolution in the growing application-centric world of broadband access, will be critical determinants of social welfare. Such an analysis would show, at a minimum, that the increased price competition among networks may reduce the returns to certain kinds of network investments. As observed in the *National Broadband Plan*, "Private capital will only be available to fund investments in broadband networks where it is possible to earn returns in excess of the cost of capital," and "expected returns to telephone companies do not justify fiber upgrades, then users may face higher prices, fewer choices and less innovation."[33] This consequence will be important and will, in turn, generate further adjustments by market participants and, most likely, regulators too. It is therefore important that regulators and others involved in these markets recognize that, in an "ecosystem," there is *never* going to be just a single consequence of any change in policy, cost, or demands. Our analysis here establishes some possible consequences of the lessening of product differentiation among broadband networks arising from changes in the nature of devices and applications markets. That there will be other consequences we do not doubt.

C. *Caveats*

As with all economic models, a number of simplifying assumptions have been made for this analysis, some of which are practically more significant than others. First, our model is limited to the analysis of prices and margins for broadband service. We do not address the service provider's choice of the level of quality or the nature of product offerings, but recognize that quality competition is, today, a primary mode by which service providers attract patrons. Second, we have assumed that the firm charges a single price for broadband service. It may be

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[33] *The Broadband Availability Gap*, OBI TECHNICAL REPORT NO. 1, FEDERAL COMMUNICATIONS COMMISSION (April 2010) at p. 1 (available at: http://download.broadband.gov/plan/the-broadband-availability-gap-obi-technical-paper-no-1.pdf); *National Broadband Plan*, *supra* n. 1 at p. 42.

possible, however, for the providers to offer multiple prices, with some of the pricing choices aimed at attenuating the effects of reduced differentiation described above. Indeed, we expect the providers to respond to changes that shrink their margins since, in the long run, such reductions could lead to lower network quality and, in turn, reduce the total demand for their services. Third, our economic model describes one of many influences presently acting on broadband market structure and performance. We believe the forces discussed above are at work in the market today. However, the innovation-led commoditization of broadband networks may be attenuated or enhanced by other activities, including the behaviors of consumers and firms, as well as regulatory intervention.

V. Conclusion

In this POLICY BULLETIN, we show the growing attenuation in consumer attachment to particular BSPs has important implications for competition among broadband networks. On the one hand, increases in the demand for new and innovative devices and applications will increase the demand for Internet connections generally, thereby growing the market for connectivity and, perhaps, increasing service provider prices and price-cost margins.[34] On the other hand, the growing role of edge devices and innovative applications in creating value for customers over broadband connections lessens the perceived differentiation among broadband service providers, leading to stronger price competition between them. This latter effect may result in competitive market outcomes even when the market contains only a few sellers. Yet, few sellers may become fewer still as a result of the reduced differentiation and increased price competition of Internet access services, a result many may find objectionable (but for the wrong reasons).[35] Moreover, the shrinking profits of network providers may even lower welfare in the long-run as firms abandon markets and curb investments, threatening the health of the Broadband Ecosystem.

The role of competition, innovation and regulation on the returns and long-run profits of the entire information sector will become a more critical topic in coming years. From the social perspective, one may speak of the *optimal* size and capability of the broadband network. In contrast, the size and capability of the *actual* network is primarily a function of (1) historical

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[34] R. Webber, *Mixed Views Over Impact of iPad on Mobile Operators*, BROADBAND EXPERT (May 4, 2010) (available at: http://www.broadband-expert.co.uk/blog/mobile-broadband-news/mixed-views-over-impact-of-ipad-on-mobile-operators/778263).

[35] *Competition After Unbundling*, *supra* n. 6; *National Broadband Plan*, *supra* n. 1, at pp. 38-39 ("building broadband networks—especially wireline—requires large fixed and sunk investments. Consequently, the industry will probably always have a relatively small number of facilities-based competitors, at least for wireline service. *** [However,] the lack of a large number of wireline, facilities-based providers does not necessarily mean competition among broadband providers is inadequate.").

development; (2) regulation; and (3) the profitability of network investments by those actors in a position to make them. In the case at hand, it is clear that the growing role of applications and devices usable across networks will necessarily change the competitive interaction of broadband service providers, and such developments may reduce both prices and the returns to certain kinds of network investments. As a result, fewer such investments may be made. As observed in the *National Broadband Plan*, if "expected returns to telephone companies do not justify fiber upgrades, then users may face higher prices, fewer choices and less innovation."[36] The difficulty arises because the overall health of the sector depends fundamentally on the health of the broadband service providers, and changes underway at the present time may unfavorably affect the incentives of those with the ability to sustain the access networks. In the long-run, therefore, while there are many actors and moving parts in the Broadband Ecosystem, the central truth remains that the financial health of those who provide network access matters to everybody. (Indeed, the Internet will continue without the iPhone, but the iPhone is useless without quality Internet access.)

A more general and important take away from this BULLETIN is that if the ecosystem analogy is appropriate for the broadband marketplace, then public policy must contemplate the full and wide-ranging effects of structural changes across the entire ecosystem, particularly when such changes are driven, in part or whole, by regulatory intervention. A disturbance to one part of an ecosystem, whether of natural or of contrived origins, inevitably flows to other parts of the system and may, in some cases, threaten the overall health and sustainability of the broadband sector. The pursuit of one type of benefit may bring with it another type of cost. Moreover, some part of the ecosystem may be more vital and some more sensitive to disturbances than are others. Understanding, and perhaps quantifying, such differences is essential to sound policymaking.

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[36] *National Broadband Plan*, *supra* n. 1 at p. 42.