Next Generation Connectivity

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Memorandum Describing Intended Updates to the Final Report

We submitted our draft report, Next Generation Connectivity, to the FCC's National Broadband Plan taskforce on October 13, 2009. The draft was posted for public comment, which yielded comments of substantial scope and detail, both positive and negative. Many were constructive and made very useful suggestions and critiques. These suggestions have been helpful in guiding additional research since the release of the draft report and in strengthening the report. The objective of this memorandum is to present a draft literature review of 57 papers related to international broadband policy. We start by summarizing the major findings of our report.

Our benchmarking report relies on diverse sources of data; refers to households as well as per capita and mobile penetration, and includes speeds and prices. Since the comment period, we have added additional data sources for speed and price, further deepening our study and increasing our confidence in the result: the U.S. is a middle-of-the-pack performer on the core relevant outcome metrics: penetration, speed, and price

In order to begin the process of learning from the experience of other nations, positive as well as negative, we first require a set of metrics by which to evaluate which countries' experiences should be regarded as exemplary, and which should count as cautionary. In our draft report we focused on three major outcome measures of consumer and small business broadband: quantity, quality, and price. Quantity has long been measured by penetration per 100 inhabitants by both the OECD and the ITU. We begin with the now well-known fact that the United States ranks 15th among OECD nations by that measure. We observed that the United States has fallen by that measure, the longest-standing measure that has consistent measurements since the beginning of the broadband transition in most OECD countries, from 4th to 15th between 2002 and 2008.

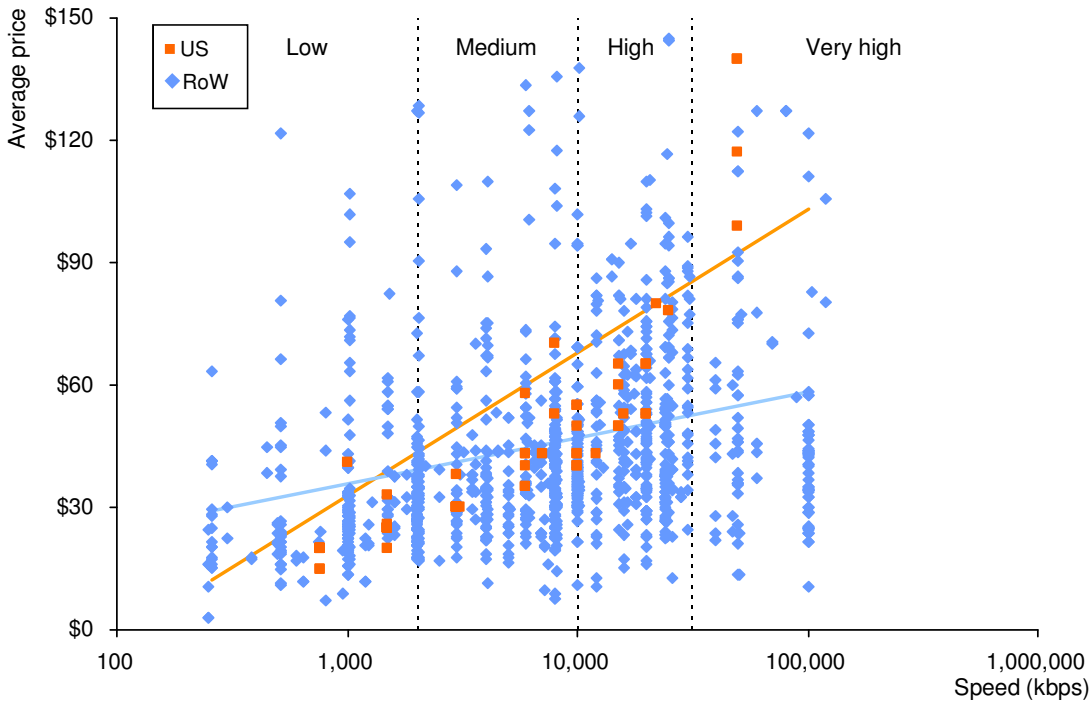
We then reviewed penetration by households, a measure preferred by many commentators. By that measure, the U.S. ranks 14th. The OECD collects and reports household penetration statistics from the respective national statistics agencies, reflecting household survey data. These measures are completely independent of the penetration per 100 metric, which are based on subscription data from firms, rather than survey responses from households. The two measures are, however, highly correlated. (R2=0.82). Per capita measures are updated more regularly, include data about broadband subscriptions by small and medium businesses that use services defined by carriers as "broadband," and have been used systematically for a longer period. Household measures, by contrast, better account for penetration in countries with larger households or fewer small businesses that use consumer broadband for connectivity, but are updated less regularly and do not reflect SME use. Because of their differences, it is useful to continue to use both. The U.S. position is practically identical in both.

We emphasized in our report not only high speeds but also ubiquitous access as a touchstone of next generation connectivity. To measure that dimension, we used OECD, UK regulator, and market data to report on levels of 3G adoption and nomadic (Wi-Fi) access. There we found that the United States is a weaker performer on 3G than it is on fixed broadband, ranking 19th. The U.S. ranks 9th in Wi-Fi

penetration. In all, we concluded that by the measures of penetration, the U.S. was consistently a mid-teens performer out of the 30 OECD countries.

In our report we also identified sources for measuring speed and price. In the original report we introduced data from actual measurements using Speedtest.net alongside OECD data on advertised speeds. Speedtest measures the actual speeds as experienced by end users, running a test application on their machines. Using 41 million actual tests from Q4 2008, we identified the U.S. as ranking 11th among OECD nations in median download speeds, and showed that this position was more-or-less stable whether using average, median, or top 90th percentile measures. We also found that, when we looked at speeds in the capitals and largest city in each of the OECD countries, New York and Washington were not among the top 20 in download speeds, despite their high urban density. Since the release of the draft report, we have added speed measurements reported by Akamai as well, which uses completely different measurement locations—in the network, as opposed to at the edges—and techniques. By Akamai's measure the United States ranks 11th among the OECD nations, as it did by Speedtest data. More generally, the two systems have a high degree of agreement with each other's measurements (R2=0.75). Adding this third entirely unrelated data source, with such high correlation, increases further our confidence in the quality of our findings

In the original report we analyzed various measures of prices reported by the OECD, and conducted our own pricing study based on information gathered from a telecommunications market research firm, Telegeography. Our original study included two entirely independent data sets, with a combined set of 1100 observations, of which we studied 717 offers from the top four providers in each market. Since the comments were filed, we added a third data set, from a separate market research firm, Point Topic. This brought our total number of observations to close to two thousand. Of these, we repeated the analysis of the offers of the top 4 providers in each OECD country that had monthly data caps no lower than 2Mbps (to account for the few countries that have low prices attached to very low data caps). This gave us 950 unique observations from 115 providers in 30 countries. The results of the new, expanded study confirm the results in our original study. In all, they show that U.S. prices are very good by international standards at the very low speeds, around 768kbps, but become more expensive at contemporary broadband speeds above 1.5Mbps. By the time we reach offers for speeds that are high or very high (above 10Mbps), U.S. broadband prices are substantially higher than elsewhere, reflecting the highest prices for the speeds closest to what we anticipate will be typical of next generation networks.



Source: OECD, Telegeography, Point Topic
Note: Top 4 providers only

While the U.S. "meets expectations" based on various predicted performance models, the question we face is whether policy can help join the group of over-performers instead.

It is important to emphasize that the benchmarking exercise is not intended to provide causal explanations. Several comments argued that the benchmarks provide no insight, because the United States' performance on penetration is well-predicted by a variety of measures that are well known to influence penetration: urban density, median income, education, etc. We note with regard to these comments two things. First, while it is entirely reasonable to debate the causal sources of differences in outcomes among countries, it is important to keep the data collection separate from the interpretation. Benchmarks that try to generate hypotheses and identify causal factors risk obscuring the straight, objective outcome measures. Second, while by many of these measures the United States performs at its predicted level, at least in terms of penetration, there are several countries that systematically over-perform their predicted levels and other countries that underperform. The basic challenge is to identify what policies, if any, can make a country join the group of over-performers, rather than settling for a flat "meets expectations."

Our review of the existing literature reveals that the econometrics analysis of broadband penetration and investment is inconclusive. Cross-country studies, in particular, are unlikely to provide useful input into policymaking. The qualitative literature constructed upon detailed case studies of international experiences with broadband deployment provides a far stronger source of policy-relevant research.

A review of the literature on international broadband policy makes up the bulk of this memorandum,

focusing specifically on the literature that assesses the choice between implementing open access versus a reliance purely on inter-platform competition. This literature review will be included in the final report as well.

We reviewed 57 pieces of writing, based primarily on a recent literature review published in *Telecommunications Policy*[1] and comments filed in response to our draft report, supplemented by our own research. We divide these papers into three categories: quantitative studies that focus on broadband penetration, quantitative studies that discuss broadband investment, and qualitative studies that detail broadband policy implementation experience, most of which cover a single country or a comparison of a small number of countries.

We begin by noting the overall weakness of cross-country studies as an approach to extracting causal explanations about a phenomenon as complex as the effects of a regulatory regime on the diffusion of broadband. These studies generally rely on data from either the 30 OECD countries or the set of EU countries. For each country, a small number of observations over time, usually no more than six, are commonly available. There are simply too few observations to tease out the influence of a very large number of potential variables at work: demography and geography; local market conditions and financial markets; strategic behavior by firms as part of the regulatory negotiation process, complemented by strategic behavior by regulators in the same process; the state of financial markets; regional variation within countries; general time diffusion effects; effectiveness of regulation; and specific influential country effects. We detail the complexities, and offer examples of how they undermine the quality of the analysis, in the body of the literature review below. We have, in our review, come across a number of recent studies that use micro-level data and genuine instruments that correct for the problems of the cross-country comparisons work (recent examples are (Sraer (2008), Alter (2009)).[2] The majority of the cross-country quantitative studies offer little useful guidance to policy-makers, although several of these studies are well written, are carried out by highly competent researchers, and contain excellent background materials and perspectives well worth reading. In these cases, although quantitative work can be a powerful heuristic tool for researchers to identify research questions and areas for further scrutiny, investing faith in the numerical results rather than in much richer historical and qualitative information is misguided.

Fifteen of the papers we reviewed analyze the effects of unbundling on penetration. Of these, three rely on data from before 2001, when most of the relevant cross-country variation began, or exhibit methodological weakness. Of these fifteen, six papers find positive effects of unbundling on penetration, three found negative effects, and six had indeterminate findings—they found either no effect or both positive and negative effects.

We have reviewed twenty-three papers related to unbundling and investment. In this set we included all the papers characterized as empirical investigations of investment and unbundling in the recent Cambini and Jiang (2009) review, which is the most recent authoritative review. Several of these are not empirical at all, but are rather conceptual; some include fatal methodological flaws, deeper than the broader limitations of the approach as a whole. Of these twenty-three papers, two show positive effects on investment by incumbents or entrants; one shows positive and negative effects; two report no findings; and one reports negative findings. The remaining seventeen papers are either conceptual or

1 Cambini, C. and Jiang, Y. Broadband investment and regulation: A literature review. Telecommunications Policy (2009). 33 559-574.

2 David Sraer. 2008. Local Loop Unbundling and Broadband Penetration. Unpublished MS.
Alter, A., 2009 The Effect of Access Regulation on Broadband Deployment. Review of Industrial Organization (forthcoming).

modeling exercises, rather than empirical studies, or have serious methodological flaws. The papers we categorize in this group are divided equally, 8:8, between finding negative and positive effects on investment, and one that reviews the literature to 2006 and concludes "Almost ten years have passed since the Telecommunications Act transformed telecommunications regulation in the United States and economists still do not have a thorough understanding (theoretically or empirically) of how local loop unbundling affects investment."[3]

We note that twenty of the thirty-eight quantitative or theoretical papers we reviewed are self-published. At least sixteen of the thirty-eight are directly sponsored by a corporate sponsor with direct interest in the outcomes of the research. The papers on investment exhibit this characteristic at a particularly high rate. Thirteen of twenty-three are sponsored by a party with direct commercial interest in the outcome. While the work should obviously be read on its merits, it is appropriate to note the conflict of interest, as many of the original papers do, but the Cambini and Jiang literature review does not, and to exercise a higher degree of caution when reading these papers.

Given the limitations of the quantitative cross-country studies, we place particular emphasis on qualitative research, which is able to take account of the nuance and local variation to a much greater degree, although it is not, of course, without its own limitations. We reviewed nineteen qualitative papers or book chapters, none of which were self-published, three of which had industry sponsorship. Of these papers, ten identified open access policies as having positive effects on broadband deployment and prices. Two papers (both industry sponsored) identified negative or no effects where positive effects would be anticipated. One found both negative and positive findings. Six found no effect, or focused on the political economy rather than on the outcomes.

Given this state of the literature, the present unstated consensus in U.S. telecommunications policy circles that open access is a theory in disrepute is without foundation in evidence. Quite the contrary, open access should be a continued subject of study, experimentation, and observation as one among the many tools in the toolbox of telecommunications policy.

Relying on fourteen country case studies focused on political economy and firm-by-firm analysis, we found that open access policies played a substantial role in generating competitive markets in many countries and that regulators see these policies as a substantial part of their toolbox when they come to plan the next generation transition.

Our country case studies led us to several observations: (a) entrepreneurial companies that entered the market by virtue of open access policies played an important role in catalyzing the first transition of broadband deployment. In many cases these entrants remain in broadband markets, either themselves or through successor firms, and continue to be important players driving the next generation transition; (b) these entrants generally entered the market using local loop unbundling, which allowed them to combine their own investments in electronics with incumbents' existing investments in trenches, ducts, and copper loops; (c) in a great majority of the best performing countries, open access entrants have complemented, rather than substituting for, facilities-based competitors; (d) we also found that one of the major differences between countries in this field is the degree to which the national regulator is willing to be, and is institutionally capable of being, effective and engaged; (e) the major policy choice facing regulators planning for the next generation is how to trade off the benefits of a mixed system of

3 Guthrie, Graeme. Regulating Infrastructure: The Impact on Risk and Investment. Journal of Economic Literature. 44(4): 925-972 at 969.

facilities-based and some access-based entrants against the potential delay in facilities-based investment. The challenge seems to be not an either/or choice, but finding the right balance.

In all, our findings suggested that the core lesson to be gleaned from the experience of peer countries is that it is possible to arrive at that balance and develop a robust, innovative marketplace, with more players than two facilities-owners. Doing so is far from trivial; not all countries we have observed have done so; and at least in the case of Switzerland, it seems possible to achieve high outcomes purely with a facilities-based market (although apparently more in penetration than in price or speed). The basic policy choice that our study poses to the national broadband plan process is the question of whether, looking from the point of view of long-term planning, a market with two competitors, where entry is entirely restricted to players who can build their own redundant facilities, is sufficiently competitive, or whether measures intended to reach a more robust, but still sustainable, market of four or five effective competitors in each market are an important avenue to explore.

Review of the literature on the effects of unbundling on performance and investment

The following represents a draft review of the literature related to the efficacy of international broadband policy. This literature review is an addition to the draft report delivered to the FCC in October 2009 and comes in response to several critiques that our report had not offered a thorough review of the existing literature, particularly in respect to the relevant literature on the effects of open access policies. We welcome that critique and use it to expand and deepen our report. We are particularly grateful for the constructive contributions that some of the comments made by suggesting relevant literature that ought to be reviewed and considered.

We review here 57 studies, dividing the papers into three categories: quantitative studies that focus on broadband penetration; quantitative studies that discuss broadband investment, and qualitative studies, most of which cover a single country or comparison of a small number of countries. At the end, we provide further analysis of the Wallsten and Hausladen (2009) paper cited by several of the comments, and the analytical work in the Empiris declaration filed in response to our draft report to the FCC. We now turn to a description of the conceptual models that inform this literature.

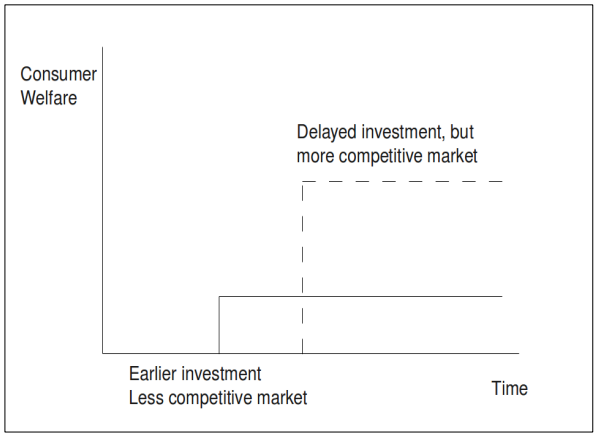
Conceptual models of the relationship between open access and investment

Five basic relationships have been proposed in the literature for the relationship between investments and access regulation, and a sixth emerges as a possible framework from our own case studies and review.

The simple theory that underlies the claim that access rules undermine investment argues that incumbents will not invest in their networks if they are forced to share their networks at inappropriately low rates. This includes two components. First, if the rates are set below costs, the negative effects are obvious, as investment will immediately have a negative value. Hausman (1998) argues that the sunk-cost nature of many of the core network investments made by incumbents, and changing technology, can systematically lead forward-looking price regulation to be too low. Second, the fixed and sunk costs make the investments in broadband infrastructure analogous to investments in innovation (Hausman 1998; Gayle and Weisman 2007), and so the innovation is pursued in expectation of rents derived from a non-competitive market (See also Pyndick 2007). The investment is driven by the expectation of rents from the downstream product, just as investment in innovation is driven by patents that exclude competition, in a downstream product market that is less competitive than it would be with access regulations in place. According to this theory, incumbents would invest less when they are subject to unbundling, unless the prices for the elements would compensate them for all the unsuccessful innovations they installed. We note, however, drawing from innovation economics, that if the prices are high they will deter entry by entrants, and the welfare and innovation benefits that would come from that entry would be lost (Gayle and Weisman 2007).[4] As a result, whether unbundling will, or will not, undermine investment, and what rates would induce the most dynamically efficient levels of investments by both, depends on the effects on both incumbents and entrants incentives.

4 Gayle, P., & Weisman, D. (2007). Efficiency trade-off in designing competition policy for the telecommunication industry. Review of Network Economics, 6(3), 322–341.

The second approach similarly posits that investment will undermine investment incentives, but also accepts that unbundling and open access improves competition, and during the period after investment, consumer welfare is enhanced by the more competitive environment that uses the infrastructure (Hoffler 2007). The figure below describes this relationship conceptually (Alter 2009). The basic trade-off for infrastructure that represents a very long term investment, as in the case of the passive elements of next generation networks, such as the trenches, ducts, holes, and dark fiber which may persist for twenty or thirty years, is the cost of delayed deployment compared to the value of increased welfare over the lifetime of the installed infrastructure.



The third, best-known theory in favor of unbundling is what was in the U.S. referred to as stepping-stone, and what is referred to now in Europe as "investment ladder," introduced by Cave and Vogelsang (2003).[5] The basic idea is that entrants will initially enter the market using wholesale access and later move into unbundled loop access, initially leasing those aspects that are hardest for them to replicate. Then, over time, entrants may be able to build a brand and customer base and shift over to compete on their own facilities to free themselves of dependence on their competitor. We will turn to the empirical literature testing these various hypotheses shortly, but we first note that our case studies do lend some support to the investment ladder theory, but suggest that there is room for further theoretical development. In the Nordic countries, investment ladder seems to have worked through investments in the form of consolidation by the neighboring incumbents entering each other's territories, in part by buying existing facilities from cable and power plant owners, combining with unbundling providers, and expanding their reach. In Japan, Softbank's moves into mobile and (very recently) fiber are consistent with the theory; and in France, the current (small) actual investments and (large) planned investments by Iliad in fiber, as well as the large investments in fiber in the core of the network by Neuf and Cegetel (Fevrier and Sraer 2007) are also consistent with that theory. There is stronger evidence for a less complete version of investment ladder, or for its existence at an early stage, indicated by the move from bitstream—which allows entry with lower investment but less flexibility—to unbundling, which requires more investment on the part of the entrant and gives it greater flexibility to use the electronics it prefers and to innovate in services. Data gathering by ECTA on the relative use of bitstream versus unbundling lines over the past few years shows that in a majority of countries for which there is data, unbundling is increasing at the expense of bitstream while total entrant lines are also increasing. This includes in particular the UK after functional separation, as well as Austria, Denmark, Finland, France, Germany, and Italy.

5 Cave, M., & Vogelsang, I. (2003). How access pricing and entry interact. Telecommunications Policy, 27(10–11), 717–727.

A fourth theory suggests that greater competition will spur investment. It suggests that low cost unbundled elements lower the costs to entrants, who in turn can offer lower cost and more differentiated products to consumers. These low cost, new products increase the consumption of communications services which in turn improves incumbents' cash flow as long as the rates are not set too low (Chang, Koski, and Mujamdar 2003; Friederiszick, H., Grajek, M. & Roller, L. 2008)

A fifth, new conceptual framework is proposed by Bauer (2010).[6] Bauer offers a neo-Schumpeterian model that sees regulatory policy as playing a role in a market dynamic in which many players, both regulated entities and non-regulated entities, react to a set of regulations. On the question of the relationship between open access or market-structuring regulation and investment, Bauer (2010) relies on a neo-Schumpeterian innovation model that suggests that the market structure most conducive to long-term, dynamic investment, is one where there is neither too much concentration, nor too much competition. Instead, a small set of large firms, with smaller firms constantly contesting, but with sufficient scope to provide a serious threat, is most conducive to dynamic investment. How to reach that state may vary from country to country, and is unlikely to be a single, one-shot decision, but will require continuous updating and "fine tuning" over time. The basic neo-Schumpeterian model is consistent with the experience of countries that have a small number of moderately sized competitors to a large incumbent—such as in Japan, France, the Nordic countries—along with the tendency in the past few years for larger players to consolidate several smaller entrants—be it Telenor in Sweden, Carphone Warehouse in the UK, or SFR in France. It is also consistent with the findings of Jung et al. (2008), that while a larger market share of entrants positively effects incumbent investment, the number of entrants does not. The core question that this model presents for the U.S. is whether two is a sufficiently large number of competitors to sustain that dynamic, or whether the regulatory toolbox needs to include a set of tools that can increase the number of competitors and allow for the entry of newer, more agile competitors (Fransman 2006). It is important to note that while critics of unbundling will often quote evidence of consolidation in the entrant market as evidence against the feasibility of competition, this framework would actually interpret such evidence as a maturation of the entrants.

Finally, our own case studies, and our synthesis of the various theories that support open access, as well as our observations of current plans for infrastructure sharing in Switzerland, the Netherlands, and perhaps in Germany and the adoption of functional separation in the UK, Sweden, New Zealand, Australia, and Italy (and voluntary effective separation in the Netherlands), suggest that as a practical matter regulators are edging away from investment ladder and towards a quite different theory, which has not been well articulated in the literature. These cases seem to suggest that much of the competition is carried on not by replicating the trenches and ducts, holes and poles, but by sharing a single, non-redundant high-capacity basic physical infrastructure, and investing in electronics and innovation in processes and services. Open access allows separating out portions of the infrastructure that are slow moving, trenches, ducts, holes in walls, and making those either monopoly of duopoly at most, but allowing competition in electronics and services on top of that slower moving shared core. This theory would be supported by Chang et al. 2003; Jung et al. 2008, Hoffler 2007; Alter 2009; and Bauer 2010. The basic idea is that open access and unbundling is not necessarily a pathway to the development of completely redundant facilities, but might be channeled towards complementary investments around a shared common set of slow-moving, extremely high cost elements: the passive infrastructure. Facilities-based competition that grows out of the happenstance of existing incumbent infrastructure would then contribute to competition, but it would complement, rather than substitute, for competition over the shared facilities as well. Completely redundant facilities are a good, but socially

6 Bauer, J., Regulation, Public Policy, and Investment in Communications Infrastructure. *Forthcoming* Telecommunications Policy. 34. 2010.

costly, hedge against regulatory failure. In principle there is nothing about the physical limitations of a trench, or a fiber optic cable that makes duplication of this infrastructure a pre-condition for competition. Rather, it is the concern that regulation will fail to detect anticompetitive behavior by the owner and operator of the shared infrastructure that the duplication insures against. Whether that insurance is worth the enormous social cost of redundant infrastructure, or the long term cost of reducing entry only to those actors able to fully duplicate facilities, is far from clear.

Systematic limitations in cross-country econometric models

This section describes the systematic weaknesses of cross country studies as an approach to extracting causal explanations regarding the complex interactions that contribute to the impact of regulatory policies on the diffusion of broadband. These studies mostly rely on data from the 30 OECD countries, or the set of EU countries. For each country, six observations over time are commonly available. This is simply too few observations to tease out the very large number of potential variables at work: demography and geography; local market conditions and financial markets; strategic behavior by firms as part of the regulatory negotiation problems, complemented by strategic behavior by regulators in the same process; the state of financial markets; and regional variation within countries. Moreover, general time diffusion effects are hard to separate out from the time effects of other factors, such as the quality of regulatory enforcement or the maturation of competition. Many of the policy variables of greatest interest are difficult to characterize correctly. The presence or absence of a regulatory intervention requires assessment of its effective implementation, rather than its mere formal existence. Measures of inter-platform competition are also highly imperfect. This is typically measured by comparing the shares of the overall broadband market that are captured by different technologies, e.g. cable versus DSL. This is quite different from measuring the extent of head-to-head inter-platform competition in retail markets. Furthermore, not all technology platforms are distinct competitors, and countries differ in the degree to which the different technology platforms are used as anchors for competing firms, as opposed to being used by firms that combine platforms and compete across platforms; the extent to which this occurs is different in different countries. Moreover, many of the variables of greatest interest are jointly determined (this is commonly referred to as endogeneity in the econometric literature). Unless this is properly accounted for through the use of complex structural models or instrumental variable approaches, the inclusion of such variables in quantitative models greatly reduces the usefulness of this approach. A reduced form modeling strategy, which drops the endogenous variables from the list of explanatory variables, can help to mitigate this problem. Such rigorous modeling approaches require more data and effective instrumental variables, both of which are rarely to be found, and almost never in cross-country as opposed to local studies using micro-level data and exploiting natural experiments.

The results of many cross-country quantitative models are driven primarily by the experiences of a small number of countries. While quantitative work can be a powerful heuristic tool for researchers to identify researcher and areas for further scrutiny, investing faith in the numerical results rather than the much richer historical and qualitative information is misguided.

The first issue alone of inadequate data is enough to cast serious doubts over the ultimate effectiveness of cross-country broadband policy studies. After careful review of the various cross-country studies and methodologies, we have concluded that the quantitative results from these studies offer little useful guidance to policy-makers, although several of these studies are well written, are carried out by highly competent researchers, and contain excellent background materials and perspectives well worth

reading. Future quantitative studies are best carried out where more granular data is available, which is typically within one country. Two recent studies (Alter (2009), Sraer (2008)) are good examples of such an approach.

A risk evident in the quantitative literature is that it may mask rather than illuminate the underlying relationships with results that are primarily driven by as little as one or two countries. At the conclusion of this literature review we illustrate this by looking at a particularly influential study of the effects of unbundling on fiber-to-the-home penetration, which appears on its face to reflect the experience of 27 countries over five years, but upon inspection in fact merely reflects the unusual experience of Lithuania and Estonia. Proper analysis can usually identify these, but aggregation will often lead to obfuscation. Where these kinds of effects occur, econometrics studies are substantially less helpful than qualitative work, because while the analysis in fact reflects one or two stories, it does not actually give useful information about those unusual stories.

A note about the role of industry-sponsored research into telecommunications policy

We organize our review based on year of publication and type of author or sponsor. We do so because, as we worked through the review, it became clear to us that the genre of literature review tends to "wash out" the disclosures that many of the authors properly make in their papers. We cluster the reviews in each of the sections into three groups: government employees and commissioned reports; academic work, as well as work in think tanks where there is no clear evidence of direct industry sponsorship; and industry-sponsored work. This is most important in the section on unbundling and investment, where there is much more work sponsored by industry. While we think that all work should be considered, as in many other disciplines, where empirical work is written to the specifications of a party with a direct commercial interest in the outcome, the work needs to be handled with a high degree of skepticism. This is true for the econometrics work in particular, because of its high sensitivity to the precise technique and model used, and the opacity of its techniques to the vast majority of policy makers. In the telecommunications literature, there appears to be no general ethical disclosure requirement (although much of the work does properly disclose its sponsor), and no practice of giving substantially different treatment to papers written by interested parties, including those papers that are not only industry sponsored, but are also self-published and not refereed. We believe the Commission would do well to institute a set of rules or expectations about what sorts of disclosure would be required about a paper's funding before it can be seriously considered in the development of an evidence-based policy.

Econometrics studies of unbundling and broadband penetration

Here we offer a review of 15 quantitative papers that focus on the impact of broadband policies. A majority of these papers are saddled with the methodological issues associated with cross-country models described earlier. Of these papers, we found six papers that found an unambiguously positive impact of unbundling on penetration and three that had a negative impact, while the other six found either evidence in favor of both propositions or were unable to uncover any relationship.[7] All of the

7 This set of papers overlaps substantially with the 12 papers reviewed by Empiris, LLC, on behalf of both the National Cable and Telecommunications Association and the United States Telecom Association in response to our draft study. They come to remarkably different conclusions from our own assessment of the same literature: "the incontrovertible fact is that open access policies have not been shown to increase broadband adoption, availability, or infrastructure

papers that studied inter-platform competition concluded that it had a positive impact on penetration levels. Three of the papers reviewed in this section were sponsored by industry. A majority of these papers are self-published by the authors or organizations for which they work. Six of the papers appear to have been in peer-reviewed publications.

Papers on Unbundling and Broadband Penetration

Citation	Published=1 Self-pub=0	Sponsor	Impact of inter-platform competition on penetration	Impact of open access policies on penetration +, -, +/-, 0	Comments
Government / Int'l organization					
Grosso 2006	0	Australian Competition Authority	N/A	+	OECD 30, 1999-2005.
Denni & Gruber 2007	~1 (not clear whether refereed)	EU Investment Bank; Italian competition authority	+ platform competition strongly positive	0, +/- small number of largish entrants beneficial	U.S. data only from 2001-2004; period with strong incentives to game regulatory system (U.S.)
De Ridder 2007	0	OECD	+ / 0	+	OECD 30; 2002, 2005; uses multiple factors; seeks to identify the effects of unbundling over time
Sraer 2008	0	ARCEP; academic	N/A	+	French data from 2006; micro-data from 1500 exchanges in France; strong instruments on entrant investment and penetration
Academic/ Think tank					
Bauer et al 2003	0	N/A		0	Old data (2001 and pre-); early innovative effort to quantify effects; Uses broad policy baskets; no policies significant
Garcia-Murillo 2005	~1	N/A	N/A	+	Older data (pre-2001). ~100 countries. Unbundling positive and significant for middle income countries, not low income countries; logit and OLS regressions, various models; not significant in some.

investment. To the contrary, the bulk of the available evidence points in the opposite direction." This response, filed by longstanding participants in the debates over telecommunications policy in the U.S., helps to illustrate why we were surprised by our findings. It well represents the state of the literature and sense of the U.S. telecommunications policy community in the past few years that open access policies had been academically disproved.

Citation	Published=1 Self-pub=0	Sponsor	Impact of inter-platform competition on penetration	Impact of open access policies on penetration +, -, +/-, 0	Comments
Distaso, Lupi, and Manteni (2006)	1	N/A	+ platform competition strongly positive	+ low LLU rates increase penetration	Paper emphasizes the inter-platform competition effects. Findings support mixed strategies
Wallsten (2006)	0	N/A	N/A	+/- different forms of open access have positive, negative, or no correlation with penetration	Paper sets out different types of unbundling regimes; finds that different forms, with different specifications, show up as alternatively significantly positive; insignificant; or negative.
Cava-Ferreruela and Alabau-Munoz (2006)	1	N/A	+	0/+	Older data (2000-2002); "Cable" represents houses passed, not actual cable upgraded to broadband; LLU formal application trends positive, not significant; likely reflects strong role of cable in early success of U.S. & Canada.
Hoffler (2007)	1	N/A	+	+ lower LLU prices increase penetration	Analyzes welfare effects of facilities based competition; suggests duplicative investment in facilities may impose more welfare costs than provide gains
Boyle, Howell, and Zhang (2008)	0	N/A	N/A	0	Authors point out that it is systematically impossible to separate the effects of straight diffusion time from the effects of unbundling over time
Hazlett & Caliskan (2008)	1	N/A	N/A	-	Fails to account for time diffusion effects; mistaken characterization of legal regime used as instrument
Industry supported					
Aron and Burnstein (2003)	0	LECG		- higher-penetration where both cable and telco present	Old data (pre-2001); finds higher penetration where cable present, during period when cable primary mode of delivery

Citation	Published=1 Self-pub=0	Sponsor	Impact of inter-platform competition on penetration	Impact of open access policies on penetration +, -, +/-, 0	Comments
Waverman 2007	0	ETNO		-	Lobbying document; emphasizes that unbundling-based access undermines investment in cable
Bouckaert et al (2008)	0	Belgacom	+	0/- resale decreases penetration; unbundling has no effect	Very weak significance on all; case study component suggest learning from French and Dutch markets that unbundling is better than resale-based competition

Unbundling and Penetration: Government-sponsored Studies

Grosso (2006)[8] is a working paper by a researcher at the Australian competition authority. It uses OECD data from 2001-2004, and reports a positive effect for unbundling on penetration significant at the 1% level.

Denni and Gruber (2007)[9] is a paper in a journal published by the market analysis firm IDATE. It analyzes data from the U.S. from 2001-2004, that is, exactly the period during which the FCC and the incumbents were battling over whether to eliminate unbundling altogether, between the initial introduction of the idea of inter-modal competition and its final approval in Brand X and the Triennial Review process. The authors find unambiguously that inter-platform competition is beneficial for diffusion. They find that intra-platform competition is beneficial to diffusion only if the number of firms entering through unbundling is not too large: "in the case of ADSL lowering the market share of the incumbent is beneficial as long as the market detained by the entrants is not too fragmented." The authors use the Herfindahl index to measure inter-platform competition, but refer to technologies market-shares as opposed to firm's market share (this is less fatal in the U.S. context, as in this paper, than it is in real international comparisons, as is used for example in another of the papers, (Waverman et al 2007), where it masks the fact that in some high performing countries cross-technology-platform competition is used to complement unbundling-based competition, rather than as its alternative). This paper looks at U.S. data alone, from a period of intense political maneuvering around the negative investment effects of open access, and so potentially reflects strategic behavior on the part of either incumbents or regulators, rather than any real incentives effect.

De Ridder 2007 was discussed extensively in our draft report, as well as in the comments. Authored by an economist at OECD and published by OECD, that report seeks to identify the effects of diverse variables on penetration. The paper finds a significant positive effect on penetration from the years since unbundling was enacted. It was critiqued in Boyle et al. 2008; we discussed both the paper and

8 Marcelo Grosso, "Determinants of Broadband Penetration in OECD Nations," Working Paper, Regulatory Development Branch, Australian Competition and Consumer Commission (2006).

9 The Empiris declaration cites this as Denni and Gruber 2005. That unpublished conference paper was later published in a market analysis firm's publication, IDATE's Communications and Strategies. M. Denni and Gruber H., The Diffusion of Broadband Telecommunications in the U.S. Communications and Strategies (IDATE) No. 68, 4th Q, 2007, 139-157.

the critique, confirming in the main de Ridder's findings in our draft report; our discussion was in turn critiqued in the comments; we provide a response to a version of that critique at the end of this memorandum.

Sraer (2008)[10] is a working paper by an academic; based on work done for the French regulator, ARCEP. Using sophisticated analysis and instruments, and fine-grained data from 1,500 local exchanges in France, representing over 70% of the French market, collected in 2006, Sraer finds that unbundling-based entry by even one entrant results in an increase in penetration of between 1.1% in the short term and 5.9% in the medium term. This represents almost a full standard deviation in penetration rate. The underlying data in the paper shows that unbundling-based entrants invest in their own fiber backbones and complementary investments to the incumbents' local loop. Moreover, the paper shows that while the effect is partly driven by price competition, a large part of it cannot be explained by price, suggesting that quality or marketing efforts in the competitive market play a role in increasing adoption.

Unbundling and Penetration: Academic and Think Tank

Two widely-cited early papers use older data, from before 2001. These early efforts were innovative for their time, but because unbundling began in earnest as a policy only at around that period, the use of the older data necessarily limits the degree to which the data can provide strong insights. Bauer et al. (2003),[11] an unpublished conference paper, was an effort to use OECD data for 26 countries to extract lessons about policy. It tried to account for a very large set of potential causes, and used relatively broad baskets to classify countries into one of several regulatory categories. Given these broad baskets, the wide range of potential explanatory variables, and limited observations, it is not entirely surprising that the study did not find statistical significance for any of the policy variables. The second academic paper that relies on old data, Garcia-Murillo (2005),[12] is a paper published in an IDATE journal. The paper analyzes data from about 100 countries, from very early in the development of broadband. It includes price as well as unbundling, which creates difficulties. It finds particular significance in middle income countries, not in higher-income countries, although it is important to recall that 2001 is prior to effective implementation in many countries, both high and middle income.

Distaso, Lupi, and Manteni (2006)[13] is a paper published in a peer-reviewed journal that develops a theoretical model that predicts that inter-platform competition will be more important than intra-platform competition. The authors then test this model on 14 countries. It is important to note here that the paper defines "penetration" not by actual uptake by consumers, but rather by percentage of all lines upgraded to transmit high-speed data. Consistent with their model, the authors find that inter-platform competition is a significant driver of broadband adoption. This is not controversial; no one who supports unbundling denies that inter-platform competition, in addition to unbundling, is beneficial. Distaso et al also find a significant association between lower unbundling prices and higher levels of penetration. Conceptually, this is not surprising: lower unbundling rates attract competitors,

10 David Sraer. 2008. Local Loop Unbundling and Broadband Penetration. Unpublished MS.

11 Bauer, J. M., Kim, J. H., & Wildman, S. S. (2003). Broadband uptake in the OECD countries: policy lessons and unexplained patterns. Paper presented at the 14th European regional conference of the International Telecommunication Society, Helsinki, Finland. August 23–24.

12 Martha Garcia-Murillo, "International Broadband Deployment: The Impact of Unbundling," Communications & Strategies 57 (2005)

13 Distaso, W., Lupi, P., and Manenti, F. Platform competition and broadband uptake: Theory and empirical evidence from the European Union. Information Economics and Policy. 18(1) 87-106.

greater retail competition leads to lower prices and better services, which in turn increase demand. Because of this finding, and the noncontroversial claim that inter-platform competition contributes to penetration, Distaso et al. is more supportive of unbundling than of the proposition that it does not matter, much less that it is harmful.

Wallsten (2006)[14] is a think tank working paper that is often cited as empirical support for the proposition that unbundling has no effect or is negative. The characterization of this paper as providing evidence that unbundling does not work is surprising. In the original paper, the author describes his findings thus:

> I begin by estimating a simple ordinary least squares regression without any fixed effects. The first three columns of Table 1 show the results of this series of regressions. Full unbundling (LLU) is significantly positively correlated with broadband penetration. Including also bitstream and subloop unbundling changes the results somewhat: LLU remains positive and significant, bitstream is not statistically significant, and subloop unbundling is negative and significant. Including year fixed effects to control for the general increasing trend in broadband penetration has little impact on the other coefficients. This series of regressions seems to suggest that local loop unbundling is correlated with higher broadband penetration over time, while the more extensive subloop unbundling reduces growth in broadband penetration.
> [After explaining that density has a significant impact on penetration, independent of regulation, Wallsten continues:]
>
> Table 2 shows the results of a similar, but more extensive, set of regressions controlling for country and year fixed effects. Here, LLU by itself is not significant. The results on the LLU coefficient are, in general, ambiguous in this set of regressions. Under some specifications it is positive and significant, under some it is insignificant, and under one it is negative and significant. Bitstream access is positive, but is not always statistically significant. Subloop unbundling—the most extensive type of unbundling included here—is negative and statistically significant under all specifications.
>
> Unbundling regulations typically coincide with other regulations on collocation and wholesale pricing. Including these additional regulation variables causes the coefficient on LLU to become insignificant (and in one case negative and significant), while bitstream access becomes just barely significant at the 10 percent level or insignificant. Subloop unbundling remains negative and significant. The coefficient on commingling is positively correlated with broadband penetration though it is insignificant in a few cases. Virtual collocation is negatively correlated with penetration. Regulatory approval of line rental charges is positively correlated with penetration though not always significantly, and approval of collocation charges is negatively correlated, though again, not always significantly. (Wallsten 2006 12-13).

In its discussion, the paper begins with its findings on subloop unbundling and price-regulation of collocation, concluding that "These results support opponents' view of unbundling by suggesting that extensive unbundling (like the sort mandated in the U.S.) has a deleterious effect on broadband investment." The paper immediately follows this conclusion, however, with the acknowledgement that

14 Scott Wallsten, "Broadband and Unbundling Regulations in OECD Countries," AEI-Brookings Joint Center for Regulatory Studies, Working Paper 06-16 (June 2006).

"Other results, however, suggest that regulation can also be an important tool in promoting broadband adoption. Rules that might be interpreted as making it more difficult for the incumbent to exercise market power — but without putting the incumbent at a disadvantage — seem to foster broadband adoption" (Wallsten 2006, at 16). The recent literature review, Cambini and Jiang (2009, described below), similarly categorize Wallsten in the set of papers that tend to support unbundling, concluding their analysis of the paper thus: "Results show that if it is true that extensive obligations on the incumbent reduce broadband penetration, regulation per se could also be an important tool in promoting broadband adoption and milder regulations ensuring easier interconnection with the incumbent can increase penetration and investment."[15] In other words: if one sees sub-loop unbundling as excessive regulation, less intrusive forms of access regulations are shown to be an important tool in promoting broadband adoption. As with the other studies in this section, this paper suffers from the limitations of quantitative cross-country policy analysis described earlier. It is unclear if the explanatory policy variables reflect actual policies or are merely reflective of policy aspirations at the time.

Cava-Ferreruela and Alabau-Munoz (2006)[16] is published in a peer refereed journal with no industry sponsorship. It uses panel data from 2000 and 2002, still reflecting mostly older data. The authors find that inter-platform competition has a statistically significant effect on broadband penetration among OECD countries. They define "cable" broadly, however, to include all cable TV, whether or not upgraded for broadband. Their positive findings therefore suggest that countries with cable TV and the possibility of cable-based competition do better, and cannot separate out countries that actually have cable broadband competition. In the extreme case, this would include Germany, a country with high television cable penetration, but where cable broadband only began to grow much more recently. Moreover, their analysis shows that countries with mandated unbundling and actual loops used for unbundling have higher penetration, but the effect is not statistically significant using their specifications. This also is a paper from a very early period, when the U.S. and Canada were both doing extremely well, and both had high cable penetration. While we have not re-analyzed their data for this review, this observation would make the data a good candidate to test for the degree to which the early, cable-based lead of these two major countries influenced the results.

Hoffler (2007)[17] is by an academic, published in a refereed journal. It disclosed no indications of industry involvement. The paper uses data from 16 European countries, between 2000 and 2004. The paper has results that are similar to those of Distaso et al. 2005, focusing on broadband performance and, to a lesser extent, investment. The paper finds that head-to-head competition between cable and telephone infrastructures has the highest effect on broadband penetration, and estimates the contribution of cable competition as an increase of about 2% in penetration, with about 4% attributed to the presence of cable in the countries where cable had the strongest presence. The paper also finds that lower unbundling rates have a statistically significant effect on broadband penetration. The interesting additional twist in this paper is more theoretical than empirical—the author estimates whether the benefits of inter-platform competition, in terms of broadband penetration, are worth the costs of redundant investment in infrastructure. Using price and capital expenditures data from the period from his 16 European countries, the author calculates that the total welfare effect of inter-platform competition was at best neutral, and quite possibly negative because the welfare losses of duplicating

15 Cambini and Jiang, at 568.

16 Inmaculada Cava-Ferreruela & Antonio Alabau-Munoz, "Broadband Policy Assessment: A Cross-National Empirical Analysis," Telecommunications Policy 30 (2006) .

17 HÖffler, F. (2007). Costs and benefits from infrastructural competition: Estimating welfare effects from broadband access competition. Telecommunications Policy, 31(6–7), 401–418.

facilities were not offset by sufficiently large welfare gains from the added facilities-based competition.

Boyle, Howell, and Zhang (2008) is a think tank paper.[18] It criticizes De Ridder 2007, and was discussed extensively in the original draft of our report.[19] Its core claim is that it is not feasible to separate out the effects of simple passage of time on the diffusion of broadband from the effects of regulation over time. We agree with the broad claim about the systematic difficulty of separating out the effects of technology diffusion over time from the increased effects of regulation over time, although we disagreed in our original report with the technique used to apply that insight to De Ridder's data and analysis.

Hazlett and Caliskan (2008)[20] is an academic paper with no observable sponsorship. It provides an excellent illustration of two of the major difficulties presented in econometric studies of the causal role of policy on penetration: separating out policy from technological diffusion rates, and separating out whether and when a rule is technically adopted from whether and when the rule is in fact subject to effective regulatory implementation. The paper seeks to estimate the impact of changes in the regulation of access to telco infrastructure as a natural experiment in studying the effect of regulation on penetration. To do so, the authors compare adoption rates of different broadband technologies in the U.S. under regulatory regimes that change over time. First, they observe that cable broadband was subject to no access obligations throughout their study period. Second, DSL was subject to three different regulatory regimes over this period: before February 2003, when the FCC formally eliminated DSL line-sharing rules; from February 2003 until August 2005, when line-sharing was no longer required, but the incumbent telcos were still regulated as carriers; and after August 2005, when telcos, like cable companies, were no longer treated as telecommunications carriers for Internet service, but as information services. The hypothesis is that, if unbundling and line sharing increases penetration, then one should see higher growth rates in DSL than in cable from the 1996 Act on; that one should see higher growth rates during the period of line sharing, and lower growth rates after line sharing was abandoned, as well as after carriage is ultimately abandoned in 2005. The papers primary findings are focused on the effects of line sharing. The authors take the growth rate between Q1 1999 and Q1 2003, and use that growth rate to project what the expected level of penetration would have been in Q4 2006 had the same growth rates continued, and claim that DSL penetration was in fact 65% higher than projecting forward the growth rate from Q1 1999 to Q1 2003, while cable was only 11% higher. They rely on this relatively higher deviation from trend by DSL to reject the hypothesis that abandoning unbundling would have a negative impact on DSL penetration growth rates.

First, the paper presents an excellent example of the difficulty that econometrics faces in separating out time diffusion effects from policy effects. What the paper assumes away is that the two technologies were at different stages of what is known to be a nonlinear diffusion curve, or an S curve, where early in the development of a technology its diffusion proceeds slowly, as it catches on, its diffusion rate increases to the sharp incline part of the curve, and as the technology matures, its growth rate again flattens out. As the paper notes, cable modem service was introduced in the U.S. as early as 1995. DSL started much later. The FCC's first 706 Report[21] from 1999, for example, reports that there were,

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18 The New Zealand Institute for the Study of Competition and Regulation is funded by Telecom New Zealand along with several other companies.

19 Howell submitted a response to our draft report critical of the econometric methods employed there.

20 Hazlett, Thomas and Anil Caliskan. 2008. Natural Experiments in U.S. Broadband Regulation, Review of Network Economics. 7(4) 460-480.

21 First 706 Report, Docket No. 98-146. January 28, 1999.

at the time, 350,000 cable modem subscribers in the U.S., but only 25,000 DSL subscribers. The Report describes DSL as a technology in the early stages of deployment: "BOCs and GTE have announced plans to offer broadband to approximately twenty million homes this year. SBC has announced a 'massive rollout' of ADSL, targeting more than 500 central offices and 9.5 million residential and business customers by year-end. In Bell Atlantic's service area, ADSL is available now to some customers in the Washington, D.C., area and in Pittsburgh, with plans to add Philadelphia and the Hudson waterfront of New Jersey next year. "[22] This was the state of relative deployment during the last report before the FCC adopted its November 1999 line sharing order, which announced the regime purportedly tested in the Hazlett and Caliskan paper. The two technologies were clearly at different places on their diffusion curve during the period of observations from which the projections are made. Projecting forward from the beginning stage of a technology diffusion curve will, of necessity, understate the anticipated level of diffusion into the future. When the baseline for the projection is from a later stage in the diffusion of a technology that follows an S curve, but while its diffusion is still accelerating, the projection will deviate less from the later-observed results—consistent with Hazlett and Caliskan's observations about cable penetration deviating only 11% above their prediction. When the projection is from the earlier part of the curve, the anticipated underestimation would be much greater, as indeed they encounter. In this regard, if one observes the market shares of cable and DSL in Switzerland (See our report, country case study on Switzerland), which had no unbundling throughout the relevant period, one again sees the same pattern—early diffusion of broadband over cable, followed by later introduction of DSL and then massive growth of the later DSL technology leading to its overtaking cable. Korea experienced a similar pattern (although cable entry there was itself open access; the telco lines used for DSL were not unbundled until 2002). In both Switzerland and Korea the pattern is complex to interpret because of the strength of the national incumbent. The reference to the two here is merely to provide baseline reference for the fact that it is unlikely that the later adoption of DSL was itself the result of the regulatory regime, but rather reflected the relative technological state in which cable and telephone lines existed in the late 1990s. Cable's upgrade path to broadband occurred earlier than the telcos' migration path, which had a later start and later climb up the diffusion S curve for DSL.

Second, the paper is an excellent example of the difficulties of identifying the effects of regulation stemming from the difference between formal or technical adoption of a regulation, and its effective implementation. The Line Sharing order that provides the core instrument for Hazlett and Caliskan was passed in November 1999, two or three quarters after the beginning of the time series that the authors apparently use as their source of projection: Q1 1999. Moreover, the order was immediately challenged. It was vacated and remanded to the FCC in May 2002,[23] almost a year before the formal abandonment by the FCC that Hazlett and Caliskan use as their "instrument." In other words, during 6 or 7 out of 17 quarters that they treat as being under the line sharing regime, in fact that regime is not in place; and this does not account for any reticence on the part of entrants to invest in entry while the suit is pending throughout the formal existence of the rule, as well as the clear signals from the FCC in the Triennial Review NPRM from December of 2001, which introduced the theory of intermodal competition as a reason to abandon access regulations,[24] the February 2002 NPRM on Appropriate Framework for Wireline[25] and the March 2002 Declaratory Ruling and NOI on cable broadband.[26] For those potential entrants who were slow and did not read the writing on the wall during the first quarter

22 Id., at the text associated with footnotes 85-90.
23 290 F.3d 415. (D.C. Cir. 2002).
24 Triennial Review NPRM, FCC 01-361, Docket No. 01-338, December 12, 2001, paras. 27-30.
25 NPRM: In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities FCC 02-42, February 14, 2002.
26 Declaratory Ruling and Notice of Proposed Rulemaking (FCC 02-77), March 14, 2002.

of 2002, the FCC's press release announcing the declaration of cable broadband as an information service specifically tied all these documents together, stating:

> Today's decision follows five other related proceedings - the Cable Modem NOI, the National Performance Measures NPRM, the Incumbent LEC Broadband Notice, the Triennial UNE Review Notice and, most recently, the Wireline Broadband NPRM. These proceedings, together with today's actions, are intended to build the foundation for a comprehensive and consistent national broadband policy.[27]

Unbundling and Penetration: Industry sponsored

Aron and Burnstein (LECG 2003)[28] is a self-published paper produced by a consulting firm that essentially finds the entirely unsurprising fact that there was higher broadband penetration in the U.S. where cable and telco provisioning occurred. This finding is expected given that the data is from 2001 and the early dominance of cable broadband in the U.S. before 2001. Their results are potentially skewed by a failure to control for endogeneity as the causation in this specification is not clearly unidirectional.

Waverman et al. (2007)[29] is a consultancy report produced for ETNO, the lobbying organization of the European telecommunications incumbents, as part of the European policy debate over levels of access regulation. Its executive summary makes very clear that it was written in response to the European Commissioned study by London Economics and PriceWaterhouseCooper (2006), that had concluded that "Results of our regression model show that better performing regulatory regimes, as measured by the OECD regulatory index, contribute to higher investment levels. "[30] The Waverman et al document focuses on the effects of unbundling on the rates of subscription to alternative access platform. In its executive summary, that report states:

> More intense access regulation, as measured by a lower LLU price, stimulates intra-platform competition and may cause the overall broadband market to expand. However, it also causes a substitution away from broadband offered over alternative access platforms to copper-based platforms. Thus, lower access prices may lead to a reduction in the total number of subscribers who take up broadband offered over alternative infrastructures if the substitution effect dominates the market-expansion effect. Our analysis tests for the strength of the substitution and market expansion effects of lower LLU prices, and quantifies the reduction in the number of subscriber lines served over alternative access infrastructures.

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27 Cable NOI news release, http://www.fcc.gov/Bureaus/Cable/News_Releases/2002/nrcb0201.html.

28 Debra J. Aron and David E. Burnstein, "Broadband Adoption in the United States: An Empirical Analysis," Abstract, (2003)

29 Waverman, Leonard, Meloria Meschi, Benoit Rellier, and Kalyan Dasgupta. 2007. Access Regulation and Infrastructure Investment in the Telecommunications Sector: An Empirical Investigation. LECG Ltd.

30 London Economics and PriceWaterhouseCoopers, "An Assessment of the Regulatory Framework for Electronic Communications—Growth and Investment in the EU e-Communications Sector", Final Report to the European Commission, July 2006. (Note that the London Economics document underscored this conclusion even though its regression model only showed that regulatory indexes were significant at the 13% level, which would not normally be considered statistically significant.)

In other words, this document does not make a clear case that open access policies reduce competition or broadband access in the countries in which it is implemented. Instead, it falls back on hypothetical analysis of "what if" to produce hypothetical numbers of lost investment in alternative infrastructures. Essentially, what the report really stands for is that open access policies increase competition in markets, and reduces the broadband market share of cable operators. That a larger market share for cable operators is itself a desirable policy goal is assumed, because of the assumed benefits of inter-platform competition. But the paper is not written in a way that allows one to confirm or deny the possibility that this loss of subscribers for the cable operators is not more than made up for by the gains for consumers and entrants. The most the report can say is that Europe will lose investment, arguing that for "a hypothetical 'Europe' (defined in Section 5), the lost long-term investment in alternative access platforms exceeds 10 billion Euros as a result of just a 10 percent LLU price reduction. "[31]

Bouckaert et al (2008)[32] is a self-published paper supported by the Belgian telecommunications incumbent, Belgacom. It looks at the Belgian market, compares it to the French and Dutch markets, and also conducts an analysis of 20 European members of the OECD countries. This smaller number of countries, of necessity, weakens the analysis. Most of the conclusions, to the extent significant, are significant only at the 10% level. These conclusions are: (a) that inter-platform competition increases broadband penetration; (b) that resale at regulated rates has a negative impact on penetration; and that (c) they can identify no significant effect, positive or negative, for unbundling. Furthermore, the authors claim that "intra-platform competition may even reduce investment incentives," although their study does not actually measure or reflect investment. They do claim that lower prices and higher speeds increase penetration, but do not attempt to explain those with regard to the presence or absence of entry.

Unbundling and Penetration: Conclusion

In this section we reviewed 15 papers that studied the relationship between unbundling and broadband penetration. Of these 15, three reported unambiguous negative effects. Of these three, two were industry sponsored, one of which used old data and the other of which used hypothetical projections; the third, which was not industry sponsored, was methodologically flawed. Six of the papers found unambiguous positive effects. The remaining six papers were indeterminate.

Econometrics studies of open access, unbundling, and investment

There is substantially more literature, and more emphasis in the literature, placed on a particular causal model for the purported negative effects of unbundling: that is, the claim that unbundling in particular, and open access regulation more generally, undermines investment incentives. Several of the industry comments criticized us for focusing only on performance outcomes—price, quality, and penetration—and not on investment. These criticisms alleged that substantial literature supports the proposition that unbundling decreases investment, and in doing so cited a just-published literature review in Telecommunications Policy to support the argument. That literature review is indeed the state-of-the-art on this subject, and given the weight afforded to it by the comments, we will use it as the foundation of our own literature review. We do note, however, that the review includes several papers that are

31 Waverman et al p. 4.

32 Bouckaert, J., Van Dijk, T., & Verboven, F. (2008). Regulation and broadband penetration—what is required to regain speed in Belgium?. Belgium: University of Antwerp and Leuven. Available at: /http://www.ua.ac.be/download.aspx?c=jan.bouckaert&n=72967&ct=68422&e=184390 .

perhaps inappropriately located in a literature review given their apparent roots in policy advocacy rather than impartial research. Nevertheless, we include them here only because they are included in that review. Upon reviewing the underlying papers, we largely concur with Cambini and Jiang's (2009)[33] own assessment:

> "The picture that emerges is not conclusive, and further research is still needed, both theoretically and empirically, to better understand the real impact of regulatory incentives on investments."[34]

Contrary, then, to the widely held background assumption in the telecommunications policy community in United States, as well as to the industries' claims in response to our study, the econometrics literature provides no definitive answer, and leads us back to affirming the centrality of the case studies. The theory that unbundling deters innovation is not proven by the empirical econometrics literature or the theoretical literature. Neither, however, have any of the alternative theories that attempt to explain why unbundling would work been proven by econometrics. We are left to account for the fact that the United States has been doing less well since it abandoned open access than countries that effectively pursued various versions of open access over the last few years, and with rich, detailed case studies that explain what role open access played in making those markets that have performed better.

Access, unbundling, and investment: Econometric evidence

There are few peer refereed papers on the question of unbundling and investment. Many of the oft-cited papers are self-published. Moreover, this part of the literature exhibits a particularly large proportion of industry-sponsored research; over half the papers received industry support. Unfortunately, as the Cambini and Jiang (2009) literature review exhibits, papers by consulting firms explicitly funded by market-participants—either incumbents or entrants—are intermingled with academic papers with no distinction. Worse, the literature review effectively "launders" papers written by academics with appropriate conflict-of-interest disclosures, so that by the time they are discussed in the literature review that disclosure is no longer visible to the reader who encounters the results only by way of the review.

Twenty three papers are described in Cambini and Jiang (2009) as empirical papers bearing on the relationship between open access regulation and investment. As you will see in this review, not all of these in fact are empirical, but we will include them in this section because it is important to clarify their status, given their recent characterization as empirical papers on investment. Of those papers, we discuss Hausman and Sidak 2005 in the section on qualitative case studies, and included Wallsten 2006 and Hoffler 2007, both noted in the Cambini and Jiang review, in the penetration effects section, where each thematically belongs, rather than here.

33 Cambini, C. and Jiang, Y. Broadband investment and regulation: A literature review. Telecommunications Policy (2009). 33 559-574.

34 Cambini and Jiang, at 559.

Papers on unbundling effects on investment.[35]

Citation	Pub=1 Self-pub=0	Sponsor	Access on incumbent investment	Access on entrant investment	Comments
Government / Int'l organization					
London Economics & PriceWaterhouseCoopers (2006)	0	EU Commission	~+	~+	This study seeks to show that effective regulation increases investment. Uses surveys and annual reports data. Econometrics weaker than descriptive evidence.
Fevrier and Sraer (2007)	0	ARCEP		0	Highly granular data from 1500 French exchanges. No negative effects on entrant investments.
Academic/ Think tank					
Hausman 1998 (&1997)	0	N/A	- TSLRIC pricing will undermine incumbent investment because of sunk costs		Theoretical study.
Christodoulos and Vlahos (2001)	1	N/A	+ mix of LLU and facilities-based best; through increasing LLU prices over time	+ mix of LLU and facilities-based best; through increasing LLU prices over time	Theoretical study.
Chang, Koski, and Majumdar (2003)	1	N/A	+/- lower access prices correlated with more digital lines in U.S.; lower investment in EU		More data on U.S.; weaker data on EU. Uses interconnection rates, rather than unbundling.

35 We include here several papers that are not empirical that were described as such in Cambini and Jiang 2009 or mentioned in comments to our draft as in this category. We identify the papers that are theoretical, not empirical, in the comments.

Citation	Pub=1 Self-pub=0	Sponsor	Access on incumbent investment	Access on entrant investment	Comments
Guthrie (2006)	1	N/A	+/- various outcomes	+/- various outcomes	Theoretical; critical review of literature to 2006; concludes that impact on investment or welfare unknown theoretically or empirically at that time
Jung et. al (2008)	1	N/A	+ Market share of entrants, in particular access-based entrants, increased investment, but number of entrants did not	+ Market share, but not number, of entrants, effected positively	Suggests that a relatively small number of entrants with credible staying power: using lower cost unbundling to enter, and remaining through lack of dissipation by excessive entry, most beneficial to investment by both incumbents and entrants
Wallsten and Hausladen 2009	1	N/A	-	-	Heavily influenced by Lithuania and Estonia; problems with specifications; discussed in body of memo
Foros et al (2009)	1	N/A	+		Theoretical study.
Alter 2009	1	N/A	- delays investment; small negative welfare effects		Detailed micro-level data from Kentucky; investment delay likely strategic; negative welfare effects small
Industry Supported					
Crandall and Singer 2003	0	Criterion Economics	-		Numeric examples and hypothetical investment losses. Primarily critique of a different paper on jobs-creation
Ingraham and Sidak (2003)	1 (student edited journal)	Criterion Economics	- Two incumbents had higher volatility than market in tech-bubble crash; two did not		Highly questionable paper. Shows increased volatility in Verizon and Bell South stock higher than major indexes, SBC not higher; and hides in footnotes that Qwest also not higher. All during periods of stock bubble crash
Phoenix Center Bull. No. 5	0	AT&T (as entrant)	+		Criticized at the time by consultants for the other side; conclusions not pursued by authors later
Phoenix Center Bull. No. 6	0	AT&T (as entrant)	+		Criticized at the time by consultants for the other side; conclusions not pursued by authors later

Citation	Pub=1 Self-pub=0	Sponsor	Access on incumbent investment	Access on entrant investment	Comments
Crandall, Ingraham, and Singer (2003)	1	Criterion Economics	- Higher LLU prices lead to higher CLEC investment in own-facilities		Primarily theoretical; more limited data
Ford and Spiwak 2004	0	Phoenix Center / AT&T			Zip-code level broadband availability; significant at 10% level; this is not an investment paper at all; but a penetration paper with low significance and weak data
Hazlett and Bazelon (2005)	0	Verizon / Analysis Group	-	-	Heavy emphasis on lower investments post tech-bubble crash; weak causal connection to LLU
Zarakas et al (2005)	0	Brattle Group / AT&T?		+ LLU but with higher prices increase innovation	Agent-based simulation; not real data; heroic assumptions (3 facilities-based competitors; all with 100% immediate uptake for all investments)
Willig (2006)	0	AT&T	0/+		Not new evidence; discusses other work in a conceptual framework
Waverman and Dasgupta (2006)	0	France Telecom	-	-	Conceptual rather than evidence-based.
Pyndick (2007)	1	Verizon	-		Theoretical paper that reconfirms Hausman 1998 using option value.
Cadman 2007	0	ECTA	+	+	Part of same exchange with London Economics and Waverman 2007; uses more powerful econometric techniques than either of the other two pieces in that exchange
Friederiszick, H., Grajek, M., & Roller, L. (2008)	0	Deutsche Telekom	0 No effect on incumbent investment in fixed line, or in mobile	- Unbundling lowers investment by fixed line entrants; no effect on mobile entrants	Suggests that the absence of an effect on incumbent investment reflects that competition driving innovation and service increases demand to a point of compensating incumbents for the lower margin

Access, unbundling, and investment: Government sponsored

London Economics and PriceWaterhouseCooper (2006)[36] is a consultancy study, commissioned by the European Commission. It began a flurry of other papers, here represented by Waverman et al 2007 and Cadman 2007. It sought to evaluate the levels of investment by incumbents and entrants, and their determinants. The data reflected company annual reports and the results of a survey of companies. The report concluded that "Results of our regression model show that better performing regulatory regimes, as measured by the OECD regulatory index, contribute to higher investment levels." However, the descriptive data was more consistent with that statement than the econometrics, which showed significance only at a level slightly below what would conventionally count as weakly significant.

Fevrier and Sraer (2007) is an unpublished piece by academics who conducted a report for the French regulator, ARCEP. It uses highly granular data from 1500 Central Offices in the French market, and develops a sophisticated econometric model to study the effects of unbundling on entrant investment. Although it begins with outlining the game-theoretical prediction that entrants would "soften" their investment to avoid too harsh a level of competition in the second stage, their data suggests that unbundling does not in fact reduce entrant investment as the model would predict.

Access, unbundling, and investment: Academic and think tank

Hausman (1998)[37] is a restatement of portions of the 1997 Brookings paper. The paper is a theoretical paper, not empirical. It argues that the fact that many of the investments incumbents make in the core of their networks cannot be reallocated to other uses when the regulated rate drops, their sunk-cost nature, given changing technology and reduced costs over time, will systematically lead cost-based price regulation to be too low. Hausman argues that fixed and sunk costs make these investments similar to investments in innovation, and incumbents would invest less when they are subject to unbundling, unless the prices for the elements would compensate them for all the unsuccessful innovations they install when entrants buy the successful network elements. This paper, while interesting in its own right on the question of the appropriate rates at which unbundling should be applied, does not speak to the question of whether unbundling, priced using a method other than TSLRIC (the technique discussed there), would in itself reduce investment.

Christodoulos and Vlahos (2001)[38] is a peer-refereed theoretical paper. It uses agent-based simulation to test three hypothetical cases: a market with only infrastructure-based competition, a market with only service-level (or wholesale) competition, and a market with unbundling. It concludes "that a 'mix' of infrastructure and service competition, like the one promoted in the Netherlands, stimulates investment by both incumbents and entrants and offers better consumer benefits. It achieves this by initially offering low ULL prices to stimulate service entry and offer price competition fairly early on.

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36 London Economics and PriceWaterhouseCoopers, "An Assessment of the Regulatory Framework for Electronic Communications—Growth and Investment in the EU e-Communications Sector", Final Report to the European Commission, July 2006.

37 Cambini and Jiang list Hausman, Pakes, and Rosston (1997) (Brookings paper; non-refereed) and Hausman (1998) (book chapter) as Cambini and Jiang as two papers in the text. In the Table in that paper, they are both more correctly described as (Hausman 1998), though the table oddly refers to them twice: they are the same paper in relevant part (the 1997 piece includes additional discussions not pertinent here; the 1998 paper is the relevant subset).

38 Christodoulou, K., & Vlahous, K. (2001). Implications of regulation for entry and investment in the local loop. Telecommunications Policy, 25(10–11), 743–757.

However, it also provides an explicit way in which the ULL prices increase to forward-looking prices, allowing entrants to assess whether they should stay in the market and invest in their own infrastructure or, should they not be as efficient, exit the market." As in the case of the Hausman paper, this is not an empirical paper, but a theoretical paper. It supports the proposition that some form of unbundling is beneficial, emphasizing the details of implementation as the relevant policy lever, in particular pricing, rather than the principle that open access regulation, properly designed, is superior to purely facilities-based competition. Its simulations are certainly consistent with the experience of the European countries we studied and Japan; although its emphasis on the beneficial effects of sunset and increasing rates is questioned by the experience of Canada. In this regard, the paper may understate the degree to which sunset periods that are too short will have an effect equivalent to unbundling prices that are too high and deter competitor entry.

Chang, Koski, and Majumdar (2003)[39] is a refereed journal article. The paper analyzes separately data from the U.S. on investment by ILECs under unbundling; and data from Europe. The U.S. data measured the ratio of fiber to total lines (this is long before fiber to the home; fiber here is in the network); and, separately, digitalization, or the ratio of digital to total fixed lines. In both cases, the target was to estimate the impact of regulation on investment in technological upgrading. The panel used included data from 41 local exchange carriers for a 5-year period from 1994-1998. Unlike many other of the studies here, it did test for influential points and removed outliers from the data. The weakness is that the paper uses access charges for interconnection as the measure of the open access regulatory intervention. While conceptually similar—in that interconnection is a form of (minimal) required access to the incumbents' network—interconnection pricing is not a perfect stand in for unbundling. The study finds that lower prices do not have a significant impact on fiber, but do have a positive significant correlation with digitization of lines. The authors hypothesize that the lower prices lead to greater competition, which in turn leads to lower consumer prices, higher usage, and higher cash flow to the incumbents, who in turn can reinvest it in increasing the capacity of the network to carry the new, higher demand. Their analysis cannot test that causal hypothesis. It does show a positive correlation between lower access prices and investment in leading edge technology of the time. The paper's results for Europe, however, trend in the opposite direction—suggesting that cost-based pricing methods and higher access prices induced higher investment. However, the paper's authors caution that their data on Europe is, as they put it, "relatively sparse, meagre and likely to be insufficient," and cannot account that for the period they were observing, one-third of the countries did not have an independent regulatory agency. The paper, then, overall offers stronger support for a positive effect of lower access prices on investment, but is not conclusive.

Guthrie (2006)[40] is a refereed journal article by an academic with no industry support. It provides an exhaustive review of the theoretical literature on various forms of regulation, in particular price and access, of infrastructure industries, particularly power and telecommunications. Guthrie reviews the various arguments, considering a range of models, from those that predict delayed investment as a result of open access, where market conditions characterize investment as a waiting game, to models that predict excessively early investment, where firms find themselves in a preemption game. The author concludes: "First, the impact of access price levels on investment is not yet fully understood, even in the relatively simple situations described here. Second, even less is known about the overall impact on welfare. For example, even if higher access prices would accelerate investment, is this

39 Chang, H., Koski, H., & Majumdar, S. (2003). Regulation and investment behaviour in the telecommunications sector: Policies and patterns in U.S. and Europe. Telecommunications Policy, 27(10–11), 677–699.

40 Guthrie, Graeme. Regulating Infrastructure: The Impact on Risk and Investment. Journal of Economic Literature. 44(4): 925-972.

necessarily good for welfare?" (965). Guthrie concludes this 2006 article with the statement: "Almost ten years have passed since the Telecommunications Act transformed telecommunications regulation in the United States and economists still do not have a thorough understanding (theoretically or empirically) of how local loop unbundling affects investment. " (969)

Jung et al (2008)[41] is a refereed journal article that does not appear to have been sponsored by an interested party.[42] It uses panel and dynamic panel analysis from the U.S. market between 1997 and 2002. It finds that the market share of competitive entrants was positively correlated to investment by incumbents—that is, the larger the market share of entrants, the higher the investment—an effect statistically significant at the 1% level; that this continued to be true at the 1% level of significance for UNE-based entrants, but its significance was only at the 10% level for facilities-based entrants; that the number of CLECs was negatively-related to incumbent investment, and that when dynamic modeling was used the significance remained, but dropped to the 10% level. In other words, the results of this study are most consistent with the claim that the market share of entrants, particularly entrants with a serious prospect of successful entry, was positively correlated with incumbent investment. A small number of entrants increases the likelihood that these entrants will not foreclose each others' markets; unbundling-based access predicts faster entry than facilities based entry. In combination, these factors suggest that a direct and immediate threat of entry that might stabilize into sustained competition will result in higher investments by incumbents. This is indeed consistent with our findings in the case studies, where the entrants began either as a small number, as in Japan, or consolidated into a small number, as in the Nordic countries, France, or the UK after functional separation was introduced.

We discuss Wallsten and Hausladen (2009) in the last section of this report in detail. The paper purported to find that unbundling reduces investment in fiber to the home. We show that the results are driven by the leapfrogging dynamic in Lithuania and Estonia, and that the paper also does not employ country level clustering, which results in treatment of the unobserved effects in each country in each year as though they are an entirely different from the unobserved effects for that country in the prior year. Correcting for this makes the results drop from statistical significant. Furthermore, the specification itself is potentially problematic as it is based on the questionable assumption that the number of unbundled connections is an exogenous variable.[43]

Alter (2009)[44] is a refereed, academic paper. It uses micro-data from Kentucky and Bell South investments to quantify the effect of unbundling and regulatory jockeying on investment. The paper suggests that (a) investment is indeed postponed under unbundling; (b) the pattern of investment suggests strategic postponement more strongly than non-strategic; and (c) the welfare costs of delayed investment are not huge, and it is unclear whether they would outweigh the benefits of a more competitive market, even with delayed investment.

Foros et al (2009)[45] is an article in a refereed journal, authored by academics with EU science funding.

41 Jung, I., Gayle, P. G., & Lehman, D. E. (2008). Competition and investment in telecommunications. Applied Economics, 40(3), 303–313.

42 Its first author's affiliation is listed as SK Telecom in Korea, which is now a facilities-based entrant. However, the study is U.S. focused; the results, if anything, are least favorable to facilities-based entrants, and there is no disclosure of funding or support from SK Telecom. In combination, these factors lead us to categorize this paper as not industry sponsored.

43 If the explanatory variable is endogenous then this introduces simultaneous-equation bias into the model.

44 Alter, A., The Effect of Access Regulation on Broadband Deployment. Review of Industrial Organization (forthcoming).

45 Foros, Øystein, Hans Jarle Kind, and Jan Yngve Sand. 2009. Entry may increase networks providers' profit. Telecommunications Policy. 33(9), 486-494.

It is a theoretical model, not an empirical model. The model takes a duopoly facilities-based market as its baseline, and explains the parameters under which "platform sponsors," that is, platform owners that provide access, either voluntarily or because of open access regulatory requirements, have an incentive to invest more in their network given the presence of access-based entrants. Their analysis combines both the effects of the increasing size of the market brought about by network effects and service innovations by entrants, and the benefits of investment that differentiate the platform owner from entrants.

Access, unbundling, and investment: Industry sponsored

The Cambini and Jiang (2009) literature review lists several papers that are industry supported, without noting their provenance. It begins with six papers that are part of an exchange between, on the one hand, the Phoenix Center, apparently funded by AT&T when AT&T was an entrant and sought access to unbundled loops,[46] and Criterion Economics, whose clients include the major telecommunications incumbents, and whose principal authors at that period are now part of Empiris, whose declaration on behalf of the industry associations introduced this literature review into the comments. While it is important to read these pieces and understand their arguments and methods, in general it is also important to approach them cautiously, and treat these papers and others like them as a different species of paper than refereed, academic papers, or government agency or international body papers. These are papers prepared for and paid by competitors in a market, about the costs and benefits of regulatory changes then being considered by the FCC, whose outcome would affect their relative viability in the market. Their conclusions are all aligned with the interests of the commissioning party. Given, however, the complexity of the problems, the subtlety with which every minor assumption or choice in model specification can affect the results, such provenance counsels great caution on the part of the reader. (As we shall see, these six are not the only papers generated with funding from the interested parties that are collected in the literature review.) It is not insignificant that AT&T was absorbed by SBC almost immediately after this regulatory battle was settled in favor of the incumbents. The fossil record of their lobbying efforts can still be seen in the literature. MCI, the other major entrant at that time, was absorbed by Verizon after the regulatory debate for which these papers were prepared was resolved in favor of the incumbents. For purposes of understanding the literature, it is also significant that the creation of the new AT&T seemed to have marked the end of U.S.-based papers of this kind. All industry-supported, U.S.-based papers that support unbundling appear to have been funded by AT&T when it was an entrant seeking access to local loops. The elimination of effective competition by entrants appears to have also eliminated industry-sponsored papers in favor of unbundling. The same is obviously not true for the winning side in that debate, in support of the opposite conclusion.

The first of the papers in this group of six, (Crandall and Singer 2003)[47] is a consultancy report by Criterion Economics, issued in response to an entrant-funded study that purported to show that

46 See Drew Clark, *Broadband*, Technology Daily July 26, 2006 ("Spiwak said the Phoenix Center is funded by "the old AT&T, the new AT&T, wireless companies, software providers" and other Bell competitors. Unlike other telecommunications think tanks, he said the Phoenix Center does not participate in lobbying coalitions or in FCC proceedings"); Drew Clark, *Telecom*, Technology Daily November 10, 2005 ("Everyone has to make a living in this town," Phoenix Center Executive Director Lawrence Spiwak said in reference to contributions from AT&T and the Bells. "The point is, go and look at the work" of the Phoenix Center, he said, describing it as "dispassionate" and scholarly.").

47 Crandall, R. & Singer, H. (2003). An accurate scorecard of the Telecommunications Act of 1996: rejoinder to the Phoenix Center Study No. 7. Report by Criterion Economics, Washington, DC.

unbundling under the U.S. 1996 Telecommunications Act added 92,000 jobs.[48] The paper aims several well taken criticisms at the weak paper it was attacking, but then launches into some questionable claims of its own. First, the paper assumes that jobs in resale and marketing are not "jobs," but are socially wasteful. The paper explains its rationale with a metaphor:

> If a principal of a high school can manage a student body of 250 efficiently by herself, society is not better off when the school hires an additional administrator. Likewise, if a Bell Operating Company requires a sales force of one employee for every 500 lines, then society is not better off when a CLEC hires one or more additional telemarketers to resell the same 500 lines. Domestic product is not increased by either new job. Presumably, the additional administrator and telemarketers could be put to better uses that would increase domestic product.

By this rationale, marketing jobs created by market actors who think they can make money by offering better deals on, say, the same cars, are not adding to the GDP. By this rationale, lower prices and more marketing do not increase the quantity sold. Indeed, the authors conclude: "The purported savings to consumers who have switched to a CLEC do not constitute an increase in economic welfare—these dollars are merely a transfer of income from the ILEC to the customers." (at p. 22). In other words, supply and demand are fixed; the only thing happening when competitors enter is transfer of rents from producer surplus to consumer surplus. We note that, in comparing LLU for voice and LLU for broadband in a paper commissioned by France Telecom, apparently in its capacity as a cross-border broadband entrant through Wanadoo, Crandall and Waverman (2006) write: "Since broadband offers consumers the prospect of genuinely new and distinctive services, marketed and bundled for them in genuinely new and distinctive ways, the consumer welfare gains from services-based broadband competition might be significant, thus sustaining entry."[49] The Crandall and Singer paper follows the questionable assumption about fixed supply and demand with an effort to establish that unbundling causes reduced capital expenditure, but rather than doing so using actual numbers of reduced investments, properly controlling for the fact that the relevant period was also a period of boom and bust in the industry, the document employs a variety of numeric examples and hypothetical losses in investment based on projected reduced cash flow from unbundled lines relative to ILEC-sold lines.

The next paper, Ingraham and Sidak (2003),[50] is an econometrics paper published in a student-edited law journal. The authors are a founder of Criterion (although in the paper he describes himself as a fellow emeritus of the American Enterprise Institute, and does not disclose the Criterion affiliation) and a Criterion Vice President, the same consultancy that produced two of the other papers over this period that purported to show negative effects of unbundling. It calculates that the volatility of Verizon and BellSouth stock was higher than that of the S&P 500 and the DJIA after the tech-bubble burst than it was during the expansion that preceded the 2001 recession, while the volatility of SBC and Qwest stock was not statistically-significantly higher than that of these two indexes over the same period. For some reason, although Qwest was part of the study, the tables simply did not report the negative results for Qwest. These were, instead, reported only in footnotes. (Ingraham and Sidak 2003: at note 29: "The coefficient on RM*Dr was not significant, either economically or statistically, in the Qwest regressions ."; note 31: "For the Qwest regressions, the coefficient on RM*Dr is insignificant in both

48 The underlying report to which this was a response was "The Positive Effects of Competition on Employment in the Telecommunications Industry, Phoenix Center Policy Bulletin No. 7, Oct. 15, 2003 ."

49 Crandall, Robert W. and Leonard Waverman. The Failure of Competitive Entry Into Fixed-Line Telecommunications: Who is At Fault. Journal of Competition Law and Economics. 2(1) 113-148. At page 140.

50 Ingraham, A., & Sidak, G. (2003). Mandatory unbundling, UNE-P, and the cost of equity: Does TELRIC pricing increase risk for incumbent local exchange carriers?. Yale Journal on Regulation, 20, 389–406.

statistical and economic respects. In particular, we cannot reject the null hypothesis that $\beta r = 0$ for Qwest. Also, the estimates of βr that we obtained for Qwest (-0.01 when using either the S&P 500 Index or the DJIA) are very close to zero. Therefore, we find no evidence that Qwest's beta changed during the recession. "). The paper argues that this "finding" (higher volatility for two of four players, not so for the other two) substantiates the hypothesis that mandatory unbundling will increase volatility of ILEC stocks in a recession.

The next two papers in the literature review are Phoenix Center Policy Bulletins. These are self-published, non-refereed documents. Policy Bulletin No. 6[51] is an effort to respond to methodological criticisms (from Criterion and other consultants) of Policy Bulletin No. 5.[52] Both attempt to show that unbundling, and in particular UNE-P, increase investment by the then-remaining Bell Companies.

The next round in this debate is Crandall, Ingraham, and Singer (2003).[53] It is a paper published in a refereed journal; its origin is in a Criterion Economics paper.[54] It is primarily a theoretical model arguing that lower unbundling rates will lead entrants to use unbundled loops to provide service, rather than invest in their own facilities. To the limited extent that data is used in this paper, it reflects data provided by the Bell Companies to the researchers, analyzing a total of 56 observations from 2000 and 2001, excluding somewhere between 15 and 20 states. From these data they claim to show that higher rates for unbundled loops are correlated with higher levels of facilities-based CLEC lines. The authors then use the theoretical model to argue that the mechanism is by displacement of incentives to invest away from unbundling, and towards facilities-based competition. Neither the model nor the data can establish the extent to which the high cost results in displacement to facilities-based competition, as opposed to exiting the market.

The parting shot in this series is again a policy paper from the Phoenix Center, seeking to establish that unbundling increases broadband availability (as measured by zip codes in which at least one provider is available and zip codes in which four or more providers are available.) (Ford and Spiwak 2004.)[55] Although it is placed in a literature review on investment, it is not a paper on investment, but on penetration. The argument for effects on investment is by derivation—if performance is high, therefore investment likely happened. However, given that entry here can be over existing lines, it is feasible in principle to get higher penetration, and greater competition, without greater investment. The results, in any event, even as specified, show only weak statistical significance, at the 10% level.

The Cambini and Jiang paper goes on to cover several other papers that either explicitly or by clear implication, are industry-sponsored. Hazlett and Bazelon (2005)[56] is an unpublished conference paper.

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51 Phoenix Center Policy Bulletin No. 6 (2003): *UNE-P Drives Bell Investment - A Synthesis Model* Available at http://www.phoenix-center.org/PolicyBulletin/PolicyBulletin6Final.pdf

52 Phoenix Center Policy Bulletin No. 5 (2003): *Competition and Bell Company Investment in Telecommunications Plant: The Effects of UNE-P*. Available at: http://www.phoenix-center.org/PolicyBulletin/PolicyBulletin5.pdf

53 Crandall, R., Ingraham, A., & Singer, H. (2004). Do unbundling policies discourage CLEC facilities-based investment. Topics in Economic Analysis & Policy, 4(1), 1136.

54 Footnote 24 of Crandall and Singer (2003) identifies what later became Crandall, Ingraham, and Singer 2004 as a Criterion Economics paper. As with Ingraham and Sidak 2003, one author, identifies himself by his think-tank affiliation, in the case of this paper, Crandall with Brookings, rather than Sidak with AEI, and not by the consultancy that he chairs and that the other author/authors work for.

55 Ford, G., & Spiwak, L. (2004). The positive effects of unbundling on broadband deployment. Phoenix Center Policy Paper No.19. The Phoenix Center. Available at: /http://www.phoenix-center.org/pcpp/PCPP19Final.pdf.

56 Hazlett, T., & Bazelon, C. (2005). Regulated unbundling of telecommunications networks: a stepping stone to facilities-based competition?. George Mason University. Available at: /http://mason.gmu.edu/~thazlett/pubs/Stepping%20Stone%20TPRC.10.04.05%20.pdf

Bazelon is a consultant with Analysis Group, where Hazlett, who holds an academic appointment at George Mason, also consulted at the time.[57] Analysis Group was, it appears, employed by Verizon during this period to produce work on unbundling.[58] As a consequence, it would be appropriate to treat the results of this paper with the caution properly associated with industry-sponsored papers, although no sponsorship is directly disclosed in the paper itself. The first conclusion of the paper—that unbundling harms investment—is based on the observation that investment in telecommunications dropped massively after the tech-bubble burst in 2001. The authors' sole effort to tie this fact, which was true in many countries, including Switzerland, which did not have unbundling during this period at all, is a graph that shows investment declining from 2001 and number of UNE-P lines increasing over the same period. No effort is made to control for overall changes in the market. Much of the causal explanation simply refers to financial analysts' beliefs that the regulatory structure is anti-investment. The second conclusion of the paper does actually rely on a regression, and claims to show that use of unbundling in earlier periods does not predict facilities-based investment by CLECs in later periods. However, it seemed to show a negative relationship initially, and a positive relationship over time, describing only the total effect over three periods as statistically insignificant. The authors final assertion is that the rate of DSL subscription increased by better-than-trend after the FCC's formal abandonment of line sharing, based on subscription data from Legg Mason. This is simply an early version of the erroneous analysis discussed in the context of Hazlett and Caliskan (2008) above.

Zarakas et al (2005)[59] is a consultancy-produced paper that relies on an agent-based simulation. The paper used strategic action modeling to claim that unbundling at TELRIC rates increased innovation.[60] The assumptions in this model are nothing short of heroic. It assumes three facilities-based competitors and one unbundling competitor, and it assumes that each of the three facilities-based competitors immediately achieves full capacity whenever it deploys lines, does not need to build market share over time, and "there is no unused capacity." (p. 16). For this assumption to be true, it would have to be the case that three separate wires would be going into each home, each capable of serving all of that household's needs, and the household would nonetheless subscribe to all three wires. Using these assumptions and various rounded-up and rounded-down data from actual markets, the paper hypothesizes the effects of different levels of prices for unbundled network elements. It predicts based on these simulations that decreases in the prices of unbundled elements would lead to increases in investments in facilities (by these firms whose every new line is immediately taken up by a new customer, even though that customer already had access to two other wires and was subscribing to both of them).

Willig (2006)[61] is a self-published paper by an academic at Princeton. The paper originated in an analysis done for a declaration on behalf of AT&T, in an FCC filing, while AT&T was an entrant.[62] It

57 Hazlett CV, 2006. http://www.law.gmu.edu/assets/files/faculty/cv/hazlett.pdf.

58 Robert Pyndick uses Analysis for his consulting, and in Pyndick 2007 properly discloses that the analysis there was commissioned by Verizon. He then thanks Hazlett and Bazelon for their help. His CV, again, with admirable candor, discloses that he was a consultant to Verizon at the relevant period (2003-2005). Similarly, the Hazlett and Bazelon paper itself, in footnote 19, cites to a declaration filed by Hazlett and Bazelon and one collaborator on behalf of Verizon, covering some of the materials discussed in the paper.

59 Zarakas, W., Woroch, G., Wood, L., McFadden, D., Ilias, N., & Liu, P. (2005). Structural simulation of facility sharing: unbundling policies and investment strategy in local exchange markets. Report by The Brattle Group, Washington, DC. Available at: /http://www.brattle.com/_documents/UploadLibrary/ ArticleReport2347.pdf .

60 Clarke, R. N., Hassett, K., Ivanova, Z. and Kotlikoff, L., Assessing the Economic Gains from Telecom Competition. NBER Working Paper No. W10482 (2004).

61 Willig, R. (2006). Investment is appropriately stimulated by TELRIC. Princeton University. Available at: /http://psc.ky.gov/pscecf/2003-00379/5200700_efs/ 04132004/MCI_ST_MTB_EX_14_04%2013%2004.pdf

62 Willig (2006) at notes 10, 24.

begins with an informal conceptual description of what it calls the Investment Deterrence Hypothesis and the Competitive Stimulus Hypothesis. The two names are self-explanatory. It primarily emphasizes that investment deterrence must necessarily rely on the idea that TELRIC price regulation does not in fact do what it is designed to do—mimic efficient investment costs for an entrant. It also emphasizes that competitive stimulus relies on the observation that entry into markets with such high fixed and sunk costs are high, and that competition, where feasible, performs better than monopoly. Lower prices will drive demand, and higher demand will drive new investment. It then reports on results of a different submission to the FCC, on several papers by the Phoenix Center, and on a dated OECD policy report.

The next paper, Waverman and Dasgupta (2006),[63] is a consultancy document prepared by LECG for France Telecom. It is a conceptual paper. It lays out the case that too much regulation will undermine incentives; it asserts that the basic high-fixed-cost structure of the telecommunications markets has largely been superseded; it specifically states that econometrics cannot capture the full complexity and multi-dimensionality of the regulatory process; and it states merely that if the purpose of regulation is to increase investment in a second infrastructure, then over-regulation is more of a risk than under-regulation.

Pyndick (2007)[64] is a refereed article[65] by an academic, whose headnote properly discloses that the study was commissioned by Verizon. It is a theoretical article. It provides an option-value approach to confirming the Hausman (1998) critique of TSLRIC pricing.

We include here the counterpart to Waverman et al 2007 produced for the entrants' side, Cadman (2007).[66] Cadman 2007 is a consultancy paper created for ECTA, the entrant's organization that is the counterpart to the incumbents' ETNO. Its provenance therefore requires as much caution as appropriate for the Waverman et al 2007 paper. Cadman 2007 provides an econometric analysis of the relationship between regulatory effectiveness and investment per capita. It uses ECTA's own regulatory effectiveness index. This raises the possibility that the index is biased, although at a minimum it likely reflects the degree to which entrants view a given country's regulatory environment as conducive to their entry. It also uses the OECD's regulatory reform index for the telecoms sectors. Running regressions controlling for GDP, population, area, and interest rate, it finds significant correlation to good performance on the regulatory efficacy indexes. It is important to emphasize that regulatory efficacy is not a direct measure of open access, and this analysis does not address itself to the effectiveness specifically of access-related regulations, but to the effectiveness of the telecommunications regulatory system more generally.

Friederiszick, H., Grajek, M., & Roller, L. (2008)[67] is an academic working paper, supported by Deutsche Telekom. It uses a sophisticated model, focuses on data at the operator level rather than the country level, and uses external indexes to identify not only formal, but also effective regulation and

63 Waverman, L., & Dasgupta, K. (2006). Investment in telecommunication networks: a 21st century perspective. Report by LECG Consulting, London, UK.

64 Pyndick, R. (2007). Mandatory unbundling and irreversible investment in telecom networks. Review of Network Economics, 6(3), 274–298.

65 The paper is published, like several others, in the Review of Network Economics. That journal states that publication requires a single referee to provide a positive evaluation. It is not clear whether this requires the absence of negative reports.

66 Cadman, R. 2007. Regulation and Investment in European Telecoms Markets. SPC Network.

67 Friederiszick, H., Grajek, M., & Roller, L. (2008). Analyzing the relationship between regulation and investment in the telecom sector. ESMI White Paper No. WP-108-01.

political environment. The paper finds that access regulation that forces incumbents to open access to their networks has a negative effect on fixed-lines entrants' investment, but no negative effects on fixed-line incumbents' investments, and no negative effects on either incumbents or entrants in mobile. While the framing of the paper strongly emphasizes its results on fixed-line entrants, its findings on incumbent and mobile investment support the proposition that open access regulation does not undermine investment overall, or socially efficient investment. The authors emphasize the displacement of entrant investment, projecting from their findings that entrants invest in a given five year period about half of what they would have invested without access regulation. As long as a strict investment ladder approach is taken, this is clearly evidence against open access. However, given that redundant investment is a regulatory hedge with ambiguous long term welfare effects, the implications of avoidance of such investment become more ambiguous.

Friederiszick et al (2008) find that open access rules do not cause incumbents to invest less in upgrading their networks. They hypothesize that "One possible explanation of this is that entrants are able to boost end customer demand due to increased variety and innovativeness of their information and communication services offered on incumbents' networks. In this case the lost profit margins of incumbents could be offset by the increase in total demand. " (Friederiszick et al 2008 p. 33). This finding is consistent with the empirical findings in Chang, Koski, and Majumdar (2003) and with some of the theoretical models discussed in Gurthrie (2006). Friederiszick et al warn, however, that their findings do not necessarily carry over to investment in next generation networks, although nothing in their data either supports or refutes that extension.

Access, unbundling, and investment: Conclusion

We review here 23 papers on unbundling and investment. These include all the papers in Cambini and Jiang, except for those more appropriately reviewed in the sections on performance or the qualitative case studies. We add three academic, one governmental, and one industry-sponsored report, and treats one double citation in that report as a single paper. Of the 23 papers, over half, 13, are industry sponsored. Of these thirteen, only two or three are published, only one refereed. All but one take the position that would support the position of the paper's sponsor. The majority of the papers exhibit weakness; several are not empirical. Of the remaining ten papers, two are government sponsored, unpublished papers. One shows that higher regulatory effectiveness increases investment, but its descriptive portions are more powerful than its econometrics. The second is methodologically powerful, hypothesizes weaker investments by entrants as a result of unbundling, but does not in fact find lower investments by entrants. The remaining eight papers are academic and think tank. They are all published. Four are theoretical, two showing positive effects on investment, one negative, and one emphasizing the current state of uncertainty about the effects of unbundling on investment. Of the remaining four, two find that investment increases. Two find that investment declines or is delayed. Of these, one has severe methodological problems which we discuss later (Wallsten and Hausladen 2009). The second supports the finding of delayed investment. However, the paper suggests that delayed investment is likely a reflection of strategic jockeying for a more favorable regulatory environment, rather than a real incentive effect, and that the welfare lost may not be very large.

Qualitative case studies of open access

Given the relative ambiguity of the sum of the quantitative data, it is appropriate to rely primarily on

the qualitative literature. For these same reasons, our own study draws heavily on qualitative work. In this section, we review the most relevant qualitative work. In comparison to the quantitative work, more of this literature is produced by academics and published in refereed journals. The studies in this segment of the literature are not as frequently sponsored by industry and largely provide more support for the proposition that open access policies have had a positive impact on the diffusion and performance of broadband.

Citation	Pub=1 Self-pub=0	Sponsor	Countries covered	Open access played role? + / - / 0	Main observations
Academic/ Think tank					
Lee & Chan-Olmsted (2004)	1		Korea; U.S.	0	Detailed study of broadband policy in Korea; attributes Korean success to wide range of geographic and demographic factors; emphasizes urban density; emphasizes government demand-side programs. Confirms that Korean early entry was by leased access over cable Confirms that a contemporaneous view of the U.S. regulatory shift was that early 2002 to early 2003 was when cable and telco broadband providers were clearly deregulated from access provisions pertaining to broadband
Frieden 2005	1		U.S., Canada, Japan, Korea	0/+	Emphasizes the different responses of the various incumbents to the regulatory and policy efforts in their countries. Emphasizes that U.S. incumbents fought to obtain an unregulated duopoly market structure. "Stakeholders appeared more intent on competing in the courtroom than in the marketplace."
Ida 2006	1		Japan	+	Highly detailed study of Japanese market, demand and supply elements. Strong emphasis on role of Softbank Yahoo!BB in driving DSL and demand. Strong emphasis on K-Opticom in fiber. Anticipates expansion of KDDI and Softbank to fiber.
Chung 2006	1		Korea	0	Emphasis on geography and demand policies. Claims "hands off" approach of Korean government played large role. Confirms that Hanaro entered over leased lines as an important way to enter at low cost.

Citation	Pub=1 Self-pub=0	Sponsor	Countries covered	Open access played role? + / - / 0	Main observations
Bauer (2006)	1		U.S.		Detailed study of the U.S. market, determinants of supply and demand, players, both incumbents and entrants, and political economy. "American broadband policy evolves in a piecemeal fashion, driven by political agendas, corporate strategies, and legal and regulatory battles." Detailed description of the regulatory battles, promises, and the retreat in early 2002 to early 2003 from unbundling for broadband.
Krafft (2006)	1		France	~+	Highly detailed study of the French market and regulatory environment. Author explains the failure to thrive of cable as in part caused by regulatory fragmentation, in part by France Telecom early control over facilities. Krafft emphasizes entry of Free/Iliad as important, but laments small market shares of Neuf, Cegetel, and Alice as too small to thrive (all are now part of SFR or Iliad). Regulatory shift in late 2002-2003; attributes to combination of change of leadership in ART/ARCEP, learning from Japan, and cooperation with the EU Framework Directive.
Bullingen (2006)	1		Germany	~	Detailed study of German market; emphasizes dominance of DT and weakness of regulatory agency; hypothesizes that the importance of DT to German industrial and labor policy immunizes it from effective regulation; confirms the regional boundaries of entrants in Germany.
Antonelli and Patrucco (2006)	1		Italy	0/~	Emphasizes highly regional nature of Italian market; the wealthy parts: 3% of landmass, 25% of population have high competition, including fiber from Fastweb; other areas lag. Emphasizes geographic concentration and facilities-based competition; sees unbundling as useful for the underserved areas of Italy.
Lindmark and Bjorstedt (2006)	1		Sweden	+	Detailed description of Swedish market. Emphasis on early entry by dial-up companies; early entry by facilities-based competitor Bredbandsbolaget; complementarities between facilities-based and LLU-based entry; concerned with too fragmented a market for the LLU portions of the market (pre-consolidation by Telenor).

Citation	Pub=1 Self-pub=0	Sponsor	Countries covered	Open access played role? + / - / 0	Main observations
Fransman (2006)	1		Synthesis of other studies of Japan, Korea, U.S., France, Germany, Italy, Sweden, informal observations about UK	+	Emphasizes role of disruptive entrants, like Softbank or Free/Iliad. Emphasizes the less innovative nature of incumbents when they are the sole competitors. Confirms then-contemporaneous view, just before functional separation in UK, of strategic obstruction by BT. Emphasizes then-clear difference between France and Germany expressed in prices and speeds.
Picot & Wernick (2007)	1		U.S., Korea, EU countries	+	"LLU and access obligations play important roles throughout Europe and have contributed to high deployment rates in countries lacking alternative infrastructure as well as in countries with competing platforms." Germany, however, continues to debate regulatory holidays "From a competition-related perspective, the leading position of Korea has been furthered by platform competition between DSL and cable modem. While LLU played a negligible role, open access obligations for cable owners were important for new entries to compete on a level playing field." "Thus, the U.S. is moving in an entirely different direction than Europe, and also in comparison to U.S. regulatory policy prior to about 2002 ".
Kushida and Oh (2007)	1		Japan, Korea	+	Detailed political economy of regulation in both countries; emphasizes effective regulator and policy programs; emphasizes unbundling in Japan, through Softbank; notes role of open access over cable in Hanaro entry in Korea
de Bijl and Peitz (2008)	1		Netherlands	-/+	More a conceptual piece than an empirical piece; seeks to persuade the Dutch regulator to phase out unbundling over time. Acknowledges that unbundling played an important role in competition and investment, but raises concerns over long term investment incentives and emphasizes the benefits of high cable penetration in the Netherlands.

Citation	Pub=1 Self-pub=0	Sponsor	Countries covered	Open access played role? + / - / 0	Main observations
Whallen and Curren (2008)	1		UK	0	Functional separation in BT was difficult; policing boundaries between the parts of the firm hard; no rush to adopt in other EU countries
Eskelinen et al (2008)	1	N/A	Finland, Sweden	+	Emphasis on comparing the level of government planning and funding; by implication, suggests that Finland's emphasis on competition, in part through early unbundling, coupled with competition among its former incumbents, was largely as effective as Sweden's more encompassing approach, although took longer to mature.
Sadowski et al (2009)	1	N/A	Netherlands	+/-	Analyzes municipal fiber initiative; argues access is important component; actual observations seem to support the opposite conclusion for a small municipality like the one studied.
Industry supported					
Hausman and Sidak (2005)	1	Vodafone	U.S., UK, NZ, Canada, Germany	-	Qualitative case studies; five countries: U.S., UK, NZ, Canada and Germany; all countries in the study had weak and contested implementations of LLU.
Crandall and Waverman (2006)	1	France Telecom	U.S., Canada, UK, rest of Europe in less detail; Japan	+ Likely positive effects for broadband competition, but not for voice	Extensive review of the covered markets; emphasis on the possibilities of unbundling to be a productive avenue for broadband, even if it is not for voice-only competition; strong emphasis on unbundling as entry strategy for incumbents in one country entering the turf of others; endorsement of Free/Iliad as a model for Europe; strong emphasis of Softbank role in Japan adoption, and more measured predictions on its future role in Japan
Crandall et al. (2009)	1	Verizon	UK, NZ, Italy, Australia, Sweden	-	Argues that functional separation harmed growth of penetration rates and investment in the countries that adopted it; emphasis on UK.

Qualitative case studies of access regulation: Academics

Lee & Chan-Olmsted (2004)[68] is a peer reviewed article by an academic and a researcher at Samsung. It provides a detailed case study of Korea and the United States. The study seeks to provide insights into what each country can learn from the relative success of the other. The U.S. is seen as performing particularly well higher-up in the stack, in e-commerce and online content, while Korea is seen as performing better at the infrastructure layer. At that level, the one more pertinent to our study here, the paper describes the range of investments, strategic programs, and interventions of the Korean government, as well as the access regime. Consistent with Picot and Wernick (2007) characterization of Korea's cable infrastructure regulatory regime prior to 2002 as "open access," Lee and Chan-Olmstead emphasize that, "It is also important to note that most Korean cable ISPs are not cable system operators but lease space from the operators. " (661). In their review of the United States, these authors had no difficulty concluding, based on the February and March 2002 NPRM and Declaratory ruling,[69] that "Thus, the phone companies' and cable companies' broadband services appear to be freed from many of the regulations in the United States."[70] The authors observe that actual competition—that is to say, at the local level where choice actually exists—is likely higher in Korea than in the U.S.: among three, as opposed to two, providers per market. The paper then goes, in detail, into comparisons of the two countries in terms of potential determinants of Internet adoption: education, age, income, online activities, self-reported reasons for not connecting, and e-commerce. The study ultimately concludes that housing patterns played a large role in broadband deployment, a conclusion that will surprise no one. But it also attributes a real role to the basket of regulatory and investment policies of the Korean government.

Frieden (2005)[71] is a peer-reviewed, academic paper with no industry sponsorship. Frieden's review of the U.S. experience juxtaposes the enormous success and innovation in the high-technology, Silicon Valley sectors of the U.S. information technology sector to the lackluster performance of U.S. telecommunications and broadband provisioning sector. He describes the history of the response to the 1996 Telecommunications Act in the United States, concluding that: "The combination of market downturn, legislative failure and lack of consensus on operating standards has removed many of the incentives for risk taking and investment, even as the need for network upgrades proved essential for the evolution of high-speed broadband ICT services. Stakeholders appeared more intent on competing in the courtroom than in the marketplace. The incumbent Bell Operating Companies made infrastructure investment contingent on securing massive regulatory liberalization which, if implemented, might result in the establishment of a shared monopoly among telephone and cable television companies without significant government oversight. " (602). In other words, Frieden's interpretation of the U.S. case is that postponement of investment was more strategic, as part of the

68 Lee, C., & Chan-Olmsted, S. M. (2004). Competitive advantage of broadband Internet: A Comparative study between South Korea and the United States. *Telecommunications Policy, 28*(9-10), 649-677.

69 Federal Communications Commission (FCC). (2002, February 15). Notice of Proposed Rule making: In the matter of appropriate framework for the broadband access to the Internet over wireline facilities; universal service obligation of broadband providers; computer III future remand proceedings: Bell operating company provisions of enhanced services (FCC 02-42). Washington, DC: FCC. Federal Communications Commission (FCC). (2002, March 15). Declaratory ruling and notice of proposed rule making: In the matter of inquiring concerning high-speed access to the Internet over cable and other facilities; Internet over cable declaratory ruling; appropriate regulatory treatment for the broadband access to the Internet over cable facilities (FCC 02-77). Washington, DC: FCC.

70 This contemporaneous assessment of the interpretation of the FCC decisions is consistent with our interpretation of the U.S. timeline, which has been disputed in comments to our report.

71 Frieden, R. (2005). Lessons from broadband development in Canada, Japan, Korea and the United States. *Telecommunications Policy, 29*, 595-613.

regulatory negotiation process, than straight incentives based. Frieden then goes on to observe the government investment and strategic planning, as well as demand side interventions in Canada, Japan, and Korea, as higher performers, as well as at their competitive strategies. The study does not dig deep into the precise dynamics of firms and their investments, but emphasizes the differences between the heavy resistance and litigation tactics of the U.S. firms, relative to the more compliant and cooperative approach taken by firms in the three other countries he observes.

Ida (2006)[72] is an academic book chapter, with no industry sponsorship. It offers a detailed description of the regulatory choices and history in the breakup of NTT, and the introduction of access regulation. The paper analyzes the different market players, provides information about market shares, then-measured elasticities of demand for the various forms of broadband, and analyzes the interactions between the market segments. Ida focuses very heavily on the role of Softbank as an entrant over unbundled DSL as a driver of the market, as well as the entry by K-Opticom as a driver of fiber competition. The paper observes the KDDI entry over leased fiber, and, in 2006, anticipates that Softbank will expand their service to offer FTTH using the facilities of others.

Chung (2006)[73] is an academic book chapter. It offers market data on the role of the major players in initial broadband adoption in Korea. Unlike the other case studies of Korea, it describes Hanaro and Thrunet as having made major facilities-based investments of their own. On the other hand, when describing Hanaro's entry strategy in detail, the chapter specifically notes the company's emphasis on using already-installed fiber (which it did not install or own) to businesses and large apartment complexes. The chapter in several places describes the Korean government's approach as a "hands off" policy, which seems at odds with all other descriptions of the Korean experience, but likely refers to the late introduction of unbundling of the copper plant. In all, the author attributes Korea's success to "market, geographic, and demographic factors, to some extent. It is important, however, to note that facilities-based competition combined with the non-interventionist policy and various incentive programs greatly contributed to the earlier establishment of the market compared with other countries."[74]

Bauer (2006)[75] is an academic book chapter that offers a detailed qualitative analysis of the state of the U.S. broadband market up to and following the decision to abandon open access policies. The chapter describes the anatomy of the U.S. broadband market after the 1996 Telecommunications Act, household and business demand, and the nature of the companies providing broadband in the market. It describes the relative dominance of the RBOCs and cable companies, while mentioning the early entry of other entrants. In particular, the chapter notes Covad's entry, based on unbundling, and what the author described as that company's uncertain future as a market participant, given the FCC's retreat from open access under Chairman Powell. The chapter describes the litigation and regulatory negotiations; and notes the promises by several of the incumbents that they would scale up investment in fiber after they received regulatory assurance that they would not need to unbundle those newer facilities. The chapter describes Verizon's investment in fiber-to-the-home, but the choice by SBC and Bell South to scale back from their fiber-to-the-home promises, and to deploy instead DSL services over fiber-to-the-node systems. (p. 144). The chapter speculates that this is a transitional approach,

72 Ida, T. (2006). "Broadband, Information Society, and National System in Japan," M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 65-86 .

73 Chung, I. (2006). "Broadband, Information Society, and National System: The Korean Case," M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 87-108 .

74 Id., at 107.

75 Bauer, J. (2006). Broadband in the United States. M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 132-163.

although looking back from late 2009, it is clear that the new AT&T continues the xDSL approach that SBC began in 2004, as described in Bauer (2006).

The paper begins its review of the regulatory history by stating "American broadband policy evolves in a piecemeal fashion, driven by political agendas, corporate strategies, and legal and regulatory battles." It goes on to detail the early implementation of unbundling, and early efforts to extend open access to cable networks, at the franchising authority level; and then the shift, under the new FCC, beginning in the March 2002 decision to declare cable broadband an information service and concluding with the February 2003 Triennial Review order phasing out line-sharing, the decision that unbundling did not apply to new fiber-to-the-home deployments, and the later clarification that that exemption also applied to fiber-to-the-curb projects, which put xDSL networks outside of the unbundling regime and enabled Bell South and SBC to pursue their trajectory. The chapter, published in 2006, expresses a hope that the changes, if indeed they will have the positive investment effects they are intended to have, will result in the U.S. closing the then-small performance gap between the U.S. and the slightly better performing Nordic countries and the Netherlands. As of 2009, however, that gap has widened, and more European countries that improved the quality of their open access regime have surpassed the U.S.

Krafft (2006)[76] is an academic book chapter providing a detailed qualitative analysis of the French market and regulatory environment. Krafft provides a highly detailed and careful analysis of the French market, its development, and in particular the regulatory developments in 2002-2003 that drove effective implementation of unbundling and France's broadband performance takeoff. Krafft attributes the failure of cable broadband in France in part to the regulatory fragmentation of markets, and in part from France Telecom's large ownership of essential cable facilities, which stifled its competitors on that platform. The author sees a major shift in French regulatory policies toward unbundling in late 2002 early 2003. She attributes these in part to insights internal to the ART, later ARCEP, and its observations of the successes of Japan and Korea, in part to a change in leadership in January of 2003, and in part in response to, and with the support of, the new European Framework Directive. At the time, Krafft describes Free/Iliad as the primary entrant, based on unbundling, and laments the relatively fragmented state of the remainder of the market, with Neuf, Cegetel, and Alice holding very small market shares. From today's perspective, however, we know that through consolidation these too-small entrants formed the basis of today's more sustainable competitive structure of the French market. The paper offers an excellent snapshot of the observations of an academic in the mid-2000s of the French performance, at a time when the change in policies had begun to bear fruit, but had not played out its full effect as can be observed with three or four more years of data available to us today.

Bullingen (2006)[77] is an academic book chapter that provides a detailed case study of Germany. Bullingen starts by noting the unusually high market share of Deutsche Telekom in the early 2000s (falling from 97% in 2001 to 88% in 2004, still unusually high), and the odd fact that although Germany had very high cable television penetration, it had almost no cable broadband competition at the time. He describes DSL as dominant, and Deutsche Telekom as dominant in DSL. While unbundling was enacted early, and there is a substantial amount of unbundling, Bullingen discusses the relatively high prices for line sharing at the time and the lack of clarity on bitstream access and entry with complementary assets by entrants. As for cable, the paper attributes much of the late start of cable to outdated infrastructure and repeated mistakes by German regulators—both competition authorities

76 Krafft, J. (2006). Emergence and Growth of Broadband in the French Infocommunications system of Innovation. M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 172-194.

77 Bullingen, F. (2006). Development of the Broadband Market in Germany. M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 195-218.

that prevented various investments and consolidations, and what appear to be the equivalent of franchising rules that resulted in a highly fragmented cable market. The paper also surveys several other efforts at other sources of entry, but largely sees them as making no real inroads. It concludes with an effort to understand the relative inefficacy of German regulation, and hypothesizes that DT forms an important part of German industrial policy and labor policy, and that weakening DT through a more competitive market was simply inconsistent with the broader industrial and labor policies of the German government.

Antonelli and Patrucco (2006)[78] is an academic book chapter that offers a detailed case study of the Italian broadband market. The authors provide a detailed description of the broadband market, demand and application, major firms, and regulatory structure. The most important insight offered by this paper is the highly segmented nature of the Italian market, and the somewhat surprising relationship between the relatively low prices in the Italian market, on the one hand, and the low penetration rates, on the other. The paper covers the large differences in wealth, density, and deployment between Lombardy, Liguria, Emiliga-Romanga, and to a lesser extent the Piedmont, which are wealthy, with high urban density, covering 25% of the population in 3% of the territory, and the lower density area of the third Italy, and the remainder of the country, mostly in the south and in some of the mountainous areas. The largest success story of competition in the northwest was Fastweb. The company was started by the Milan power utility, AEM, which in December 2004 merged with e.Biscom. Its strategy relied on using the utility's own ducts to lay fiber to the home, bypassing Telecom Italia's infrastructure, in the most densely settled municipalities—Milan, initially, and then in the other major Italian urban centers: Rome, Turin, Genoa, Naples and Bologna. Only later did Fastweb begin to combine its own fiber with unbundled loop to extend it service beyond the core high-density, higher wealth areas. The paper classifies Italy, therefore, as primarily a story about facilities-based entry, with a high geographic and demographic bias. In most of the country, however, competition is weak.

Lindmark and Bjorstedt (2006)[79] is an academic book chapter that provides a detailed case study of the Swedish broadband market. It begins with the history of the early and vigorous dial-up market, tracks the privatization of Telia, the divestment of its cable holdings in ComHem, the emergence of broadband through, in particular, early entry by Bredbandsbolaget into the fiber to the home business and significant early price competition that it introduced in the major urban centers, public investment in a national backbone, alongside public-private deals, most prominently mentioned was Tele2 and the Swedish Railway Administration. The chapter also describes the public investments through the municipalities. Particularly interesting is the description of the competitive dynamics in 2004, as Telia and Bredbandsbolaget competed by lowering installation charges; in response, Glocalnet, a ULL entrant, lowered installation charges to zero, while unbundling-base Bostream began to offer higher data rates. At the time of that writing, Telenor had not yet moved to consolidate these smaller broadband entrants.

Fransman (2006) is an edited volume that includes the prior book chapters and several synthesis segments. Fransman provides the synthesis of the specific and detailed case studies discussed above as book chapters. He argues that effective regulation clearly played an important role in the successful performance of the high performing countries, in particular Japan and Korea. He attributes the success to the combination of effective access regulation and disruptive entrants, more entrepreneurial than the

78 Antonelli, C. and Patrucco, P.P. (2006) Broadband in Italy. M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 219-239.

79 Lindmark, S. and Bjorstedt, P. (2006). The Swedish Broadband Market. M. Fransman (ed.), Global Broadband Battles, Stanford University Press: 240-265.

large incumbents that typify the U.S. market, even where they do compete. His classic example is Softbank in Japan. He seems more skeptical that Iliad in France is indeed of the same type, although he does suggest that Iliad was inspired by, and self-consciously followed the model of, Softbank. Published as a book in 2006, and likely written therefore in 2005, the synthesis is clearly consistent with our own observations nearly five years later about the role of agile, entrepreneurial competitors entering over access to incumbent networks. The synthesis also coheres with our own observations regarding the difference between the reluctance of the German regulator to impose access regulation, the relatively concentrated market structure in Germany, and the relative switch in the performance of France and Germany, particularly along dimensions of price and speed, rather than penetration, following the French regulatory changes in the face of German reluctance to adopt open access. Fransman adds insights into the UK market, because his description is written contemporaneously with the consideration of the imposition of functional separation on BT. He emphasizes that unbundling in particular was weakly implemented in the UK, and while wholesale competition existed, more disruptive entry of the Softbank style was impossible without unbundling. Fransman then quotes from an interview with the Director General of Oftel that "had 'he realised earlier that BT was playing a long game' he would have 'handled local loop unbundling differently,'" and would have been "more directive" (Fransman 2006, p. 189). This description is consistent with the observations of Ofcom, as well as the observation of the history since introduction of functional separation in the UK.

Picot & Wernick (2007)[80] is a peer reviewed, academic article with no visible industry sponsorship. It offers qualitative case studies of EU countries, Korea, and the United States. It does not seek to draw normative conclusions about which of the various approaches is, overall, better. Its findings are largely consistent with our own. The authors concluded that "LLU and access obligations play important roles throughout Europe and have contributed to high deployment rates in countries lacking alternative infrastructure as well as in countries with competing platforms." (672). They do, however, note the continuing debates over whether open access obligations undermine investment incentives, pointing in particular to the debates over regulatory holidays in Germany. (672). With regard to Korea, the authors offer an interpretation similar to ours of the history of Korean deployment. That is, most of the work in Korea was done by the various government intervention programs, but the competition policy component should be seen as a piece of, as opposed to entirely distinct from, the open access debate. Looking at the early use by Hanaro and Thrunet of leased access lines over cable: "From a competition-related perspective, the leading position of Korea has been furthered by platform competition between DSL and cable modem. While LLU played a negligible role, open access obligations for cable owners were important for new entries to compete on a level playing field." (671). Finally, with regard to the U.S., the authors conclude in 2007: "Thus, the U.S. is moving in an entirely different direction than Europe, and also in comparison to U.S. regulatory policy prior to about 2002." (671).

Kushida and Oh (2007)[81] is an academic peer reviewed article. It describes the political regulatory history of Japanese and Korean broadband development, surveying the relationships between the regulators and the incumbents and describing the market dynamics between the major firms. The paper suggests that the balance of power and professionalism between the regulator and the incumbent played a large role in the takeoff in broadband in both countries, and that access regulation played a significant role in Japan. Kushida and Oh, like Lee and Chan Olmstead (2007) and like Picot and Wernick (2007),

80 Picot, A., & Wernick, C. (2007). The role of government in broadband access. *Telecommunications Policy, 31*(10-11), 660-674.

81 Kenji Kushida and Seung-Youn Oh, The Political Economies of Broadband Development in Korea and Japan, Asian Survey, Vol. XLVII, 2007. 49 0-504.

observe the open access nature of cable infrastructure entry in Korea: "In April 1999 Hanaro commenced broadband services, utilizing both DSL and cable, using its own DSL network and leasing cable capacity from Powercomm, a subsidiary of KEPCO and KT " (495).

De Bijl and Peitz (2008)[82] is a peer reviewed journal written by an academic and a researcher at an independent government research center. It is addressed to Dutch policy makers, but is largely a conceptual piece, not a qualitative or quantitative analysis piece. It seeks to persuade the Dutch regulator to focus on an approach for phasing out unbundling and open access over time. While the study acknowledges that unbundling played a role in spurring competition and investment in the Netherlands as a practical matter, it raises concerns about longer term investment incentives. In particular, it emphasizes the fact that the Netherlands has a high degree of cable competition to DSL to argue that open access policy is unlikely, in the long term, to be better for the Netherlands.

Whallen and Curren (2008)[83] is a paper by two academics with no visible corporate sponsorship. It is published in Communications and Strategies, the IDATE journal. It is a relatively simple descriptive paper. It primarily tells the story of BT's functional separation as a difficult one. The emphasis is on the difficulty of practical implementation and the necessity of extensive, continuous monitoring and adjustment by the regulator to define the boundaries between the wholesale and retail divisions, and the content of what needs to be offered by Openreach. The paper also briefly reviews the experience of other countries and suggests that the Italian case was primarily driven by an effort to prevent AT&T's entry into the market in order to keep Telecom Italia under Italian control; it further suggests that elsewhere in Europe regulators were not jumping on the functional separation bandwagon.

Eskelinen et al (2008)[84] is an academic paper in a refereed journal with no industry support. It very broadly compares the Swedish early broadband plan and government funding model to the somewhat later Finnish national plan, which did not depend on government funding but rather on entry by former incumbents into each other's markets. It concludes that the Swedish approach resulted in earlier growth of penetration and lower prices earlier; but that the Finnish approach ultimately caught up. The authors conclude that the choice of approaches—government investment driven or competition driven—did not result in substantially different results. While the paper does to some extent note the historical difference between the incumbency structures in the two countries, it focuses primarily on the difference in funding policies, and does not seek to explore the different ways in which competition was introduced into the markets; the relative roles of cable and utilities in each of the markets, or the role and take-up of unbundling and access regulation in creating the competitive environment. Because of these omissions, the paper leaves much of what appears to be relevant and contested in the policy analysis under-explored. Nonetheless, its implication is that Finland's access-based competition, among incumbents entering each other's traditional regions using, in part, unbundling, is that competition in the presence of open access performed as well in the medium term as the more state-sponsored approach pursued by Sweden.

Sadowski et al (2009)[85] is an academic paper with no corporate sponsorship, published in a refereed journal. It provides a detailed case study of one municipal fiber-to-the-home network, and an overview

82 de Bijl, P., & Peitz, M. (2008). Innovation, convergence and the role of regulation in the Netherlands and beyond. *Telecommunications Policy, 32*(11), 744-754.

83 "Is Functional Separation BT-Style the Answer?" Communications and Strategies. (71), 3rd quarter 2008, p. 145-165.

84 Heikki Eskelinen, Lauri Frank, and Timo Hirvonen. 2008. Does strategy matter? A comparison of broadband rollout policies in Finland and Sweden . Telecommunications Policy, 32:412-421.

85 Sadowski, Bert. M, Alberto Nucciarelli, and Marc de Rooij. 2009. Providing incentives for private investment in municipal broadband networks: Evidence from the Netherlands. Telecommunications Policy. 33:582-595

of several others in the Netherlands. The paper outlines several approaches, ranging from public utility-like models to a joint-venture like model. It concludes that there is significant room for municipalities to play a role in constructing fiber networks, although its description suggests that implementation is far from simple. Moreover, the paper concludes that municipalities should mandate open access obligations on new networks. The case study itself, however, suggests that vertical integration turned out to be important in that case to recover the costs of deployment; that the studied system itself ended up being taken over by Reggefiber and operated, as a practical matter, as a vertically-integrated operation; that competitive service providers did not enter, and that open access was available for passive, Layer 1 elements, not for active components higher up in the stack.

Qualitative case studies of access regulation: Industry sponsored

Hausman and Sidak (2005)[86] is a peer-reviewed article. The headnote properly discloses that the research was commissioned by Vodafone.[87] The paper uses case studies to argue that none of the rationales of unbundling is borne out by the evidence from five countries' experience: the United States, the United Kingdom, New Zealand, Canada, and Germany. We note that all five countries are those that we, and other case studies described here, diagnosed as, at least at the time, having weak, ineffective, or strategically contested unbundling regimes. The study is from a period when the United States was passed the peak of its unbundling policy; the UK and New Zealand were both on the verge of reaching a decision that their approach had failed, and were about to shift to functional separation; Canada and Germany, in turn, were two of the countries that had adopted unbundling formally, but were among the most reticent in implementation. There are various places where Hausman and Sidak interpret their evidence more favorably to their position than we would have, but these are not fatal to the analysis. Given the countries they chose, however, the analysis primarily comports with the observation that half-hearted implementations of unbundling do not work very well. The study does not include a single country that was at the time effectively implementing unbundling.

Crandall and Waverman (2006) is a refereed paper sponsored by France Telecom. Its abstract and some of the discussion suggest that this analysis was focused on "the emerging broadband strategy in Europe of large ISPs owned by incumbent telecommunication companies in other countries (for example, France Telecom's Wanadoo)": in other words, cross-border market entry by incumbents in one country to compete in their neighbor's erstwhile backyards. In our own case studies this was most visible in the entry of the Nordic incumbents into each other's markets. As such, it is an interesting paper by authors who normally write from the incumbents' perspective, who are asked to write from the perspective of an incumbent in one jurisdiction as it seeks to enter another.

About the U.S., discussing primarily voice, rather than broadband, unbundling, Crandall and Waverman write:

> AT&T and MCI largely abandoned mass-market local services because of the recent

86 Hausman, J., & Sidak, G. (2005). Did mandatory unbundling achieve its purpose? Empirical evidence from five countries. Journal of Competition Law and Economics, 1(1), 173–245.

87 This does not necessarily connote a conflict. Vodafone at the time owned Arcor, in Germany, which is a facilities-based based CLEC, not an unbundling-based CLEC. It also owns shares in SFR, which at the time had not yet bought Neuf-Cegetel, and so was in mobile, not home-broadband. It certainly is not an incumbent-supported paper. To the extent that there is a conflict we have not detected, it would suggest bias in favor of entrants, rather than incumbents. The paper, however, supports the incumbents' case. The authors had written in opposition to unbundling several times in the prior years.

> court decision that overturned the FCC's liberal unbundling rules and have since been acquired by SBC and Verizon, the two largest incumbents." (at 119.) "The continued growth of local competition in the United States through June 2004 was due almost entirely to the growth of the unbundled network platform, which had been leased by incumbents at rates 40 – 60 percent of the incumbents' average revenues per line. … This form of competition was nothing more than regulatory arbitrage, but it may have been profitable until the incumbents responded with their own bundled service packages. This conjecture is now largely irrelevant because the courts have forced the FCC to change its network unbundling rules. As a result, AT&T and subsequently MCI largely abandoned the mass market for local and long-distance services and merged into the two largest Bell companies.

Regarding the UK, they write:

> In the United Kingdom, unlike the United States, there was little CLEC entry aimed at residential markets. This may have been due to the fact that LLU began five years later than in the United States (2001 versus 1996), as well as capital market constraints that surely existed a year after LLU began in the EU. (p. 130)
>
> In the United States, some commentators blame regulation, that is, the implementation of the 1996 Telecommunications Act, which resulted in very large wholesale discounts for entrants, for providing incentives for inefficient entry. Yet similar excessive entry occurred in the United Kingdom, where mandated resale and LLU did not exist. This suggests that capital markets as well as regulatory incentives played crucial roles in stimulating uneconomic entry into telecommunications generally. (132).

Reviewing the experience of Europe, the authors write:

> However, there is one large and significant difference between narrowband and broadband services competition. In narrowband markets such (LLU based) competition merely replaces an incumbent's services with identical services from an entrant. The welfare gains—and thus the overall prospects for revenue growth and sustainable entry—are likely to be limited. Broadband, however, is a relatively new service with a rapidly increasing number of residential subscribers in Europe. Since broadband offers consumers the prospect of genuinely new and distinctive services, marketed and bundled for them in genuinely new and distinctive ways, the consumer welfare gains from services-based broadband competition might be significant, thus sustaining entry.
>
> Some analysts suggest an inverse relationship between the use of LLU and the rollout of broadband, because LLU diminishes the incentives for the incumbent to upgrade its network for broadband. In Europe, however, we see no simple inverse relationship between the number of lines unbundled and the percentage of homes with broadband, but there is a compounding issue. In Germany and France the incumbent telco is the major ISP, unlike the United Kingdom where BT until recently has been a minor ISP provider. It may be that the incumbent's desire to maintain its position as an ISP offsets the adverse incentives created by LLU in Europe. (141).
>
> As broadband providers however, Wanadoo, AOL, and other ISPs control the broadband portion of the local loop. Moreover, if they do not use LLU but rather bitstream access,

they have incentives to use VoIP, competing directly with the incumbent telco. Note the number of large multi-country ISPs in Table 11: Tiscali (an independent and the second largest ISP in Europe), Wanadoo, Tele-2, Chello Broadband (controlled by the Dutch cable company UPC), Easynet (controlled by the founders of Easyjet, the successful low cost airline), AOL, and NTL. These represent a potentially large, diversified set of competitors for telcos offering ADSL.

The experience of Iliad/Free in France also suggests that broadband ISPs with differentiated and innovative offerings can be viable. Free is the only nationwide "triple play" operator offering "ADSL 2+" technology over unbundled loops. By 2005, Free accounted for 43 percent of all unbundled lines in France. Further, Free reported 130,000 paying subscribers to Freebox TV services, and 1,135,000 telephone users. Iliad, Free's parent company, reported a 52 percent increase in revenue between the first quarter of 2004 and the first quarter of 2005, largely thanks to an 83 percent jump in Internet revenues. Free's stated goal is to reach 1.5 million ADSL customers for the year 2005. As of 30 June 2005, the firm had achieved an ADSL subscriber base of 1,316,000.73 Michel Boukobza, Managing Director of Iliad recently declared, "Our business model is simple, we have a E29.9 monthly rental [from our retail customers] and we pay France Telecom E10.5 per month per subscriber. The difference allows us to amortise our network as well as R&D costs." This would suggest that there is plenty of scope for entrants to use low LLU rates to operate profitably. However, other entrants have not replicated Free's successes, and French LLU rates are not significantly different from the European average. There is nothing obviously different about France (relative to the rest of Western Europe)—such as vastly lower input costs for entrants—that would explain how and why Free has been successful. On the other hand, Free has been offering innovative products such as TV over DSL, and it is this product differentiation and innovation that might explain its rapid increase in subscribership. Indeed, France's relatively low cable penetration might create an opportunity for ISPs that offer bundles of broadband along with Digital TV.

On Japan Crandall and Waverman write:

In December 2000, the Ministry of Public Management, Home Affairs, Posts, and Telecommunications introduced a network unbundling requirement in Japan, allowing new entrants to offer DSL services over shared NTT lines. At that time, there were less than one million broadband subscribers in Japan, and most of them were subscribing to cable modem service. DSL has since grown rapidly, attracting 12.8 million subscribers by September 2004, while cable modems have grown more slowly to just 2.68 million lines and fiber to the home has increased to 2.0 million lines. The new entrants had accounted for nearly 62.5 percent of Japanese DSL subscriber lines by March 2004, thanks largely to aggressive price competition from Yahoo!Broadband ("Yahoo!BB"), which is offering DSL for as little as 2280 Yen (about $20) per month, not including the cost of the modem. In its first year, Yahoo!BB had more than 1 million lines, and by March 2004 it had increased its subscribers to 4.9 million using lines shared with NTT. Yahoo!BB is a subsidiary of Softbank, which provides the financing and infrastructure for Yahoo!BB's operations. Although Yahoo!BB has reported substantial profits from its operations, Softbank has continued to report very large losses in its "Broadband Infrastructure Division." Softbank's objective is to build a very large customer base to which it can sell a variety of entertainment and information services, as well as VoIP. It has been

> extremely successful in selling VoIP to its subscribers, with 4.7 million of its 4.9 DSL subscribers accepting the service. Whether its strategy of building market share and eventually selling enough content to offset its huge start-up losses can succeed no one can know at this time.

Crandall et al. (2009)[88] is a forthcoming publication funded by Verizon; its authors are identified both by their affiliation as Empiris consultants and by other institutional affiliation, most prominently the Brookings Institute. The article is a qualitative analysis of the effects of functional separation in the UK, New Zealand, Italy, Sweden and Australia. The paper begins with a background conceptual framing of the costs of functional separation in terms of lost efficiencies of vertical integration. It then reviews the experience of the UK, in particular, and to a lesser extent the remaining four countries that adopted separation. The paper argues that the UK's efforts support the proposition that vertical separation has no positive effect on penetration and will undermine investment. In particular, the paper discusses the slower levels of growth in penetration in the UK by comparison to its own growth rate during the period of September 2002 to September 2005, and to the growth rate of the EU 15.

This claim is difficult to interpret because of the relatively low base from which the UK grew in the earlier period, relative to the later period. It is common for growth rates from a higher base to be lower than growth rates from a lower base, earlier in the diffusion process. From Q4 2002 to Q4 2003, the UK broadband penetration rate grew from 2.3% to 5.4%, and then the following year from 5.4% to 10.4%. The following year penetration grew from 10.3% to 16.3%. After separation, the yearly increases continued from 16.3% to 21.4%, then 25.8%, and 28.5% by 2008. By comparison, in the U.S over the same period, without functional separation and after the elimination of all access rules, penetration also started from an identical level to that of the UK in Q4 2005, 16.3%, but then grew more slowly than in the UK, to 20.3%, 23.4%, and 25.8% over the same periods. It is possible that the diffusion curves of each country are different, but that would make the comparison to the EU 15 at least as problematic. The Crandall et al paper does not address the dramatic increase in unbundled lines, from under 200,000 to five million, which suggests substantial complementary investment from entrants, or the substantial annual drop in prices emphasized by Ofcom in its own review of the separation.

Crandall et al then move to focus on investment. The authors acknowledge that BT's investment levels are among the highest in the EU, but attribute it to "the dreadful condition of BT's network at the end of the 20th century." No attempt is made to explain why the dreadfulness of the condition of the network has any bearing on whether or not an incumbent has incentives to invest. They do emphasize that BT's capital expenditures have grown more slowly since the recovery from the burst bubble than the average growth of 12 of the EU 15, but again, do so without identifying the base from which that growth has occurred. The paper recognizes that BT's base levels of investment were relatively higher than those in the other countries. Proceeding to compare BT's rate of growth in investment from the higher base is less revealing when compared to an average of 12 countries if those countries grew from lower baseline levels of investment. Finally, the paper underscores the difficulties of transposing open access to fiber, the relatively low levels of investments in fiber in the UK, and the increasing interest of the UK government to find government sources of funding for fiber deployment to much of the country. This description raises valid concerns with the application of separation to fiber, in particular the extent to which functional separation indeed can be contained to passive elements only, as opposed to be extended to standardized active elements. On the other hand, the comparisons in the paper between

88 Crandall, Robert, Jeffrey Eisenach, and Robert Litan. 2009. Vertical Separation in Telecommunications Networks: Evidence from Five Countries. *Forthcoming* Federal Communications Law Journal.

BT's (absence of) investments in fiber to the home relative to Virgin Media's investments in DOCSIS 3.0 rollout are difficult to justify, since the cost structures of the two investment pathways are different—this is the great short-term advantage cable has over fiber—the near-term rough equivalence of performance coupled with an order-of-magnitude cheaper upgrade path. Furthermore, the comparison to U.S. investment in fiber is also complicated by the fact that U.S. fiber to the home reflects only Verizon's investments; it does not explain the absence of similar investments by AT&T and Qwest.

In discussing the other four countries, the Crandall et al paper also discusses penetration and investment. For penetration, because it focuses on growth, the paper uses a log-scale to show broadband penetration per 100. The authors write "In fact, if one plots the growth of broadband across most of the major OECD countries, one observes a convergence in both the level and the rate of growth of broadband penetration, as shown in Figure 4." (emphasis added). With regard to the level of penetration, however, the log scale is inappropriate and distorts the penetration data preventing a real comparison. It treats Italy's level of penetration in Q2 2008, of 18.2%, as "converged" with Denmark's rate of 36.7%. On a log scale, this looks no greater than the difference between 2% and 4%, and as drawn in Crandall et al 2009, Figure 4, that near 20% difference is drawn as no greater than the difference between 0.2% penetration and 0.4% penetration earlier in the decade.[89] Furthermore, even on this scale, in Figure 3 of the paper, it is clear that New Zealand at the time of adoption of functional separation was well below the OECD average penetration, and well below Italy. After separation, New Zealand's penetration level reached that of the OECD average, and passed that of Italy, which had not yet, during this period, adopted functional separation (the paper itself pegs the approval of separation in Italy at December 2008, two quarters after the end of the evidence on penetration that is supposed to show the effects of separation on penetration). The paper's analysis of fiber implementation by the companies that "succumbed to functional separation," as the paper puts it (p. 28), suffers from the fact that it is looking at outcomes of fiber investment, investments with a multi-decade horizon, as responses to regulatory interventions that are, in the case of Italy, less than a year old, and in the case of Sweden, about 18 months old. Moreover, in Sweden, the market for fiber-to-the-home is influenced by the presence of municipal networks. The paper states, for example, "While Telia-Sonera began to roll out fiber to the home in 15 major cities in Finland in 2007, it has not launched a similar program in Sweden ."[90] In Sweden, however, much of the fiber to the home market begins with municipalities, and TeliaSonera does offer triple play bundles over the municipal fiber networks, and is itself a contractor for some of the municipal networks. The Swedish regulator's report on dark fiber states that "TeliaSonera accounts for 53 per cent of the total supply of optical fibre in Sweden and approximately 47 per cent of the coverage of all optical fibre ;"[91] and also that "Municipal authorities and municipal companies represent the highest rate of growth, but, of the other stakeholders, TeliaSonera is by far the largest stakeholder rolling out fibre."[92] While these statements refer to fiber generally, not to fiber to the home, they do suggest that it is difficult to discuss Sweden as a case of failure in fiber-to-the-home deployment, much less that such a "failure" was occasioned by the recent adoption of functional separation.

89 If one were for a moment to take seriously the World Bank's recent calculation that a 10 point increase in penetration rate translates into 1.21% higher GDP growth, the paper is in effect treating as "convergence" a difference in penetration between countries that would translate into about 2.3% growth rate per year: more than the average growth rate of a developed economy in the period between 1980 and 2006.

90 Crandall et al 2009, p. 28.

91 Dark Fibre: Market and State of Competition. PTS-ER-2008:9. p. 22.

92 Id. at 19.

Qualitative case studies of access regulation: Conclusion

Of nineteen qualitative papers (several are discrete country chapters in a single 2006 edited volume), only two present clearly negative conclusions about unbundling. Both were industry funded. The observations of the older of the two papers are purely based on countries that at the time had not implemented unbundling effectively. The observations of the newer paper emphasize growth rates without regard to relative maturity of the market, and treat convergence on a log scale as convergence for practical policy purposes, characterizing vast differences such as between 20% and a 40% level of penetration as "converged." Of the remaining papers, nine view access regulations, where implemented, as having played a positive role in penetration, consumer use, and / or investment. One of these nine was industry sponsored. The remaining papers focus on the political economy, on the political and practical difficulties of effective implementation, or, in the case of Korea, on the importance of other factors. The case studies, in the main, comport with our own observations in our case studies. They present a very clear picture of the extent to which in the U.S. unbundling and open access were litigated and blocked by the incumbents at every step. They suggest that in Germany too this was the case. They suggest that, while Korea likely exhibits other factors as more important, early entry indeed was based on open access to cable plant, rather than on unbundling. They emphasize the role of entrepreneurial entrants, like Softbank Yahoo!BB in Japan, or Free/Iliad in France. In all, these qualitative case studies provide substantial support for our own independent review of evidence, which brings the history that these earlier papers discuss up to date.

The empirical literature does not support the present dismissal of open access as a serious potential tool in the regulatory toolbox. We suggest that the Commission expand its data reporting requirements, and use these data to support further studies of the advisability of variants of open access and their potential application to next generation connectivity.

Further analysis of selected studies highlighting the challenges of cross-country econometric studies

Here, we show in more detail how the limitations of the cross-country quantitative approaches emerge. Considerable emphasis was placed in several of the comments to our study on the effects of unbundling on investment, and in particular, many of the comments pointed to a recent paper, Wallsten and Hausladen 2009, which analyzed numbers of unbundled loops and fiber penetration per capita, and purports to show that "more unbundled lines are associated with fewer fiber broadband connections." We review that paper here and show that its findings are influenced primarily by the experience of two countries, and that it is limited by other methodological issues.

Second, we analyze the data presented in the Empiris declaration filed in response to our draft report, which builds on our analysis in the draft report and, extending it with new data, purports to show that unbundling has a negative coefficient for penetration per capita. Reviewing the new data underlying this claim, the implication of that negative coefficient found in the Empiris declaration is that our new role models should be the countries that have no unbundling in the dataset, or few years of unbundling. These countries include not only high-performing Switzerland, but also several of the weakest performers on the measured outcome variable—penetration: Turkey, Mexico, the Czech Republic, Hungary, and New Zealand. This suggests something quite wrong with the model. Indeed, when we use the appropriate panel corrected standard errors (Beck and Katz, 1995), rather than the inappropriate-for-this-data Parks Method (FGLS) employed by Empiris, unbundling is no longer

significant (though it is still negative). On the other hand, the better measure, GUyrs, which reflects the idea that unbundling regulatory systems learn from experience and become more effective over time, is positive and statistically significant on this new, expanded data set, with the new setup proposed by Empiris. We do not claim to have provided through this analysis definitive evidence of the positive impact of unbundling on penetration levels, but rather to illustrate the inherent fragility of cross-country econometric studies that make them prone to manipulation.

Wallsten and Hausladen 2009: 27 EU countries, unbundling and FttH per capita

Wallsten and Hausladen (2009)[93] is a recent study of the effects of unbundling on deployment of fiber-to-the-home in Europe. It has been cited frequently by industry comments to the initial draft of our report as evidence that open access policies clearly harmed, rather than helped, next generation connectivity. The paper is published in a peer-reviewed journal with no apparent industry backing. The paper analyzes data from 27 European countries, from 2002 to 2007, and claims to find a negative correlation between the presence of effective unbundling, as measured by the number of unbundled loops per capita, and the deployment of fiber to the home, as measured by FttH subscriptions per capita.

Taking the actual model used by Wallsten and Hausladen without any critique, the paper is highly sensitive to specific country effects. Specifically, because Lithuania and Estonia, two post-soviet Baltic republics with dynamic governments and markets have no unbundling and substantial fiber deployments, their results drive the outcomes. In the annex to this memorandum, we include replications of Wallsten and Hausladen Table 3a, in each case removing one country. What is important is to observe the effect of removing each country on the coefficients for unbundling to entrant and incumbent fiber (and similarly for bitstream.) The coefficient on incumbent fiber remains roughly -0.04, as it is in the original, when any single country is removed, except Estonia. When Estonia is removed, the coefficient is 0.000. Estonia is driving the entire result for effects of unbundling on incumbent fiber, reflecting the big moves by Elion, the wireline arm of the formerly state-owned incumbent, now majority owned by TeliaSonera, into fiber, leapfrogging the Soviet-era copper infrastructure. The coefficient on entrant fiber remains within 5% to 10% of its original value in the table when removing any single country, except that it drops 40% when removing Lithuania, from -0.103 to -0.062,[94] and it drops about 25% when one removed Estonia, to -0.079. Removing both of these fast-growing post-Soviet Baltic republics eliminates almost three-quarters of the effect, dropping the coefficient from -0.103 to -0.031.A similar relationship holds for the impact of bitstream. Estonia and Lithuania are essentially driving the results. To grasp the problem intuitively, however, one need not go to the regressions. Below is a copy of Figure 4 from Wallsten and Hausladen. It is easy to observe with the naked eye that Estonia and Lithuania have a highly unusual share of fiber, relative to virtually non-existent unbundling.

93 Wallsten, S. and Hausladen, S. Net-Neutrality, Unbundling, and their Effects on International Investment in Next-Generation Networks. Review of Network Economics 8(1) 90-112. March 2009. Scott Wallsten was gracious enough to provide us with the data.

94 It is not entirely clear whose investments these entrant investments reflect, given that reports on Lithuanian fiber investment identify TEO LT, the incumbent, now majority-owned by TeliaSonera, as the primary source of fiber investment, alongside an EU-funded rural fiber project, RAIN.

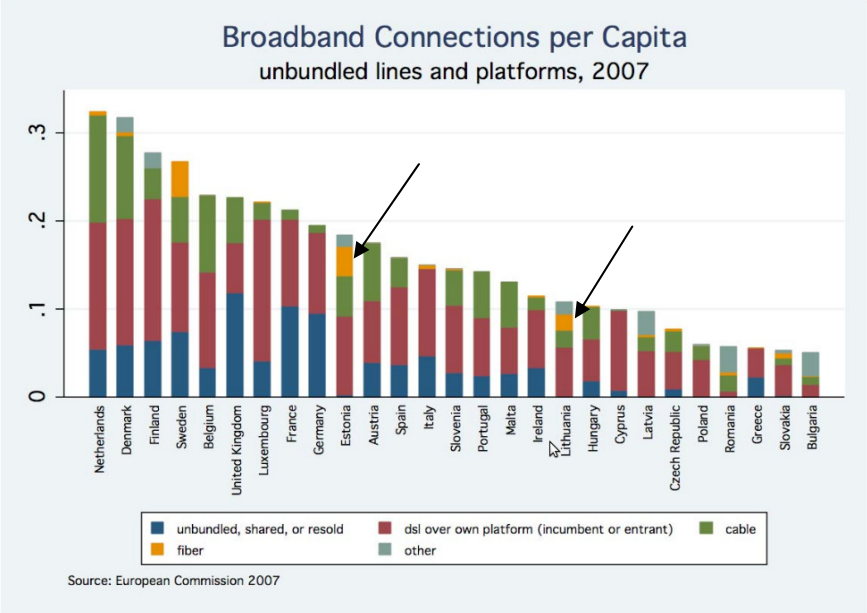

Figure 4: Broadband connections per capita

Rather than providing new insights into the relationship between fiber investments and unbundling, the quantitative analysis obscures the basic observation that these small post-Soviet countries share an unusual mix of broadband access conditions.

Second, it is important to understand that fiber subscription rates are co-determined by subscriber demand, as well as by supplier costs and investments. The most obvious confounder here is that if incumbents and entrants, in fierce competition though extensive use of combining their own fiber or electronics with incumbent copper loops, are successfully delivering 50 or 100 Mbps service at low prices, demand for fiber will be delayed. It is far from obvious that the welfare implications of delay in fiber deployment because of substitution to high speed, low cost DSL are negative.

Third, when treating cross-country data over time, as here, country-level clustering is appropriate. Without clustering, the model treats each year as an entirely new observation, as though the random unobserved effects in country X in year 1 are entirely independent of the random unobserved effects in that same country X in year 2.[95] Correcting this problem in the model results in larger standard deviations, smaller t-statistics, and loss of statistical significance even with Lithuania and Estonia in the dataset.

95 "Heteroskedasticity-Robust Standard Errors for Fixed Effect Panel Data Regression", James H. Stock and Mark Watson, Econometrica, January 2008, Vol. 76, No. 1, pp. 155-174.) ; Petersen, Mitchell A. "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches." *Review of Financial Studies*. Volume 22, Number 1, 2009.

Table 3a: Without Lithuania

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.062	-0.046		
	(0.042)	(0.049)		
GDP per Cap	0.009	0.025	-0.050	0.011
	(0.174)	(0.062)	(0.248)	(0.091)
Bitstream Lines per Cap			-0.188	-0.070
			(0.137)	(0.060)
Constant	0.004	0.001	0.007	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	235	235	224	224
Number of Countries	26	26	25	25
Adjusted R-squared	0.15	0.05	0.20	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 3a: Without Estonia

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.079	0.000		
	(0.054)	(0.003)		
GDP per Cap	-0.043	0.027@	-0.087	0.021
	(0.142)	(0.015)	(0.211)	(0.017)
Bitstream Lines per Cap			-0.177	-0.015
			(0.134)	(0.014)
Constant	0.006	-0.001	0.008	-0.000
	(0.005)	(0.000)	(0.007)	(0.001)
Observations	235	235	224	224
Number of Countries	26	26	25	25
Adjusted R-squared	0.15	0.02	0.18	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 3a without Lithuania and Estonia

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.031	-0.000		
	(0.031)	(0.003)		
GDP per Cap	0.020	0.026@	-0.028	0.019
	(0.144)	(0.015)	(0.197)	(0.017)
Bitstream Lines per Cap			-0.138	-0.016
			(0.136)	(0.016)
Constant	0.003	-0.001	0.005	-0.000
	(0.004)	(0.000)	(0.006)	(0.001)
Observations	226	226	215	215
Number of Countries	25	25	24	24
Adjusted R-squared	0.11	0.02	0.15	0.06

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Fourth, the use of unbundled access share as an explanatory variable is problematic. This variable is itself the result of a complex set of demand and supply relationships that match consumers with broadband providers shaped by government policy. This variable is jointly determined with the other broadband shares such as the share of broadband connections that are cable and fiber and does not thereby constitute an appropriate explanatory variable.

In conclusion, the Wallsten and Hausladen (2009) paper at most can be brought as evidence to focus attention on the positive experience of Lithuania and Estonia that have successfully and admirably emerged from their post-Soviet experience with increasingly advanced fiber networks.

The Empiris Re-Analysis of the econometric annex in the draft report

In the draft report we included a reanalysis of a paper written by an OECD economist (De Ridder 2007), and critiqued by Boyle, Howell and Zhang (2008). We took those papers on their own methods, and explored the particular effects of influential points, in that case Switzerland, and the sensitivity to assumptions about the formal adoption of rules versus the actual effectiveness of implementation. That analysis drew several responses, in particular in comments from one of the authors of Boyle, Howell, and Zhang, as well as in the Empiris declaration itself.[96] The Empiris declaration in particular took the challenge head on, cleared up some of the quirks in the approaches of the two earlier papers, and added

96 One other document, by the Phoenix Center, was more a vehement denunciation than a critique. We note only that both Empiris and Howell managed to analyze and criticize our analysis without mischaracterizing our technique or findings as downward sloping supply curves. We also note that the Empiris declaration, footnote 19, explains that the data do not provide sufficient price data to perform the two-stage least squares method that the Phoenix Center protested to be the only way to analyze these data, and which it then used to "find" the "errors" in our study.

new data. It thus provides a cleaner and more complete platform to analyze.

The Empiris declaration cleans up the data and analysis, partly by removing price. The Empiris declaration agrees with our own explanation that price is correlated with unbundling to a point where it is preferable to drop it as an explanatory variable. It then removes Greece and Slovakia, and adds several other potential explanatory variables. There are two particularly difficult parts of the analysis that carry through, from De Ridder (2007), through Boyle, Howell, and Zhang (2008), through our own annex, the Empiris declaration, and the Howell comments submitted here. The first issue is that technology diffuses over time, and most observers agree that it diffuses in some form of an S curve—slowly at first, then at higher rates, and then slowly again as markets approach saturation. The second thing is that regulatory regimes are not "on/off" affairs. The date of formal passage of a rule is rarely the day on which it is effectively implemented and creates results. Regulators learn; entrants learn; incumbents learn. They all adjust their behavior over time, so that it is reasonable to assume that a regulatory system will function more effectively three or five years after initial implementation than immediately on the first year. De Ridder sought to account for this effect with a variable GUyrs (Government- unbundling-years). Efforts to account for the second fact, however, encounter the problem that they might be simply capturing the natural S-curve diffusion. This was the nub of the Boyle, Howell, and Zhang critique; it is what they tried to control for in their analysis; it is what we tried to control for in our original analysis. This is indeed a genuinely hard problem to solve. It is what Empiris tried to control for by using a variable describing the number of years since DSL was introduced into a country, and a separate dummy variable, for every year on which a country did, or did not, have unbundling in place.

When they introduce DSL years, Empiris finds that the significant effect of unbundling over time, GUyrs, is rendered insignificant, supporting Boyle, Howell, Zhang. However, when they replace GUyrs with their simple dummy variable for unbundling, they find that "Unbundling is negative and statistically significant," proving that with more data over more time one can show that "unbundling has slowed the pace of broadband adoption in the sample countries." (Empiris declaration, para. 27.) Empiris admirably provided their data in Table D.2. of the declaration allowing us to replicate the analysis using their data.

As a reality check, it is first important to recognize the value for the 'unbundling' variable is 1 for almost all countries in the dataset. Only Turkey, Mexico, the Czech Republic, Hungary, New Zealand, and Switzerland have a value of 0 for any appreciable amount of time in this dataset. The conclusions of the analysis, in other words, are that the rest of the countries have been doing something wrong, and this particular set of countries have done better by not adopting unbundling. The analysis suggests that the results of one country in the top quintile, plus four countries from the bottom quintile and one from the fourth quintile, should lead us to follow those countries' strategy of rejecting unbundling.

Two things are wrong with the Empiris analysis that lead to its odd conclusion. The first is that, while GUyrs and DSLyears do have a simple correlation coefficient of 0.58, a multicollinearity test reveals that including both GUyrs and DSLyears in the model does not bias the results. This means that including only unbundling, and losing the data on how long an unbundling regime has been functioning, unnecessarily omits useful data. The second is that according to numerous sources, the correct method to employ with this type of data is not the Parks Method (FGLS) employed by Empiris. The Parks method is only efficient when the number of time periods is substantially greater than the

number of units.[97] In this data set, the number of units is twice as large as the number of time points, and therefore leads to an underestimation of standard errors by at least 20%. One way to correct for this is apply a method of panel corrected standard errors (Beck and Katz, 1995). The following table was calculated using panel corrected standard errors for heteroskedastic error terms and autocorrelation. When employing this method, the dummy variable for unbundling is negative, but no longer statistically significant. Replacing unbundling with the GUyrs variable, we can see a positive and statistically significant relationship. In other words, on these new data that Empiris introduces, when we use the proper test and account for the increasing effectiveness of a regulatory regime over time, we see that unbundling has a positive effect on penetration.

Panel Corrected Standard Error Model

VARIABLES	(1) GUyrs	(2) Unbundled
guyrs	0.887**	
	(0.300)	
dslyears	2.299***	3.014***
	(0.278)	(0.172)
pop_density	0.011@	0.011@
	(0.006)	(0.006)
pops_mils	-0.025***	-0.014*
	(0.007)	(0.007)
gdp	0.000*	0.000***
	(0.000)	(0.000)
unbundled		-1.328
		(0.814)
Constant	-8.407***	-10.207***
	(1.990)	(2.124)
Observations	168	168
R-squared	0.492	0.460
Number of country1	28	28

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Again, as we stated numerous times in the draft report itself, we do not argue here that by this analysis we have proven that unbundling is a panacea. The data are not capable of delivering that kind of certainty. Separating out the effects of diffusion over time, and the effects of improved regulatory effectiveness over time is genuinely hard. Deriving determinate causal claims from a simple cross-

97 The Parks method can underestimate standard errors. (Hurwicz, L. 1950. "Least-Squares Bias in Time Series." In Statistical Inference in Dynamic Economic Models, ed. T. Koopmans. New York: Wiley.) Although the Parks method performs well in large samples (Cramer, J. 1986. Econometric Applications of Maximum Likelihood Methods. New York: Cambridge University Press.), the Parks method should not be used unless T is at least as big as N (Beck, Nathaniel, Jonathan N. Katz, R. Michael Alvarez, Geoffrey Garret, and Peter Lange. 1993. "Government Partisanship, Labor Organization, and Macroeconomic Performance: A Corrigendum." American Political Science Review 87: 945-48). Even if T 4 times greater than N, the Parks method still underestimates standard errors by 20% (Beck, Nathaniel, Jonathan N. Katz, 1995. "Nuisance vs. Substance: Specifying and Estimating Time-Series-Cross-Section Models" Political Analysis, 6:1.

country regression is highly uncertain. This is true even when we ignore that many of the actions may be strategically driven, or the regional variation within countries, or any one of many complexities. This is why it is so important to use case studies and qualitative analysis, or narrow and well designed econometric studies using micro-data and exogenous instruments and natural experiments.

Annex:

Table 1: Without Austria

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.098@	-0.040		
	(0.055)	(0.044)		
GDP per Cap	-0.050	0.034	-0.106	0.020
	(0.172)	(0.066)	(0.263)	(0.093)
Bitstream Lines per Cap			-0.219	-0.064
			(0.133)	(0.055)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 2: Without Belgium

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.119@	-0.045		
	(0.059)	(0.049)		
GDP per Cap	-0.064	0.029	-0.100	0.021
	(0.170)	(0.066)	(0.256)	(0.090)
Bitstream Lines per Cap			-0.219	-0.065
			(0.139)	(0.057)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.21	0.05	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 3: Without Bulgaria

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.103@	-0.041		
	(0.056)	(0.045)		
GDP per Cap	-0.048	0.034	-0.100	0.021
	(0.167)	(0.065)	(0.255)	(0.090)
Bitstream Lines per Cap			-0.219	-0.064
			(0.133)	(0.055)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	242	242	231	231
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 4: Without Cyprus

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.107@	-0.042		
	(0.057)	(0.046)		
GDP per Cap	-0.065	0.028	-0.125	0.014
	(0.163)	(0.063)	(0.257)	(0.090)
Bitstream Lines per Cap			-0.231	-0.068
			(0.138)	(0.058)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	236	236	225	225
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.24	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 5: Without Czech Republic

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.104@	-0.042		
	(0.057)	(0.045)		
GDP per Cap	-0.048	0.033	-0.101	0.021
	(0.168)	(0.065)	(0.257)	(0.091)
Bitstream Lines per Cap			-0.222	-0.065
			(0.135)	(0.056)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	238	238	227	227
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 6: Without Denmark

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.105@	-0.041		
	(0.056)	(0.044)		
GDP per Cap	-0.056	0.040	-0.121	0.025
	(0.161)	(0.074)	(0.239)	(0.097)
Bitstream Lines per Cap			-0.226	-0.064
			(0.134)	(0.055)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.17	0.04	0.22	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 7: Without Finland

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.097	-0.042		
	(0.058)	(0.047)		
GDP per Cap	-0.042	0.035	-0.093	0.024
	(0.176)	(0.067)	(0.266)	(0.095)
Bitstream Lines per Cap			-0.218	-0.065
			(0.134)	(0.056)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 8: Without France

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.101	-0.043		
	(0.062)	(0.049)		
GDP per Cap	-0.054	0.034	-0.102	0.021
	(0.165)	(0.065)	(0.273)	(0.097)
Bitstream Lines per Cap			-0.268	-0.084
			(0.165)	(0.070)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.24	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 9: Without Germany

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.108	-0.052		
	(0.075)	(0.059)		
GDP per Cap	-0.048	0.041	-0.183	0.021
	(0.164)	(0.070)	(0.246)	(0.092)
Bitstream Lines per Cap			-0.261@	-0.065
			(0.147)	(0.055)
Constant	0.007	0.001	0.012	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.26	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 10: Without Greece

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.116@	-0.045		
	(0.059)	(0.048)		
GDP per Cap	-0.054	0.031	-0.103	0.021
	(0.176)	(0.067)	(0.266)	(0.092)
Bitstream Lines per Cap			-0.226	-0.065
			(0.141)	(0.055)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.20	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 11: Without Ireland

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.106@	-0.042		
	(0.057)	(0.045)		
GDP per Cap	-0.023	0.040	-0.091	0.023
	(0.195)	(0.075)	(0.273)	(0.096)
Bitstream Lines per Cap			-0.221	-0.064
			(0.134)	(0.055)
Constant	0.007	0.001	0.009	0.001
	(0.006)	(0.002)	(0.008)	(0.003)
Observations	235	235	224	224
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 12: Without Italy

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.103@	-0.040		
	(0.055)	(0.044)		
GDP per Cap	-0.049	0.028	-0.094	0.017
	(0.171)	(0.063)	(0.267)	(0.090)
Bitstream Lines per Cap			-0.220	-0.063
			(0.133)	(0.054)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.18	0.04	0.22	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 13: Without Latvia

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.107@	-0.044		
	(0.059)	(0.048)		
GDP per Cap	-0.049	0.033	-0.102	0.021
	(0.169)	(0.067)	(0.258)	(0.093)
Bitstream Lines per Cap			-0.222	-0.066
			(0.136)	(0.057)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	237	237	226	226
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 14: Without Luxembourg

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.091	-0.036		
	(0.057)	(0.041)		
GDP per Cap	0.723	0.345	1.063	0.476
	(0.633)	(0.325)	(0.720)	(0.419)
Bitstream Lines per Cap			-0.259@	-0.079
			(0.144)	(0.067)
Constant	-0.011	-0.007	-0.017	-0.009
	(0.015)	(0.007)	(0.016)	(0.009)
Observations	234	234	223	223
Number of Countries	26	26	25	25
Adjusted R-squared	0.21	0.06	0.29	0.09

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 15: Without Malta

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.113@	-0.044		
	(0.059)	(0.048)		
GDP per Cap	-0.072	0.026	-0.124	0.014
	(0.160)	(0.061)	(0.254)	(0.089)
Bitstream Lines per Cap			-0.227	-0.067
			(0.137)	(0.057)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	237	237	226	226
Number of Countries	26	26	25	25
Adjusted R-squared	0.20	0.04	0.24	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 16: Without Netherlands

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.108@	-0.040		
	(0.055)	(0.044)		
GDP per Cap	-0.051	0.033	-0.100	0.021
	(0.163)	(0.067)	(0.255)	(0.090)
Bitstream Lines per Cap			-0.219	-0.064
			(0.133)	(0.055)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	233	233
Number of Countries	26	26	26	26
Adjusted R-squared	0.18	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 17: Without Poland

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.114@	-0.045		
	(0.059)	(0.048)		
GDP per Cap	-0.070	0.026	-0.122	0.014
	(0.162)	(0.062)	(0.258)	(0.090)
Bitstream Lines per Cap			-0.229	-0.067
			(0.138)	(0.058)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	236	236	225	225
Number of Countries	26	26	25	25
Adjusted R-squared	0.20	0.04	0.24	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 18: Without Portugal

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.100@	-0.040		
	(0.056)	(0.044)		
GDP per Cap	-0.092	0.027	-0.193	0.000
	(0.146)	(0.063)	(0.230)	(0.086)
Bitstream Lines per Cap			-0.246@	-0.070
			(0.143)	(0.060)
Constant	0.009@	0.001	0.012	0.002
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.25	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 19: Without Romania

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.103@	-0.041		
	(0.056)	(0.045)		
GDP per Cap	-0.048	0.034	-0.100	0.021
	(0.167)	(0.065)	(0.255)	(0.090)
Bitstream Lines per Cap			-0.219	-0.064
			(0.133)	(0.055)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	242	242	231	231
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 20: Without Slovakia

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.096	-0.045		
	(0.060)	(0.048)		
GDP per Cap	-0.048	0.032	-0.103	0.019
	(0.164)	(0.067)	(0.250)	(0.094)
Bitstream Lines per Cap			-0.216	-0.068
			(0.138)	(0.058)
Constant	0.007	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	236	236	225	225
Number of Countries	26	26	25	25
Adjusted R-squared	0.17	0.05	0.21	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 21: Without Slovenia

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.104@	-0.041		
	(0.056)	(0.045)		
GDP per Cap	-0.053	0.032	-0.105	0.020
	(0.168)	(0.065)	(0.257)	(0.091)
Bitstream Lines per Cap			-0.221	-0.064
			(0.134)	(0.055)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	236	236	225	225
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 22: Without Spain

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.108@	-0.042		
	(0.057)	(0.046)		
GDP per Cap	-0.053	0.032	-0.118	0.015
	(0.174)	(0.067)	(0.276)	(0.096)
Bitstream Lines per Cap			-0.247@	-0.073
			(0.144)	(0.063)
Constant	0.008	0.001	0.010	0.001
	(0.005)	(0.002)	(0.008)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.20	0.04	0.25	0.06

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 23: Without Sweden

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.098@	-0.041		
	(0.056)	(0.045)		
GDP per Cap	-0.080	0.027	-0.090	0.018
	(0.101)	(0.053)	(0.156)	(0.080)
Bitstream Lines per Cap			-0.115	-0.058
			(0.084)	(0.062)
Constant	0.007	0.001	0.006	0.001
	(0.004)	(0.002)	(0.005)	(0.002)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.19	0.02	0.16	0.02

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1

Table 24: Without United Kingdom

VARIABLES	(1) Entrant Fiber per Cap	(2) Incumbent Fiber per Cap	(3) Entrant Fiber per Cap	(4) Incumbent Fiber per Cap
Unbundled Lines per Cap	-0.111@	-0.043		
	(0.058)	(0.047)		
GDP per Cap	-0.049	0.034	-0.100	0.023
	(0.178)	(0.070)	(0.261)	(0.093)
Bitstream Lines per Cap			-0.216	-0.063
			(0.134)	(0.054)
Constant	0.008	0.001	0.009	0.001
	(0.005)	(0.002)	(0.007)	(0.003)
Observations	233	233	222	222
Number of Countries	26	26	25	25
Adjusted R-squared	0.20	0.04	0.23	0.05

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, @ p<0.1