VERTICAL INTEGRATION AND SABOTAGE:
EVIDENCE AND REGULATION

A Dissertation
presented to
the Faculty of the Graduate School
at the University of Missouri-Columbia

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
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DECEMBER 2009
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VERTICAL INTEGRATION AND SABOTAGE:
EVIDENCE AND REGULATION

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For my family, Nana, Levan and Rezo.
ACKNOWLEDGEMENTS

I would like to thank Professor David Mandy for his endless support during my years in the doctoral program. His brilliant skills as a teacher and a researcher motivated me to study industrial organization. I would also like to thank my committee members, Dr. Emek Basker, Dr. X.H. Wang, Dr. Harstad and Dr. Michael Sykuta for their comments and support.
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1 Introduction

Many network industries have an upstream monopolist that sells an essential input to downstream firms. Examples include electricity markets where a firm owning transmission lines sells access to generating companies, telecommunications where a local operator sells access to a competitive long distance market or to other communications providers such as wireless firms or providers of high speed internet services,\(^1\) cable telephony where a local cable monopolist sells access to firms providing long distance and local voice services,\(^2\) and software markets where Microsoft provides a key resource, the Windows operating system, while also competing with other firms for other software components (media players, for example) that seek compatibility with Windows.

The access offered to downstream firms by an upstream monopolist consists of two parts, an access charge and quality of access. Often the upstream monopolist is regulated in terms of the access charge while the downstream market is deemed sufficiently competitive and is therefore unregulated. There is a large literature on access charges and the regulation thereof to optimize social welfare (Armstrong et al. 1996; Laffont and Tirole 1990 and 1994; Bustos and Galetovic 2007; Reiffen 1998; Vickers 1995; Weisman 1995 and 1998; Weisman and Kang 2001). In an unregulated market, quality of access probably would not be a concern as the upstream monopolist

\(^{1}\)Digital Subscriber Line (DSL) is a family of technologies that provide digital data transmission over the wires of a local telephone network. See http://en.wikipedia.org/wiki/DSL.

\(^{2}\)Voice Over Internet Protocol (VOIP) is a recent technology, where voice is carried through the internet. See http://en.wikipedia.org/wiki/Voip.
could extract monopoly profits via access charges. Even with regulated access charges an unintegrated upstream monopolist still would probably not want to degrade access quality since doing so may be costly and does not generate additional revenues for the monopolist.

However, access price regulation may create incentives to degrade the quality of access when the upstream monopolist is affiliated with one of the downstream competitors and thus receiving profits from retail markets. Absent the ability to extract monopoly profits via access pricing, the upstream monopolist may degrade the quality of access to its downstream rivals to increase its own retail profits and possibly foreclosure its rivals. This type of non-price discrimination by an upstream monopolist has been labeled “sabotage” in the literature.

This dissertation is a collection of three essays. The first essay is an industry survey that answers the key question whether vertically integrated firms actually engage in sabotage. Despite the growing concern about the detrimental effects of sabotage and designing policies to combat it, there has been little work on discovering and documenting actual examples of sabotage. Most of the works are restricted to anecdotal or indirect evidence of sabotage. This essay fills the gap by collecting evidence of documented instances of sabotage. Doing so provides a valuable service to the academic, business and policy communities interested in whether sabotage is a real concern or merely a theoretical possibility. The available theoretical literature suggests that an upstream monopolist is more likely to engage in non-price discrimination of unaffiliated downstream rivals when the price of access it sells is regulated. Therefore we restrict attention to the US natural gas, electric and telecommunications industries as
these have been traditionally regulated by various Federal and state agencies. There are other reasons to study these industries. First, identification of an essential input or a bottleneck used in downstream production is relatively easy. For example, in the natural gas industry, various shippers seek to transport the commodity across or within states via pipelines that traditionally held market power within their service areas. Second, due to various Federal regulations these industries saw a transformation from traditional utilities that dominated and provided service at all chains of production to nontraditional utilities that still kept monopoly provision of a key input but competed downstream through functionally separate affiliates. In each of the cases identified in the first essay the respective regulatory agencies or courts imposed significant monetary fines or administrative penalties on the vertically integrated firms or on their affiliates, indicating the regulators’ concern and belief that such favoritism in parent-affiliate relationships were detrimental for unaffiliated rivals.

Sabotage can take various forms such as favoring the affiliated firm’s customers over the rivals’ customers in terms of voice quality or bandwidth they receive, making rival software incompatible, making the customer switching process from the affiliate’s network to the rival network costly and lengthy, and increasing the technical support waiting times for rivals’ consumers. For example, we found that in the US natural gas industry the integrated parent pipeline company can directly affect the non-affiliated rivals’ costs by unexpectedly interrupting of natural gas supply justifying such action for the system reliability while no such action is applied to the affiliated firm when both the affiliate and non-affiliate are under the same tariff or contract terms. Also we found that in the US telecommunications industry the incumbent local area service
provider can delay or poorly maintain switching facilities that are necessary for the unaffiliated long distance voice carrier to interconnect with the incumbent’s local network. Given that such selective discriminations of quality of access are real, there may be a need for regulation of access quality along with regulation of access prices.

The second and third essays bring the study of optimal regulatory policies for a vertically integrated upstream monopolist to a setting that may involve sabotage. Existing regulatory policies have long acknowledged the tension between access price regulation designed to encourage efficiency downstream and the potential that such regulation may encourage sabotage. Policies intended to maximize welfare and deter sabotage in network industries include marginal cost pricing of access, restrictions on vertical control between the monopolist and its downstream subsidiary, nondiscrimination requirements, performance monitoring of input quality, penalties for violations of nondiscrimination requirements, and limitations on the tools employed by regulators.\textsuperscript{3} “Vertical control” in this setting means the extent to which the upstream monopolist can align the objective of its downstream affiliate with the objective of the overall firm. Despite the explicit vertical control policies used in practice, formal

\textsuperscript{3}All of these policies are present in contemporary telecommunications regulation. On May 31, 2000 the US Federal Communications Commission (FCC) adopted the proposal of the Coalition for Affordable Local and Long Distance Service (CALLS) to rapidly move access charges toward the marginal cost of supplying access (FCC, 2000). Section 272 of the Telecommunications Act of 1996 restricts the vertical control a Bell company can exert over its long distance affiliate by requiring that the affiliate operate independently and maintain separate books from the Bell operating company; have separate officers, directors, and employees; have separate credit arrangements; and conduct all transactions with the parent company at arm’s length. This section also requires that the Bell company not discriminate in the provision of services between its affiliate and other suppliers of long distance. To enforce nondiscrimination, the FCC has required substantial performance monitoring agreements and pre-specified fines for violations as a condition of a Bell company’s entry into long-distance markets (for example, see FCC 1999). Regulatory tools are limited, however. Price discrimination and Baron-Myerson (1982) style incentive mechanisms are rarely used in practice, despite their established theoretical advantages.
modeling of vertical control as a policy parameter has not previously appeared in the literature.

The second and third essays study the welfare optimal access charge and vertical control policies under two different downstream market structures, differentiated goods Bertrand duopoly and the dominant firm competitive fringe model. As there is no consensus in the literature about modeling the form of downstream competition we consider two different basic market structures. The regulator in both essays is endowed with limited but realistic policy tools. Since most of the former regulated downstream industries, such as electricity generation and distribution, have been deemed sufficiently competitive by regulators and discriminatory access charges are rarely used in practice, regulation of the downstream market and regulatory price discrimination are not permitted in these models. Instead, the regulator sets a nondiscriminatory uniform access price and a level of vertical control. Limited internal control is due to external restrictions imposed by the regulator on the organization of the firm, not because of partial ownership or agency problems. In these essays the control of non-price discrimination to maximize welfare is the primary concern, so the Ramsey pricing aspects of covering fixed costs and the mechanism design issues associated with asymmetric information are both ignored. The access price and vertical control policies modeled here are representative of the tools used under the US Telecommunications Act of 1996 to regulate local network access for long-distance suppliers once a Bell company enters the long-distance market.\footnote{In the case of vertically integrated providers in electricity markets, the US Federal Energy Regulatory Commission (FERC) does not currently require “corporate” or “structural” unbundling of transmission and generation services. FERC Order No. 890 (Docket Nos. AD05-17-000 and RM05-25-000) only requires “functional” unbundling. That is, FERC requires that employees engaged in}
We find the regulator can induce the first best in limited cases in both Bertrand and competitive markets. More interestingly, when the first best is not achievable the regulator faces a trade-off between reducing the double markup problem by pricing access low, versus pricing access high in order to deter non-price discrimination. Under Bertrand competition we find a general complementarity between welfare-optimal access charge and vertical control. Full restriction on vertical control must be used when low access charges are used and full vertical control must be allowed when high access charges are allowed. In this case discrimination costs and competition intensity determine which policy is optimal. Under price-taking, the optimal vertical control policy is chosen to balance a trade-off between achieving an efficient downstream production mix and sabotage deterrence. In this case relative efficiency of firms and discrimination costs determine which policy is optimal.

transmission functions operate separately from employees of energy affiliates and marketing affiliates. However, several members of the industry have urged FERC to take more decisive steps toward corporate unbundling (FERC 2007).
2 Evidence of Sabotage by Vertically Integrated Upstream Monopolist

Many network industries have the feature that a vertically integrated upstream monopolist sells access to an essential input to downstream firms, including downstream affiliate of the upstream monopolist firm. If left unregulated, the upstream monopolist can usually extract monopoly rents from downstream firms via access charges. Traditionally the access price is regulated in industries such as electricity, natural gas and telecommunications; thus the upstream monopolist’s ability to extract monopoly profits via access pricing is limited. Instead, the upstream monopolist may degrade the quality of access to its downstream rivals to increase its own retail profits and possibly foreclosure its rivals. This type of non-price discrimination by an upstream monopolist has been labeled “sabotage” in the literature. The literature on sabotage agrees that such non-price discrimination is a socially costly activity, but is equivocal on whether incentives for sabotage are always present (see Ordover, Sykes, and Willig 1985; Economides 1998; Reiffen 1998; Sibley and Weisman (SW) 1998; Mandy 2000; Beard et. al. 2001; Weisman and Kang 2001; Mandy and Sappington 2007). Therefore a key question is whether vertically integrated firms actually engage in sabotage.

Despite the growing concern about the detrimental effects of sabotage and designing policies to combat it, there has been little work on discovering and documenting actual examples of sabotage. Most of the works are restricted to anecdotal or indirect
evidence of sabotage. This paper fills the gap by collecting evidence of documented instances of sabotage. Doing so provides a valuable service to the academic, business and policy communities interested in whether sabotage is a real concern or merely a theoretical possibility.

The available theoretical literature suggests that an upstream monopolist is more likely to engage in non-price discrimination of unaffiliated downstream rivals when the price of access it sells is regulated. Therefore we restrict attention to the US natural gas, electric and telecommunications industries as these have been traditionally regulated by various Federal and state agencies. There are other reasons to study these industries. First, identification of an essential input or a bottleneck used in downstream production is relatively easy. For example, in the natural gas industry, various shippers seek to transport the commodity across or within states via pipelines that traditionally held market power within their service areas. Second, due to various Federal regulations these industries saw a transformation from traditional utilities that dominated and provided service at all chains of production to nontraditional utilities that still kept monopoly provision of a key input but competed downstream through functionally separate affiliates. In each of the cases in this essay the respective regulatory agencies or courts imposed significant monetary fines or administrative penalties on the vertically integrated firms or on their affiliates, indicating the regulators’ concern and belief that such favoritism in parent-affiliate relationships were detrimental for unaffiliated rivals.

In sections 1 to 3 we study the occurrence of sabotage in natural gas, electricity and telecommunications industries, respectively. Such occurrences are examined in
light of underlying changes in regulatory environments since such changes have had major roles in shaping the structure and competition of these industries. Our primary sources of information are public filings at the respective regulatory agencies found on respective websites\(^1\) and federal court filings found in the Federal Register and Federal Reporter.\(^2\) Section 4 summarizes the main findings.

### 2.1 Natural Gas

The natural gas industry consists of roughly three entities: producers, pipelines and local distribution companies (LDCs). Producers extract and transport gas from the wellhead to a processing plant to distill “pipeline quality” natural gas. Natural gas pipelines (intra or interstate) transport natural gas to LDCs and to large industrial and commercial users. LDCs deliver gas to retail consumers. Recently, entities referred to as natural gas marketers and traders (usually affiliated with either producers or pipelines) have actively participated in the natural gas spot and futures markets. Natural gas marketers sell natural gas by identifying customers, arranging transportation and storage, and ensuring that purchasers’ demands are satisfied.

Federal regulation of natural gas started in 1938 when Congress passed the Natural Gas Act (NGA) that gave jurisdiction to the Federal Power Commission, now Federal Energy Regulation Commission (FERC), to regulate interstate transportation and sale of natural gas. Under this Act, the Commission had an obligation to regulate both the wellhead price and the price charged by pipelines to end-users and LDCs. In 1978, Congress passed the Natural Gas Policy Act (NGPA). This Act as well as

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\(^1\)www.ferc.gov and www.fcc.gov.
\(^2\)www.gpoaccess.gov/fr/ and bulk.resource.org/courts.gov/c/.
the Natural Gas Wellhead Decontrol Act of 1987 marked a new era of regulatory approach. These two Acts required full deregulation of wellhead prices and prompted the Commission to pursue open access for the natural gas transmission network. At the time, pipelines served not just as transporters but as the gas marketers, meaning they were involved in all three steps of the supply chain. Deregulation of natural gas production posed a new challenge for the Commission that now had to ensure that pipelines would not use their monopoly power to exclude other parties from using transmission facilities. To achieve its regulatory goals, FERC issued its landmark Order 436 in 1985. Order 436 declared the bundling of transportation and marketing services “unduly discriminatory.” In 1992, FERC followed up by issuing Order 636 which fully mandated the unbundling of transportation and marketing by directly requiring pipelines to offer transportation service on a non-discriminatory basis.

In the late 80s, with a shift in regulatory paradigm toward unbundled marketing and transportation functions, pipelines established marketing affiliates that would sell gas in a competitive market free from regulation. However, non-affiliated marketers expressed concern that pipelines providing open access to sellers were violating the principle of equal access by granting their marketing affiliates undue preferences, such as by divulging inside information regarding future capacity that would provide competitive benefits to pipelines’ affiliates. On November 14, 1986, the Commission issued its “Notice of Inquiry into Alleged Anticompetitive Practices Related to Marketing Affiliates of Interstate Pipelines” (NOI).³ The NOI solicited comments on general issues related to specific cases which had raised the issue of potential abuse of the

pipeline-marketing affiliate relationship, the Commission’s legal authority to regulate pipelines’ marketing affiliate activity, and possible remedies. Pipeline commenters argued that the general rule for governing pipeline-marketing affiliate relationships was unnecessary and most of the “anecdotal” instances of abuse resulted from pipelines adjusting to the new conditions created by Order 436. However, the Commission maintained that it was necessary to establish standards of conduct governing relationships between pipelines and marketing affiliates in light of the numerous documented abuses.⁴

For example, in one case the Commission ordered a $130,000 fine against Panhandle Eastern Pipe Line Company as a result of a complaint brought by Independent Petroleum Association of Mountain States, claiming that Panhandle had improperly discriminated in favor of its marketing affiliate, Panhandle Trading Company (PTC). The Commission held that Panhandle gave advance notice to PTC of its intent to implement interim open access transportation in violation of section 284.9⁵ of the Commission’s regulations. Additionally, the Commission found irregular behavior by Panhandle in the way it curtailed services. From time to time, the gas company may need to interrupt service to its customers due system-wide or localized shortage, or as an emergency procedure. Usually high priority is given to firm customers.

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⁵18 C.F.R. § 284.9.
and lower priority is given interruptible customers. The Commission noted that if Panhandle is forced to curtail transportation service, it must do so on a last-on, first-off basis. Although the Commission stopped short of requiring corporate divorce, it stated that Panhandle and PTC may not share personnel and that Panhandle must submit certain information to the Commission including a complete list of facilities shared with PTC, information concerning transportation requests, procedures used to resolve shipper complaints, procedures for informing affiliates and non-affiliates of the availability and price of service and capacity, and tariff provisions to put those conditions in place.

Among other complaints submitted under the NOI, a number of unaffiliated marketers alleged that pipelines were using information obtained by their dominant market power to subtly discriminate against nonaffiliated shippers in favor of their own affiliates. For example, in one case reported to the Commission, an independent marketer reported that a pipeline with which it was dealing delayed its transportation requests on several occasions while the pipeline’s marketing affiliate, using information obtained from the non-affiliate’s transportation request, approached the gas supplier and sought to purchase gas for itself.

Similarly, comments submitted by a group of gas producers reported how a pipeline had discriminated against nonaffiliated marketers by releasing valuable capacity infor-

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6Firm service is offered to customers under contracts which anticipate no interruptions. Interruptible service is a volume or pipeline capacity made available to a customer without a guarantee for delivery. “Service on interruptible basis” means that capacity used to provide service is subject to a prior claim by another customer. Hence pipelines are more likely to curtail service to customers who have interruptible service contracts to adjust to seasonal shortfalls in supply or pipeline capacity without incurring liability.

mation only to its marketing affiliate. As explained by one commentor, such selective
disclosure of capacity information placed nonaffiliated marketers at a severe compet-
itive disadvantage:

The location of capacity bottlenecks has a dramatic effect on trans-
portation routes and costs, and availability of capacity at bottleneck
points can change quickly. If a bottleneck on the system opens up and
makes available a cheaper route, the affiliate will learn of the change
through routine information exchanges, while the independent buyer or
seller may never hear of it. Or if he does hear of it, it may be too late
because the affiliate has absorbed the capacity.8

That same commenter reported on two pipelines which had withheld public dis-
closure of their intention to begin “open access” transportation until their marketing
affiliates had an opportunity to line up new customers. By the time competing inde-
pendent marketers became aware of the new pipeline capacity, the affiliated marketers
had garnered a substantial portion of the market and the available transportation ca-
pacity.9

In response to pipelines’ undue favoritism toward their marketing affiliates, FERC
issued a landmark Order 497 in 1988 which set out Standards of Conduct to govern
the relationship between pipelines and their marketing affiliates. Central provisions
of Order 497 are:10

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8Joint Comments of Indicated Producers (Dec. 29, 1986) Appendix B at 8.
9Id. at 10-11.
10Inquiry Into Alleged Anticompetitive Practices Related to Marketing Affiliates of Interstate
Pipelines, Order 497, FERC Stats. & Regs. ¶ 30,820.
• **Independent Functioning**: A pipeline’s employees who engage in transmission operations ordinarily “must function independently of its Marketing Affiliates’ employees,” with an exception of “emergency circumstances.” Further, a pipeline generally may not permit its affiliates’ employees to engage in transmission system operations or reliability functions or to access the system control center.

• **Non-discrimination and Contemporaneous Disclosure**: A pipeline must ensure that its affiliates’ employees have access only to the information available to all transmission customers and that such employees are prevented from obtaining non-public information about the pipeline’s transmission system.

• **Posting Requirements**: A pipeline must post such information as the names and addresses of its affiliates, the organizational structure of its parent corporation, a list of facilities shared with affiliates, a list of business units and job descriptions, and a schedule for implementing the Standards.

This Order came under fire from both sides, pipelines and independent marketers, as the former challenged the contemporaneous disclosure and independent functioning requirements and the latter claimed that discrimination by pipelines would disappear only when pipelines and their marketing affiliates were physically separate. Pipelines and other entities filed petitions to the D.C. Circuit Court of Appeals in 1992. The court largely upheld the contemporaneous disclosure and independent functioning requirements noting that

.. the record demonstrated both a straightforward theoretical threat of abuse and substantial record evidence that pipelines had been granting
their marketing affiliates undue preferences.\textsuperscript{11}

The court also upheld the independent functioning requirement noting that

\ldots it preserved some benefits of vertical integration, particularly in contrast to the more draconian possibilities of complete physical separation, divorce, or divestiture.\textsuperscript{12}

In order to discover irregular and preferential behavior by pipelines toward their affiliates in a timely and accurate manner, FERC established the Office of Market Oversight and Investigations (OMOI)\textsuperscript{13} in August 2002 which expanded enforcement and audit capacity of the Commission. In 2004 alone, the Commission completed more than 90 separate investigations through OMOI.\textsuperscript{14} Not all of these investigations involved abuse of pipeline-affiliate relationships, but we can get a good idea of severity and the general nature of abuse by looking at several investigations listed in the report:\textsuperscript{15}

- Dominion, et al.\textsuperscript{16} Basis for investigation was alleged violation of the Commission’s Standards of Conduct by providing non-public gas storage information to affiliates, select entities and individuals that was not provided to the public at large.

- Transco, et al.\textsuperscript{17} Basis for investigation was alleged violations of NGA, NGPA,

\textsuperscript{11}Tenneco, 969 F.2d. 1197-99.
\textsuperscript{12}Id. at 1204, 1209.
\textsuperscript{13}OMOI also investigates violations in electricity markets that will be covered in the next section.
\textsuperscript{15}Id. Appendix A.
\textsuperscript{16}108 FERC ¶ 61,110 (2004).
\textsuperscript{17}102 FERC ¶ 61,302 (2003).
and the Standards of Conduct including: Giving undue preference to affiliates; allowing an affiliate access to computer databases in order to optimize its transportation nomination on Transco’s pipelines; and disclosing to its marketing affiliate information about a non-affiliate shipper.

- National Fuel.\textsuperscript{18} Basis for investigation was alleged violations of NGA and relevant regulations including: The prohibition on giving an undue preference or advantage to any person regarding the provision of gas transportation information; failure to satisfy reporting requirements.

- Texas Eastern Transmission, LP, et al.\textsuperscript{19} Basis for investigation was alleged violations of NGA, and the Commission’s Standards of Conduct, reporting and posting requirements including: The prohibition on giving an undue preference or advantage to any person regarding the provision of gas transportation information; failure to satisfy reporting requirements.

In the Transcontinental Gas Pipeline Corporation (Transco) stipulation agreement, FERC imposed civil penalties of $20,000,000 and specified a four year plan that Transco and its affiliates, WEM&T and TWC, must follow. FERC found that Transco engaged in several severe violations during the audit period from 1999 to 2002. According to the filings, in 1994 WEM&T created an “optimization” program that was used to communicate with Transco mainframe computers to compile WEM&T’s sale and purchase transactions and search for the least costly nomination paths. Also, throughout the audit period Transco created Transco mainframe database access IDs

\textsuperscript{18}103 FERC ¶ 61,192 (2003).
\textsuperscript{19}110 FERC ¶ 61,188 (2005).
for certain WEM&T employees. Along with valid passwords these IDs provided WEM&T employees nonaffiliated customers’ contract, invoice and transportation data. Furthermore, Transco maintained the SCADA system that included real-time gas flow information related to Transco’s pipeline system. According to Transco, during the audit period it inadvertently posted an access portal to SCADA information on the TWC Intranet site. Transco did not give nonaffiliated shippers comparable access to SCADA information. In addition, FERC concluded that Transco violated several reporting requirements, such as omitting contract records for some sub-interval of the audit period.

More recently, FERC issued an order to fine Oasis Pipeline Company (Oasis), a Texas intrastate pipeline that is owned by Energy Transfers Partners (ETP), a marketing affiliate, for unduly discriminating against non-affiliated shippers, unduly preferring one or more affiliated shippers and charging rates in excess of the maximum lawful rate for service under section 311 of the NGPA. Oasis Pipeline provided interstate service on an interruptible basis only and intrastate on both firm and interruptible bases during audit period 2004-2006. Oasis pipeline systems linked supply areas in West Texas such as Waha with East and South Texas market centers such as Katy. FERC concluded Oasis had an economic incentive to discriminate against non-affiliates when the basis differential between Waha and Katy exceeded the maximum lawful rate for interstate transport of $0.1239 per MMBtu\textsuperscript{20}. “by providing this service an affiliated shipper, Oasis Pipeline, could ensure that these profits stayed within

\textsuperscript{20}One million British Thermal Units, a unit of energy.
the ETP corporate family, rather than losing them to a non-affiliate.”

For example, UBS (a non-affiliated shipper) requested transportation on Oasis Pipeline from Waha to Katy for June 2005. The Oasis Pipeline dispatcher stated that interruptible service was not available, but that if UBS wanted to ship intrastate gas, Oasis Pipeline would sell UBS firm service if firm capacity was available. Oasis Pipeline shipped an average of 33,500 MMBtu/day using interstate, interruptible service for its affiliates in June. On several occasions throughout the audit period, Oasis rejected interruptible inter and intrastate requests from non-affiliated shippers, but provided the similar service to the affiliated shipper during the same time period. In addition, Oasis Pipeline provided affiliated shippers with preferential access to information regarding available capacity and pricing. It informed ETP marketing personnel in advance when interruptible, interstate capacity became available. According to FERC, “this market advantage does not appear to have been extended to non-affiliated shippers, who had to call back day after day to see whether any space had become available.” The Commission imposed civil penalties in the amount of $15,500,000 and required Oasis to disgorge $267,122 in unjust profits.

In 2004, FERC decided to extend Order 497 to broaden “the definition of an affiliate covered by the standards of conduct.” FERC cited its concern “that a transmission provider’s market power could be transferred to its affiliated businesses because existing rules do not cover all affiliate relationships” and pointed to “signif-

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21ETP, et al., Order to Show Cause and Notice of Proposed Penalties, 120 FERC ¶ 61,086, pg. 56.
icant changes” in the range of services offered by various companies in the natural gas industry. FERC issued Order 2004 in 2003 that contained two major differences from Order 497. First, it extended the Standards beyond pipelines’ relationships with their marketing affiliates to govern also pipelines’ relationships with numerous non-marketing affiliates - processors, gatherers, producers, local distribution companies, and traders. Second, the new Standards covered a pipeline’s relationships even with those affiliates that do not hold or control any capacity on the pipelines. For example, a pipeline is subject to the Standards in its relationship with an affiliated producer that transports gas on other pipelines. FERC’s rationale was that pipelines could communicate information to affiliates who in turn could profit in the natural gas financial markets. FERC believed that a pipeline could, for instance, inform its affiliate of an upcoming transmission constraint that would affect the price of the commodity in the New York Mercantile Exchange, enabling the affiliate to enter into a profitable futures contract and gain a competitive advantage.

Several petitioners challenged FERC’s Order 2004 in the D.C. Court of Appeals. Entities such as Interstate Natural Gas Association of America challenged several aspects of Order 2004 such as the extension of the Standards to non-marketing affiliates; the extension of the Standards to entities that do not hold or control capacity on their affiliated pipelines; and the restriction of the activities of risk management employees and lawyers. The Court of Appeals granted the pipelines’ petition, vacated Order

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23 Id. at 34,090.
25 Id. at 30,827-30,828.
2004 and remanded it to the FERC instructing that “To justify Order 2004, FERC has relied on both an asserted theoretical threat of undue preferences and a claimed record of abuse. The Commission did not seek to justify the Order based solely on the theoretical danger. We find that the claimed record evidence does not support the Order, therefore we cannot uphold it.” In other words, even though the Court agreed with FERC that there was clear theoretical danger of pipeline and non-marketing affiliate relationship abuse, the Court hesitated to uphold Order 2004 because FERC did not provide sufficient, in fact, as the Court claims, any hard evidence of past abuse.

FERC responded by revising the Standards of Conduct for Transmission Providers in late 2008 by eliminating the concept of energy affiliates and eliminating the corporation separation approach (no employees of pipeline company can interact with employees of marketing affiliates) in favor of the employee functional approach (only employees involved with transmission planning and operating are barred from interaction with employees of marketing affiliates involved in natural gas trading).\textsuperscript{27}

\section*{2.2 Electricity}

The electricity industry is similar in structure to natural gas. As in natural gas, the electricity industry can be divided into power generation, transmission and distribution. Both industries are characterized by large numbers of marketers and traders that buy and sell the commodity either in spot or futures markets. Also, interstate transmission providers are regulated by the same agency, FERC.

\textsuperscript{27}Standards of Conduct for Transmission Providers, Order No. 717, FERC, Docket No. RM07-1-000, 2008.
For much of the 20th century the electric power industry was dominated by regulated vertically integrated monopoly utilities that owned power generation, transmission and distribution facilities. In 1978 the US Congress enacted the Public Utility Regulatory Policies Act (PURPA) as a response to the energy crises of the 1970s and the growing criticism of the cost-of-service regulation paradigm. Under cost-of-service regulation rates were set to cover the companies’ reasonable costs plus a fair return on shareholders’ investment. Desire to change cost-of-service regulation as well as to challenge the paradigm that electricity generation possessed heavy economies of scale or scope led to PURPA which sought to promote alternative energy technologies and to reduce oil and gas consumption through improved technologies and regulatory policies. As a response to PURPA the industry saw an influx of new independent power generators, effectively shaping the wholesale market. In essence, PURPA changed the dominant view that only the vertically integrated utilities could provide power efficiently and reliably and showed that nonutilities could provide power effectively without disrupting the electric network.

Despite considerable entry into the power generation sector, many industry analysts and regulators expressed the concern that the major obstacle for developing competitive wholesale generation markets was the fact that the generators of cheaper electricity could not easily access the transmission grid to reach potential customers. At that time, under the existing legal framework, FERC had limited authority to order access. To remedy this, Congress issued the Energy Policy Act of 1992 (EPAct). EPAct expanded FERC’s authority to order transmission utilities to provide transmission service for wholesale power sales to any electric utility and also reduced the
entry barriers so that additional power generating companies could enter the market. EPAct encouraged FERC to assess the reality of discrimination in electricity transmission and to seek new rules and policies that would aim at eradicating transmission owners’ ability to deny or restrict access. Indeed, an overview of comments and complaints submitted to FERC reveals the magnitude of such abuse.

For example, in 1994, Indiana Michigan Power Agency (IMPA) and American Municipal Power-Ohio, Inc. (AMP-Ohio) filed petitions against American Electric Power Service Corporation (AEP). The senior officials from IMPA and AMP-Ohio alleged the following:\textsuperscript{28}

- In December 1989, AMP-Ohio negotiated a 20 megawatt (MW) purchase of short-term power from Louisville Gas & Electric Company (LG&E). AEP refused to wheel because LG&E had earlier that day told AEP it had no power to sell to AEP. AEP then bought the power from LG&E and offered to resell it to AMP-Ohio.

- In January 1990, AMP-Ohio solicited bids for February power purchases from a number of utilities including AEP. AEP was not the winning bid. AMP-Ohio made arrangements to purchase the power from four winning bidders and sought transmission through AEP. When AMP-Ohio gave AEP the schedule for delivery, AEP refused to transmit the power, matched the average price of the winning bids, and made the sale itself.

\textsuperscript{28}64 FERC ¶ 61,279; 67 FERC ¶ 61,168.
\textsuperscript{29}Wheeling refers to transporting electric power over transmission lines.
wheeled through Public Service Company of Indiana (PSI) and AEP to serve IMPA’s load at Richmond. The delivered price was $.292 per KW-day plus a 1 mill adder. At the same time AEP arranged to buy 300 MW from PSI at $.30 per KW-day plus out-of-pocket energy costs. Hence, PSI was shipping total of 380 MW to AEP with 80 MW of that amount to be delivered to IMPA’s load at Richmond. Then, on a day when IMPA should have received 80 MW, AEP told IMPA that PSI had sold everything to AEP and that IMPA would have to buy from AEP at $.63 per KW-day plus the cost of energy from AEP. AEP used its control over transmission to intercept 80 MW at a lower price and resell it as short-term power to IMPA.

In 1989 the cities of Riverside, Azusa, Banning and Colton, California (Cities) filed complaints against Southern California Edison Company (Edison). The Cities alleged the following:

- Edison’s policy was to curtail the Cities any time it could be justified using any of a list of acceptable reasons to deny interruptible transmission service.

- Edison would not generally provide transmission service when Edison could save money by itself purchasing economy energy that would be wheeled. The Cities called Edison every hour to request interruptible transmission service. Edison often refused to sell energy available in Western Systems Power Pool to the Cities and then made available higher cost contract energy.

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30 A common method of pricing electricity. Tenths of a cent per kilowatt-hour.
31 Order No. 888, 75 FERC ¶ 61,080, Appendix C at 11.
• Edison would not provide long-term firm transmission service to the Cities. One of Edison’s reasons for denying long-term transmission was that Edison desired to reserve the transmission for its own future (unspecified) needs.

• Edison would not respond in a timely manner to the Cities’ requests, routinely taking months to respond.

• In 1986-87, the Cities purchased 20 MW from Pacific Gas and Electric (PG&E) and 80 MW from Deseret G&T Cooperative. Edison stated that without reinforcement of its transmission system, Edison would not provide the transmission. There was a five-month delay during which the Cities were forced to purchase from Edison at a higher cost. Then Edison decided that the transmission system did not need reinforcement.

• Edison also refused to provide a service priority equal to that of native load. It would curtail the Cities in order to purchase more economy energy for itself. When Edison curtailed the Cities, they were not able to purchase economy energy and instead purchased energy from Edison.

The examples above deserve careful examination. On the surface, these examples do not seem to suggest that the transmission owners were favoring their affiliates over other downstream competitors; rather they provide textbook examples of an upstream monopolist using its market power to extract monopoly rents. The abuse of parent-affiliate relationships are not explicit, due to yet undeveloped electricity markets that lacked presence of various power marketers and traders and the fact that transmission owners were allowed to directly buy and sell power from generators to end-customers.
As we will see shortly, concerns about the abuse of parent-affiliate relationships became much more explicit after FERC mandated the unbundling of wholesale power services from transmission services. One can argue that the unbundling of transmission and marketing functions by FERC did not reduce the incentives of transmission owners to abuse their monopoly power. Rather, instead of directly harming end-users, the transmission owners resorted to more subtle methods of favoring marketing affiliates who now were in charge of buying and selling power while competing with other power marketers.

In 1996, FERC followed up EPAct of 1992 with Order Nos. 888 and 889 that would affect the transmission and wholesale competition. In Order No. 888 FERC found that undue discrimination and anticompetitive practices existed in transmission services (as the examples above suggest). FERC determined that non-discriminatory open access transmission service was an appropriate remedy and one of the most critical components of a successful transition to competitive wholesale electricity markets. Accordingly, FERC required all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce to file open access transmission tariffs (OATTs) containing certain non-price terms and conditions. They also were required to “functionally unbundle” wholesale power services from transmission services.\(^\text{32}\) This meant that a public utility was required to: (1) take wholesale transmission services under the same tariff of general applicability as it offered its customers; (2) define separate rates for wholesale generation, transmission and ancillary services; and (3) rely on the same electronic information network that its transmission

\(^{32}\)Order No. 888, FERC Stats. & Regs., ¶ 31,036.
customers rely on to obtain information about the utility’s transmission system.

Concurrent with Order No. 888, FERC issued Order No. 889 that imposed standards of conduct governing communications between a utility’s transmission and wholesale power functions to prevent the utility from giving its power marketing arm preferential access to transmission information. Order No. 889 requires each public utility that owns, controls, or operates facilities used for the transmission of electric energy in interstate commerce to create or participate in an Open Access Same-Time Information System (OASIS). OASIS must provide information regarding available transmission capacity, prices, and other information that will enable transmission customers to obtain open access to non-discriminatory transmission service.\(^\text{33}\) In summary, Order Nos. 888 and 889 attempted to reduce opportunities for price or nonprice discrimination by transmission owners as they were ordered to provide transmission service and information about transmission service in an open and nondiscriminatory manner.

Creation of OMOI in 2002 significantly enhanced FERC’s ability to detect and monitor any irregular behavior by transmission providers. Along with investigating pipelines’ exercise of market power (see above), OMOI documented the following violations of transmission standards of conducts:

- Idaho Power, et al.\(^\text{34}\) Basis for investigation was alleged violation of Standards of Conduct such as giving preferential access to non-public transmission infor-

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\(^{33}\)Open Access Same-Time Information System (Formerly Real-Time Information Networks) and Standards of Conduct, Order No. 889, 61 Fed. Reg. 21,737 (May 10, 1996), FERC Stats. & Regs., ¶ 31,035.

\(^{34}\)103 FERC ¶ 61,693 (2003).
mation to its own wholesale marketing employees.

- Cleco, et al.\textsuperscript{35} Basis for investigation was alleged violations of the entity’s own Codes of Conduct and Commission regulations. Stipulation to having participated in unauthorized power sales, transmission transactions, and operational arrangements among affiliates.

In Cleco et al., Cleco Marketing & Trading LLC (CMT) and Cleco Evangeline LLC (Evangeline) were affiliates of Cleco Power engaged in generating and marketing power through Cleco’s transmission facilities. CMT and Evangeline shared similar codes of conduct: to operate separately from the employees of Cleco Power “to the maximum extent practical” and to disclose all market information\textsuperscript{36} they share with Cleco Power simultaneously to the public. During the audit period 1999-2002, CMT provided Cleco with a variety of services including resource coordination; marketing and customer relations services; monitoring, energy management, scheduling, dispatch and accounting and billing services; retail and wholesale marketing, and energy trading. CMT and Cleco also shared employees and CMT operated nearly all aspects of Cleco Power trading operations. CMT also managed the trade books of CMT and Cleco in a single database. As a result, non-affiliated customer information was shared between Cleco and CMT. Cleco and CMT also shared a single trading floor, which contributed toward sharing of information. CMT also provided transmission scheduling services for Cleco whereby a single CMT employee performed this service.

\textsuperscript{35}104 FERC ¶ 61,125 (2003).

\textsuperscript{36}“Market information” was defined broadly to include “all market information, including but not limited to, any communication concerning power or transmission business, present or future, positive or negative, concrete or potential.”
for both CMT’s own transmission scheduling needs and those of Cleco.

Consequently, the Commission determined that Cleco violated Section 205 of the Federal Power Act (FPA) by providing an undue preference to an affiliate (CMT) with a unique type of transmission service not made available to non-affiliates. Cleco also violated: a) Section 37.4(b)(4)(i) of the Commission’s regulations, which prohibits disclosure of non-public, transmission system information by transmission provider employees to affiliate employees engaged in wholesale merchant functions, if that information is not contemporaneously disclosed to other customers; b) Section 37.4(b)(4)(ii) of the Commission’s regulations, by failing to post on the OASIS transmission information regarding the unique form of transmission service disclosed to an affiliate; c) Section 37.6(b) of the Commission’s regulations, which requires transmission providers to post all types of available transmission capacity on its OASIS, by failing to post the unique type of firm transmission service that it provided to CMT on Cleco’s OASIS; d) Section 37.4(b)(6) of the Commission’s regulations, which requires transmission providers to maintain books of account and records separately from those of their affiliates. CMT and Evangeline also violated their respective Codes of Conduct by sharing market information with Cleco Power that was not simultaneously disclosed to the public. The Commission assessed civil penalties of $750,000 and required CMT and Evangeline to disgorge $2 million of profits.

In Idaho Power, transmission provider, and IDACORP Energy, marketing affiliate of Idaho Power, the Commission found several violations during the audit period of

\[39\] 18 C.F.R. & 37.6(b)(2003).
2000-2002. First, Idaho Power favored its wholesale marketing affiliate IDACORP by providing access to transmission on the basis that certain requests for non-firm transmission by IDACORP where necessary to serve Idaho Power’s native load when in fact they were not. By incorrectly designating requests for non-firm transmission service as being necessary to serve native load, the wholesale marketing affiliate gained a priority over competing power marketers that also requested non-firm transmission service from Idaho Power.

Second, the Commission also determined that Idaho Power violated its Standards of Conduct when 1) employees involved in wholesale merchant activities had unescorted access after regular business hours to Idaho Power’s transmission control area and had computer access to transmission-specific information; 2) wholesale merchant and transmission function employees discussed transmission information on a preferential basis; 3) Idaho Power failed to post on its OASIS all transfers of personnel between the transmission and wholesale merchant functions; and 4) transmission function employees conveyed in telephone conversations (e.g., a non-public forum), prompted by wholesale merchant traders, decisions regarding transmission requests. The Commission concluded that these activities violated Idaho Power’s standards of conduct and indicated unduly preferential access to non-public transmission information by employees with duties related to sales functions. The Commission assessed civil penalties of $321,518 and required IDACORP to transfer $5,820,456 to Idaho Power.

41Native load customers are the transmission provider’s wholesale and retail power customers on whose behalf the transmission provider has undertaken an obligation to construct and operate its system to meet their reliable electric needs. Requests for non-firm transmission service to serve native load have a priority superior to other requests for non-firm service.
In December of 1999, FERC adopted Order No. 2000 which encouraged the creation of Regional Transmission Organizations (RTOs) as a way to address “important operational and reliability issues and eliminate any residual discrimination in transmission services that can occur when the operation of the transmission system remains in the control of a vertically integrated utility.” Following the Order, several RTOs were created in parts of the country, including PJM Interconnection (Pennsylvania-New Jersey-Maryland Interconnection) and ISO NE (Independent System Operator New England) in the Northeast, MISO (Midwest Independent Transmission System Operator) in the Midwest and SPP (Southwest Power Pool) in the South. RTOs were in charge of planning and expansion of transmission grids to ensure system reliability. However, according to FERC, there still remained complaints by transmission customers that comparable transmission service was not provided.

In the early 2000s, the Commission became convinced that OATT adopted in Order No. 888 could not fully remedy undue discrimination because transmission providers retained both the incentive and the ability to discriminate against third parties in areas where OATT left a transmission provider with significant discretion. In 2005 the Commission solicited comments with proposed reforms of Order No. 888. Generally, commenters agreed that reforms to the OATT were needed because of the continued existence of both the opportunity and incentive for transmission providers to engage in undue discrimination. One commenter, Constellation, claimed that on multiple occasions it has been denied a transmission request when the transmission

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43Preventing Undue Discrimination and Preference in Transmission Service, Order No. 890, Docket Nos. RM05-17-000 and RM05-25-000.
provider’s OASIS indicated that there was available transfer capacity (ATC), but the commenter had no effective and timely way to challenge that determination because the ATC was a “black box.” The commenter asserted that it was often forced to accept the determination of the transmission provider that ATC was not available and seek alternate transmission paths. Another commenter, Powerex, alleged that a transmission provider granted short-term firm transmission service requests and allowed transmission customers to say in the queue, even when zero ATC was posted on the transmission provider’s OASIS. Powerex argued that this clogged the transmission queue with multiple requests and was concerned that the lack of transparency indicated the possibility of preferential treatment. Also, Williams alleged that the transmission provider, despite having an OATT, persistently used its transmission system to benefit its merchant function. Williams alleged that its interests were consistently compromised by the discretion the transmission providers afforded in the interpretation of the OATT and the lack of transparency in requesting, scheduling or interrupting of transmission service.

Based on the suggestions and opinions expressed by the industry participants, FERC issued Order No. 890 in 2007 to reduce opportunities for undue discrimination, to promote greater transparency in applying tariffs by transmission providers and to achieve more efficient utilization of the national transmission grid. Order No. 890 contained several reforms including, perhaps most important for this paper, consistency and transparency of ATC calculations. The Commission noted that

44 The Commission used the term “Available Transmission Capability” in Order No. 888 to describe the amount of additional capability available in the transmission network to accommodate additional requests for transmission services.
The calculation of ATC is one the most critical functions under the OATT because it determines whether transmission customers can access alternative power supplies. Despite this, the existing OATT does not prescribe how ATC should be calculated because the Commission sought to rely on voluntary efforts by the industry to develop consistent methods of ATC calculation. This voluntary industry effort has not proven successful. The Commission therefore acts today to require public utilities, working through the North American Electric Reliability Corporation (NERC), to develop consistent methodologies for ATC calculation and to publish those methodologies to increase transparency. This important reform will eliminate the wide discretion that exists today in calculating ATC and ensure that customers are treated fairly in seeking alternative power supplies.\textsuperscript{45}

Other reforms under Order No. 890 included: a) Requirement for coordinated, open and transparent transmission planning, where the Commission amended OATT to require coordinated, open, and transparent transmission planning on both a sub-regional and regional level to ensure that comparable transmission service was provided by all public utility transmission providers; b) Transmission pricing reforms which included reformed pricing rules for the several components of public utilities’ services such as energy and generator imbalance charges and capacity reassignment pricing; c) Reforms that aimed at increases in transparency to lessen the opportunities to discriminate and reduce transaction costs in addition to proper calculation of

\textsuperscript{45}Preventing Undue Discrimination and Preference in Transmission Service, Order No. 890, Docket Nos. RM05-17-000 and RM05-25-000, at 5.
ATC. These included various requirements for posting information on OASIS such as transmission providers’ designation of network resources, business rules, practices and standards; and d) Miscellaneous OATT improvements such as reservation priorities for various transmission requests.

2.3 Telecommunications

The telecommunications industry saw a significant transformation with an antitrust lawsuit by the U.S. Department of Justice against AT&T culminating in the Modified Final Judgment of 1984 (MFJ). In MFJ, AT&T was required to divest its local exchange services but retained its long-distance services. The AT&T break-up resulted in seven independent Regional Bell Operating Companies (RBOCs) and a surge of competition in long-distance communications by Sprint and MCI. The divestiture also created Local Access and Transport Areas (LATAs). Under the terms of MFJ, RBOCs were generally prohibited from providing services that originated in one LATA and terminated in another. That is, Incumbent Local Exchange Carriers (ILECs) were prohibited from providing long-distance voice services due to a fear they would use their established position in local markets to gain unfair advantage against other independent Interexchange Carriers (IXCs). The seminal work by Bernheim and Willig (1996) explores and documents anti-competitive behavior, including

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46 The original “Baby Bells” included Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, and US WEST. Since then Ameritech, BellSouth, Southwestern Bell and Pacific Telesis became part of the new AT&T Inc., BellSouth and NYNEX became part of Verizon and US WEST became part of Qwest.

47 MCI was eventually acquired by Verizon in 2006.

48 Seven RBOCs, two other non-RBOC Bell system members including Cincinnati Bell and SNET and other large independent operators, such as GTE.

49 Due to various state and federal regulations “long-distance” service could be an intra LATA call within the same state, an inter LATA call within the same state or other combinations of State/LATA origin/destination pairs.
non-price discrimination, by dominant RBOCs.

Twelve years after the break-up of AT&T, Congress issued the Telecommunications Act of 1996 (the “Act”) as a response to ongoing technological advances in the telecommunications industry and to a need for reconstructing and shaping competition in local exchange markets. Two central provisions of interest are:

- Introducing competition in local exchange markets. Section 251 of the Act mandates interconnection to the potential entrants. Sections 251 and 252 envisioned entry of Competitive Local Exchange Carriers (CLECs) by requiring the incumbent to allow for physical collocation of equipment on its premises (“facilities based entry”) or by requiring the incumbent to unbundle the elements of its network and to offer them for sale or leasing at non-discriminatory prices (“unbundled network elements”).

- Allowing RBOCs to provide long-distance services. Section 271 of the Act specified that in order to enter the long-distance market, RBOCs were required to file applications with Federal Communications Commission (FCC) on a state-by-state basis. The request would be granted if RBOCs met a long checklist. In general, RBOCs had to demonstrate that the local exchange market where they served as an incumbent was deemed sufficiently competitive and the entry into the long-distance service was in the public interest. In addition, Section 272 of the Act required RBOCs to provide in-region, interLATA telecommunications services through a separate corporate affiliate. Section 272 also established structural and transactional restrictions on the relationship between an RBOC
and its section 272 affiliate in order to prevent RBOCs from giving unfair advantage to their own long-distance affiliates.\(^{50}\)

At first, Section 271 approvals were slow to take off. Verizon was the first RBOC to receive section 271 approval in New York in 1999. By the end of 2003 all RBOCs received Section 271 approvals in all states (Qwest was the last one to receive the approval in Arizona).\(^{51}\) The approval process was under heavy scrutiny from both state regulators and the FCC, and was becoming increasingly complex as regulators had to accommodate the introduction of new advanced telecommunications services (such as Digital Subscriber Line or DSL). There were concerns that initially RBOCs would cooperate with regulators to receive the Section 271 approval but, after entry into the long-distance market, they would wield variety of discriminatory tools, both price and non-price, against unaffiliated IXCs.\(^{52}\)

Non-price discrimination as applied to RBOCs providing long-distance service can generally be thought as either affecting rival’s costs or demand. For example, the basic structure of local telephone loops includes end-users that are connected to an end office switch by small capacity lines which are in turn connected to a tandem switch by large capacity lines. A tandem switch serves as a hub of the local system, as well as a connection point between the local network and long-distance lines.\(^{53}\) As competing IXCs seek access to an RBOC’s service area, the monopolist can potentially delay the provision of access, or artificially prolong repair times of facilities that are


\(^{52}\)For example, see Economides, 1998.

\(^{53}\)Reiffen and Ward, 2002.
dedicated to carrying unaffiliated IXC’s signals to the local loop. As for the actions that affect long-distance rivals’ demand, the incumbent can potentially increase costs for customers who want to switch services, withhold information from customers about available competing long-distance carriers, use its already established brand name as a local service provider to promote long-distance services, and use inserts promoting long-distance service into bills that the incumbent already sends to its customers for local services when the competing long-distance carrier has no such low-cost alternative. Introductions of new telecommunications services, such as DSL and wireless communications, pose additional concerns to regulators to monitor the quality of access. Both DSL and wireless providers seek access to bottleneck facilities that RBOCs own in a similar fashion to long-distance providers. As RBOCs were allowed to compete in these markets after Section 271 approval, they could potentially use sabotage methods similar to those described above.

The FCC’s Enforcement Bureau (EB) monitors compliance with Section 271 requirements. It has authority to initiate its own investigations as well as provide dispute resolution between industry participants. Several cases filed under the Section 271 enforcement actions deserve special attention.

In a complaint filed by MCI WorldCom against Ameritech operating companies the FCC was concerned about the use of 1-800-AMERITECH service. This service permitted Ameritech’s local subscribers to place local and long-distance calls originating both inside and outside of the Ameritech area by dialing the toll-free number. In 1996 Ameritech chose TelTrust Communications as an IXC that would provide interLATA calls for Ameritech customers. The FCC found that this constituted a
violation of Section 271 as Ameritech did not have approval to offer long-distance services at that time. Additionally, the FCC alleged that Ameritech:

- relied on its brand name in marketing the combined offering.
- promoted the combined offering through bill inserts to Ameritech’s local calling subscriber base.
- served as the exclusive point of contact for customer service.
- reserved the right to substitute its own services in place of the contracting provider.\(^{54}\)

The Commission concluded that Ameritech’s name and logo were prominently featured in commercials, bill inserts and customer services. It seemed that customers had little knowledge that the long-distance service was provided by a company different from Ameritech. The Commission stated that

... the Service permits Ameritech to accumulate a significant base of customers who rely on the Service. After receiving section 271 authority, Ameritech would be well positioned to substitute the interLATA service of its section 272 affiliate for that of the IXC currently supporting the Service. The ability of Ameritech to avail itself of a ready base of customers that is positioned for migration to its eventual interLATA service is a troublesome material benefit uniquely associated with the ability to include a long-distance component in the 1-800-AMERITECH service.\(^{55}\)


\(^{55}\)Id, pg. 7.
Also, the Commission found concerning the contract terms between Ameritech and TelTrust that the contract specified that Ameritech could terminate the agreement at any time for any reason by giving 75 days prior written notice. The Commission stated that “these contract provisions give Ameritech the right to replace TelTrust’s services with the services of Ameritech’s section 272 affiliate once the Commission grants Ameritech authorization to provide long distance services in-region.”56 Moreover, the Commission found that Ameritech used advertising venues available only to it as a monopoly provider such as bill inserts and other mailings.57

There were similar allegations that the FCC handled during 2000-2003 (Verizon in 2000, US West in 2001, BellSouth in 2003). All of these allegations were about a premature provision of long-distance services, building up customer base and promoting its own brand name by RBOCs before Section 271 approval. In some cases, the violators were required to make voluntary contributions to the US Treasury as a part of the Consent Decree.58

Following the limitations contained in Sections 271 and 272 of the Act between RBOC and its long-distance affiliate, the FCC implemented a series of orders and rules that further specified and limited relationships within vertically integrated companies. For example, in order to deter RBOCs from unfairly favoring their in-region inter-LATA operations by discriminating in favor of their long-distance operations against unaffiliated competitors, the Commission established a rule prohibiting the Section

56Id, pg. 8.
57...through the use of bill inserts, Ameritech can effectively promote the Service at a slight fraction of what a stand-alone mailing would cost one of its competitors, even if those competitors had access to Ameritech's subscriber mailing list.” Id, pg. 9.
58$5.7 million in the Verizon case and $1.4 million in the BellSouth case.
272 affiliate from receiving OI&M services from RBOC.\textsuperscript{59}

In a consent decree issued by the FCC in 2004, the Commission found that Verizon provided certain OI&M functions to Verizon’s Section 272 affiliates.\textsuperscript{60} The Commission also found that the RBOC obtained pre-paid calling card services from the affiliate without soliciting bids from other qualified firms and Verizon’s service representatives did not inform some customers of their right to choose a long-distance carrier other than the Verizon Section 272 affiliate.\textsuperscript{61} In a similar case, the Commission found that BellSouth violated independent operation requirements when BellSouth’s affiliate BellSouth Carrier Professional Service performed OI&M functions for BellSouth Long Distance. Justifying the structural separation, the Commission expressed that “...clear prohibition [performing OI&M services] was established for the purpose of avoiding the burdensome regulatory involvement that would result from the Commission’s need to police subtle distinctions and procedures in the absence of a clear rule.”\textsuperscript{62} Verizon and BellSouth were fined $300,000 and $75,000, respectively, by the Commission.

After a series of consultations and regulatory proceedings, the FCC modified its separation requirements of Section 272 in 2004. The commission found that “OI&M sharing prohibition is not a necessary component of the statutory requirement to op-

\textsuperscript{59}OI&M functions generally include all activity related to installing, operating, and maintaining switching and transmission facilities. See Implementation of the Non-Accounting Safeguards of Sections 271 and 272 of the Communications Act of 1934, as Amended, First Report and Order and Further Notice of Proposed Rulemaking, 11 FCC Rcd 21905 (1996); Third Order on Reconsideration, 14 FCC Rcd 16299 (1999).

\textsuperscript{60}These affiliates included Bell Atlantic Communications, NYNEX Long Distance, and Bell Atlantic Global Networks.

\textsuperscript{61}Consent Decree, FCC 04-180, EB-03-IH-0245, 2004.

erate independently and is an overbroad means of preventing cost misallocation or discrimination by BOCs against unaffiliated rivals.” The Commission admitted that structural safeguards, such as OI&M restrictions, were helpful in monitoring certain behaviors by RBOCs including cost misallocation and performance discrimination. However, as the Commission stated, such safeguards could be costly and burdensome and certain non-structural safeguards could afford a similar level of transparency and protect against discrimination. The Commission decided to eliminate the OI&M sharing prohibition and continue to monitor the performance of an RBOC’s provision of OI&M functions through application of other Section 272 requirements and the Commission’s affiliate transactions and cost allocation rules. The Commission, however, retained the joint facilities ownership restriction of the independent operation provision of Section 272. The joint facilities ownership restriction provides that “[a] section 272 affiliate and the BOC of which it is an affiliate shall not jointly own transmission and switching facilities or the land and buildings where those facilities are located.” The Commission stated that the elimination of the above-mentioned rule would create “significant joint and common costs that would be inherently difficult to allocate properly.” Therefore, the prohibition of joint ownership greatly diminished an RBOC’s ability to cross subsidize its long-distance operations at the expense of the local customer base, as well as the RBOC’s ability to grant certain preferences to the long-distance affiliate in providing and maintaining facilities.

63Report and Order; Memorandum Opinion and Order; FCC 04-54, WC Docket No. 03-228, CC Docket Nos. 96-149 and 01-337, 2004.
6447 C.F.R. § 53.203(a)(1).
65Report and Order; Memorandum Opinion and Order; FCC 04-54, WC Docket No. 03-228, CC Docket Nos. 96-149 and 01-337, 2004.
2.4 Summary

Due to the similarity between the natural gas and electricity industries, examples of sabotage found in both industries are also similar in nature. In both industries transmission providers and pipelines play a central role in shipping or wheeling respective commodities from producers to end users; transmission providers and pipelines own key facilities within a certain region and users of a grid have few options to bypass those facilities; capacity of transmission lines or pipelines plays a central role in meeting the demands of shippers; a part of the capacity is reserved for “firm” or “native load” (usually for residential customers); and both industries are regulated by the same agency, FERC. We find that sabotage by transmission providers or pipelines most commonly involves sharing critical information with affiliates while at the same time withholding this type of information from non-affiliates. Below is the summary of types of sabotage seen in natural gas and electricity industries.

- Informational:

  1. Sharing information about supply and delivery points when opportunities for arbitrage exists.

  2. Sharing information about available current or future system capacity which is key for securing timely contracts.

  3. Sharing information about available current or future off-system capacity.

Due to the dominant position of pipelines or transmission providers, and existence of network effects between different grids, it is more likely that a pipeline that holds monopoly power within a certain region will have
privileged information about available capacity on different grids in other regions.

4. Sharing classified information about non-affiliated customers’ contract terms and conditions with affiliates.

5. Sharing information with and involving affiliates in the current or future scheduling, planning, maintaining or expanding of a transmission or pipeline network.

• Direct:

1. A pipeline or transmission provider applies different curtailment procedures in times of emergency shut-downs or maintenance.

2. Concealing available capacity when a non-affiliated company requests a service or applying different standards in computing available capacity.

3. Giving priorities to requests for service by an affiliate instead of serving on a first-come first-serve basis. For example, classifying an affiliate’s request as necessary for system reliability and consequently denying non-affiliates’ requests for service.

4. Routinely taking a long time to respond to non-affiliates’ requests for service.

The telecommunications industry is different in nature from the electricity and natural gas industries for several reasons: Capacity is not a major concern, at least at current capacity and usage levels; there is a differentiated commodity and con-
sumers are relatively sensitive to brand names, whereas natural gas or electricity is a homogeneous good; and most residential customers are not sophisticated, have relatively high search costs and prefer simple bills, whereas natural gas or electricity shippers are specialized firms with necessary expertise. Consequently, sabotage that influences a non-affiliate’s demand is more prominent in telecommunications. Below is the summary of types of sabotage seen in the telecommunications industry.

- Demand Side:
  1. Increase switching costs of customers who would like to switch long-distance carriers.
  2. Withhold information about availability of alternative long-distance carriers.
  3. Aggressively promote brand name as an established local area provider in favor of an affiliated long-distance carrier.
  4. Use unique advertising channels, such as bill inserts, available only to the affiliated long-distance carrier due to the established position of the incumbent local area affiliate.

- Cost Side:
  1. Delay installment of switching facilities.
  2. Delay or provide preferential treatment in maintaining switching facilities.
  3. Provide poor quality interconnection by under-investing in switching facilities.
This is by no means a comprehensive study of sabotage, as we merely attempt
to provide a first (in our best knowledge) systematic examination of types of non-
price discrimination in US natural gas, electricity and telecommunications industries.
There is clearly room for future extensions. For example, one area that we have
not examined is provision of advanced communications services, such as DSL and
wireless communications. Competition in these areas is fairly intense as new entrants
are seeking interconnection with incumbent local exchange providers that are also
providing the same service. As theoretical literature suggests, there is danger that
an incumbent upstream monopolist might resort to non-price discrimination against
unaffiliated rivals.

We found most of the examples discussed in this paper by searching filings and
databases of federal regulatory commissions (FERC and FCC). We believe that fil-
ings with various state commissions is another area where one might find numerous
examples of sabotage. For example, instances of abuse between an ILEC and a com-
pany that is providing DSL services within a certain state would not show up in FCC
investigations. Instead, such abuses would be investigated by the state commission.
Despite the limited scope of this paper we believe that it provides a first system-
atic examination of non-price discrimination in light of technological and regulatory
changes in natural gas, electricity and telecommunications markets.
Many network industries have an upstream monopolist that sells an essential input to downstream firms. Examples include electricity markets where a firm owning transmission lines sells access to generating companies, telecommunications where a local operator sells access to a competitive long distance market or to other communications providers such as wireless firms or providers of high speed internet services,¹ cable telephony where a local cable monopolist sells access to firms providing long distance and local voice services,² and software markets where Microsoft provides a key resource, the Windows operating system, while also competing with other firms for other software components (media players, for example) that seek compatibility with Windows.

The access offered to downstream firms by an upstream monopolist consists of two parts, an access charge and quality of access. Often the upstream monopolist is regulated in terms of the access charge while the downstream market is deemed sufficiently competitive and is therefore unregulated. There is a large literature on access charges and the regulation thereof to optimize social welfare (Armstrong et al. 1996; Laffont and Tirole 1990 and 1994; Bustos and Galetovic 2007; Reiffen 1998; Vickers 1995; Weisman 1995 and 1998; Weisman and Kang 2001). In an unregulated

¹Digital Subscriber Line (DSL) is a family of technologies that provide digital data transmission over the wires of a local telephone network. See http://en.wikipedia.org/wiki/DSL.
²Voice Over Internet Protocol (VOIP) is a recent technology, where voice is carried through the internet. See http://en.wikipedia.org/wiki/Voip.
market, quality of access probably would not be a concern as the upstream monopolist could extract monopoly profits via access charges. Even with regulated access charges an unintegrated upstream monopolist still would probably not want to degrade access quality since doing so may be costly and does not generate additional revenues for the monopolist.

However, access price regulation may create incentives to degrade the quality of access when the upstream monopolist is affiliated with one of the downstream competitors and thus receiving profits from retail markets. Absent the ability to extract monopoly profits via access pricing, the upstream monopolist may degrade the quality of access to its downstream rivals to increase its own retail profits and possibly foreclosure its rivals. This type of non-price discrimination by an upstream monopolist has been labeled “sabotage” in the literature. The first essay provides documentation that such sabotage occurs in the US energy and telecommunications industries. The literature agrees that sabotage is a socially costly activity, therefore there may be a need for regulation of access quality along with regulation of access prices.

The literature on sabotage has focused on theoretical possibilities of when access quality degradation may or may not occur. The upstream monopolist’s incentives to sabotage vary as relative efficiencies of the downstream affiliate and rival change as well as with the degree of competition. Although it is well-established that it may be possible to manipulate regulated access charges in order to decrease sabotage

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3 Various Orders and quality monotoring requirements issued by the FCC and the FERC to eradicate such quality discrimination also indicates that regulators agree that sabotage is a real concern. For example, see “Notice of Inquiry into Alleged Anticompetitive Practices Related to Marketing Affiliates of Interstate Pipelines,” pg. 9.

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and thereby enhance overall welfare (Ordover, Sykes, and Willig 1985; Economides 1998; Sibley and Weisman (SW) 1998; Mandy 2000; Mandy and Sappington 2007), there have been no attempts to derive welfare-optimal regulatory policies for a vertically integrated upstream monopoly when the upstream monopolist can sabotage its downstream rivals.

The present paper fills this gap in the literature by bringing the study of optimal regulatory policies for a vertically integrated upstream monopolist to a setting that may involve sabotage. Existing regulatory policies have long acknowledged the tension between access price regulation designed to encourage efficiency downstream and the potential that such regulation may encourage sabotage. Policies intended to maximize welfare and deter sabotage in network industries include marginal cost pricing of access, restrictions on vertical control between the monopolist and its downstream subsidiary, nondiscrimination requirements, performance monitoring of input quality, penalties for violations of nondiscrimination requirements, and limitations on the tools employed by regulators.4 “Vertical control” in this setting means the extent to which the upstream monopolist can align the objective of its downstream affiliate

4All of these policies are present in contemporary telecommunications regulation. On May 31, 2000 the US Federal Communications Commission (FCC) adopted the proposal of the Coalition for Affordable Local and Long Distance Service (CALLS) to rapidly move access charges toward the marginal cost of supplying access (FCC, 2000). Section 272 of the Telecommunications Act of 1996 restricts the vertical control a Bell company can exert over its long distance affiliate by requiring that the affiliate operate independently and maintain separate books from the Bell operating company; have separate officers, directors, and employees; have separate credit arrangements; and conduct all transactions with the parent company at arm’s length. This section also requires that the Bell company not discriminate in the provision of services between its affiliate and other suppliers of long distance. To enforce nondiscrimination, the FCC has required substantial performance monitoring agreements and pre-specified fines for violations as a condition of a Bell company’s entry into long-distance markets (for example, see FCC 1999). Regulatory tools are limited, however. Price discrimination and Baron-Myerson (1982) style incentive mechanisms are rarely used in practice, despite their established theoretical advantages.
with the objective of the overall firm. Despite the explicit vertical control policies used in practice, formal modeling of vertical control as a policy parameter has not previously appeared in the literature.

The regulator in our model is endowed with limited but realistic policy tools. Regulation of the downstream market and regulatory price discrimination are not permitted. Instead, the regulator sets a nondiscriminatory uniform access price and a level of vertical control. Limited internal control is due to external restrictions imposed by the regulator on the organization of the firm, not because of partial ownership or agency problems. In this paper the control of non-price discrimination to maximize welfare is the primary concern, so the Ramsey pricing aspects of covering fixed costs and the mechanism design issues associated with asymmetric information are both ignored. The access price and vertical control policies modeled here are representative of the tools used under the US Telecommunications Act of 1996 to regulate local network access for long-distance suppliers once a Bell company enters the long-distance market.\(^5\)

We find that optimal access price and vertical control policies vary depending on the relative efficiency of the downstream suppliers and the intensity of downstream competition. The regulator may be able to achieve the first best welfare outcome even with limited regulatory tools if there is an efficient downstream rival selling a

\(^5\)In the case of vertically integrated providers in electricity markets, the US Federal Energy Regulatory Commission (FERC) does not currently require “corporate” or “structural” unbundling of transmission and generation services. FERC Order No. 890 (Docket Nos. AD05-17-000 and RM05-25-000) only requires “functional” unbundling. That is, FERC requires that employees engaged in transmission functions operate separately from employees of energy affiliates and marketing affiliates. However, several members of the industry have urged FERC to take more decisive steps toward corporate unbundling (FERC 2007).
product that is a close or perfect substitute to the downstream affiliate’s product. This is accomplished by pricing access below its marginal cost to overcome the “double margin” problem. The upstream monopolist does not engage in sabotage in this setting provided the relative efficiency of the rival is large enough and sabotage costs increase rapidly with the level of sabotage. In contrast, we show it is not possible to achieve the first best when the downstream affiliate of the access monopolist is an efficient producer.

We explicitly derive the optimal access price and vertical control policy for the important case of equally efficient downstream firms and a simple sabotage cost specification. If the access monopolist’s sabotage cost increases relatively slowly with the level of sabotage then it is welfare-optimal to price access above marginal cost and allow full vertical control. On the other hand, if sabotage cost increases relatively rapidly with the level of sabotage then it is welfare-optimal to price access below marginal cost and restrict vertical control. The latter provides greater inducement to increase downstream output when the monopolist’s cost of sabotage can be more heavily relied upon to control the level of sabotage.

Hence we find a complementarity between the access price and vertical control policy parameters. Full vertical control is optimal when a high access prices is needed for control of sabotage, whereas limitation on vertical control is optimal when exogenous sabotage costs are sufficiently high to make a low access price viable from a welfare perspective. It is never optimal in this setting to price access at marginal cost because then the level of vertical control is effectively eliminated as a policy tool, having no impact on welfare. Thus we cannot rationalize some current regulatory
practices that aim to both price access at marginal cost and impose restrictions on vertical control.

Our results formally verify a conjecture that has appeared in the literature (see, for example, Laffont and Tirole 2000, Chapter 4), that it is sometimes optimal to price access above marginal cost in order to deter sabotage. However, in this case full vertical control provides the maximum inducement to increase downstream output, so our model refutes the notion that restrictions on vertical control are generally part of an optimal sabotage-deterrence policy. In general, the welfare effects of vertical control depend on whether the upstream access margin is positive or negative.

Section 1 presents the model and Section 2 derives the downstream equilibrium. Section 3 identifies the situations in which the regulator can achieve the first best and the policies that do so. Then section 4 studies the second best when the downstream firms are equally efficient. Section 5 concludes.

3.1 The Model

The downstream market is a differentiated products Bertrand duopoly\(^6\) where the representative consumer has a symmetric quadratic utility function for the outputs of the affiliate \((q^d)\) and the rival \((q^r)\):

\[
U(q^d, q^r) = \alpha q^d + \alpha q^r - \frac{1}{2} \left[ \beta (q^d)^2 + 2\gamma q^d q^r + \beta (q^r)^2 \right] \tag{1}
\]

\(^6\)A duopoly model may be appropriate for some industries. For example, small cities where DSL service is provided by the affiliate of the local incumbent provider and a competitive carrier.
for $\gamma \in [0, \beta]$. This utility function gives rise to the following linear inverse demand functions and the corresponding demand functions:

$$p^i (q^i, q^j) = \alpha - \beta q^i - \gamma q^j$$

(2)

for $i, j = d, r$ ($i \neq j$) and

$$q^i (p^i, p^j) = \frac{1}{\beta} \left[ \frac{\alpha}{1 + \theta} - \frac{p^i}{1 - \theta^2} + \frac{\theta p^j}{1 - \theta^2} \right],$$

(3)

where $\theta = \frac{\gamma}{\beta} \in [0, 1)$.

The parameter $\theta$ reflects the degree of product homogeneity in this setting. When $\theta = 0$, the products of the affiliate and the rival are fully differentiated in the sense that the demand for each firm’s product is not affected by the competitor’s price or output level. When $\theta \to 1$, the products of the affiliate and the rival become homogeneous, because each firm’s demand declines as its own price rises at the same rate that its demand increases as the price of its competitor rises.\(^7\)

We assume that marginal costs are constant but asymmetric, sabotage raises the marginal cost of the rival, and adopt the standard assumption in the literature on network industries that the downstream technology is fixed coefficients.\(^8\) Let $c^d, c^r \geq 0$ denote downstream marginal costs, $a$ denote the regulated price of access\(^9\) and $s \geq 0$

\(^7\)A differentiated goods model is more appropriate, as noted in the survey essay, in the telecommunications industry where brand names matter. On the other hand, in electricity and natural gas industries goods are more homogeneous.

\(^8\)For example, one minute of long-distance call requires one minute of local access.

\(^9\)As noted regulators do not generally use discriminatory access charges. Also, if discriminatory access charges were used then an integrated monopolist would probably not have incentives to sabotage, leaving unexplained the examples of sabotage in the survey essay.
the degree of sabotage. Then the downstream profits are

\[ \pi^r = (p^r - c^r - a - s) q^r \]  

\[ \pi^d = (p^d - c^d - a) q^d. \]

Let \( c^u \) denote the marginal cost of the upstream monopolist and \( K(s) \) the cost to the upstream monopolist of engaging in \( s \) units of sabotage. We assume \( K(0) = K'(0) = 0 \) and \( K''(s), K'''(s) > 0 \) for \( s > 0 \), so the cost of the first increment of sabotage is zero but sabotage costs are strictly increasing and strictly convex in the degree of sabotage.\(^{10}\) In parts of the analysis we will assume \( K \) is sufficiently convex to ensure that second order conditions are satisfied. Then the upstream profit is

\[ \pi^u = (a - c^u) (q^d + q^r) - K(s). \]

We assume throughout that any upstream viability constraint can be met with non-distorting transfers, so upstream fixed costs are ignored and the marginal cost of access may even exceed the access price (i.e., \( a < c^u \) is a feasible regulatory policy).

As mentioned above a new innovation in our model is the explicit parameterization of vertical control as a policy tool. We use the vertical control parameter \( \lambda \in [0, 1] \) to measure the degree of influence exercised by the upstream monopolist over the

\(^{10}\) There is no consensus in the literature about costs of sabotage. According to Weisman (1998) direct costs of sabotage include increased likelihood of error of inadvertently sabotaging the affiliate’s own facilities and a decrease in operating efficiency when the integrated parent creates at least two different sets of operating practices. Mandy (2000) points out that costs of sabotage may include the likelihood of getting caught coupled with the penalties imposed if caught. In practice regulators monitor input quality and impose penalties for violations of nondiscrimination requirements as found in the survey essay. As the likelihood of getting caught is likely very low for small levels of sabotage, and increases thereafter, this can provide one foundation of the structure of \( K \) assumed herein. Another evidence that sabotage generally is costly is the fact that we found examples of partial sabotage (Panhandle in the natural gas industry and Idaho Power in electricity industry) in the survey essay. We would expect no sabotage or full foreclosure of non-affiliated rivals if sabotage were costless.
choices of its downstream affiliate. Letting $IA$ denote “Integrated Affiliate” and $IP$ denote “Integrated Parent,” we specify their objectives as

$$\pi^{IP} = \pi^u + \pi^d \tag{7}$$

$$\pi^{IA} = (1 - \lambda)\pi^d + \lambda\pi^{IP} = \pi^d + \lambda\pi^u. \tag{8}$$

If $\lambda = 0$ (zero vertical control) the affiliate maximizes only its own profit $\pi^d$, while if $\lambda = 1$ (full vertical control) the affiliate maximizes the profit of its upstream parent. Note that this vertical control specification is not the usual agency approach to modeling separation of ownership and control. The IP has full information in our model, but is still unable to perfectly control the IA (when $\lambda < 1$) because of legal restrictions on the control mechanisms that can be used (for example, the restrictions that are imposed by Section 272 of the Telecommunications Act of 1996, and the various rules promulgated by the FCC to implement this legislation).

Aggregate welfare is the sum of consumer’s surplus and profit. Taking the utility function (1) as monetarily valued gross consumer surplus, welfare is

$$W = CS + \pi^u + \pi^d + \pi^r$$

$$= U(q^d, q^r) - [c^r + c^u + s]q^r - [c^d + c^u]q^d - K(s). \tag{9}$$

There is perfect and complete information in our model except for simultaneity in the downstream price choices. The timing of decisions is as follows. First the regulator chooses an access charge and control policy $(a, \lambda)$ to maximize $W$. This is observed by all three firms. Next the IP chooses a level of sabotage $s$ to maximize $\pi^{IP}$. This is observed by both downstream firms. Finally the downstream firms
simultaneously choose prices \((p^r, p^d)\) to maximize \(\pi^r\) and \(\pi^{IA}\), respectively.\(^{11}\) The equilibrium concept is subgame perfection. We use backward induction to study the regulator’s choice of welfare optimal access charge and vertical control given the outcomes in the downstream and upstream markets. This is the first formal modeling of vertical control as a regulatory policy and provides insight into the extent to which current regulatory practice is optimal.

### 3.2 Downstream Equilibrium

First rewrite IA’s profit function as \(\pi^{IA} = (p^d - c^d - a)q^d + \lambda[(a - c^u)(q^d + q^r) - K(s)]\).

The first order conditions for an interior equilibrium are:

\[
\frac{\partial \pi^r}{\partial p^r} = \frac{1}{\beta} \left[ \frac{\alpha}{1 + \theta} - \frac{2p^r}{1 - \theta^2} + \frac{\theta p^d}{1 - \theta^2} + \frac{\hat{c}^r}{1 - \theta^2} \right] = 0 \quad (10)
\]

\[
\frac{\partial \pi^{IA}}{\partial p^d} = \frac{1}{\beta} \left[ \frac{\alpha}{1 + \theta} - \frac{2p^d}{1 - \theta^2} + \frac{\theta p^r}{1 - \theta^2} + \frac{\hat{c}^d}{1 - \theta^2} \right] = 0, \quad (11)
\]

where \(\hat{c}^r = c^r + a + s\) and \(\hat{c}^d(\theta) = c^d + a - \lambda(a - c^u)(1 - \theta)\) are “effective” marginal costs for the rival and affiliate, respectively. Note that the affiliate’s effective marginal cost depends on \(\theta\) and also when \(a - c^u\) and \(\lambda\) are positive, and \(\theta < 1\), the effective marginal cost of the affiliate is lower than marginal cost \((c^d + a)\), reflecting the fact that bigger output increases access revenues for the parent. The notation \(\hat{c}^r\) and \(\hat{c}^d\) is used throughout the paper to denote effective marginal cost. To ensure that we have an interesting problem, we assume throughout that \(\alpha\) exceeds both effective marginal costs for all values of \(a\) and \(s\) under consideration.

Taking into account corner outcomes (i.e., price pairs for which one firm is foreclosed), the augmented demand functions are:

\(^{11}\)See Figure 9.
\[ q^d(p^d|p^r) = \begin{cases} 0 & \text{if } p^d \geq \alpha(1 - \theta) + \theta p^r \\ \frac{1}{\beta} \left[ \frac{\alpha}{1 + \theta} - \frac{p^d}{1 - \theta^2} + \frac{\theta p^d}{1 - \theta^2} \right] & \text{if } \frac{p^r}{\theta} - \frac{\alpha(1 - \theta)}{\theta} \leq p^d \leq \alpha(1 - \theta) + \theta p^r \\ \frac{\alpha}{\beta} - \frac{p^d}{\beta} & \text{if } p^d \leq \frac{p^r}{\theta} - \frac{\alpha(1 - \theta)}{\theta} \end{cases} \] (12)

and

\[ q^r(p^d|p^r) = \begin{cases} 0 & \text{if } p^r \geq \alpha(1 - \theta) + \theta p^d \\ \frac{1}{\beta} \left[ \frac{\alpha}{1 + \theta} - \frac{p^r}{1 - \theta^2} + \frac{\theta p^d}{1 - \theta^2} \right] & \text{if } \frac{p^d}{\theta} - \frac{\alpha(1 - \theta)}{\theta} \leq p^r \leq \alpha(1 - \theta) + \theta p^d \\ \frac{\alpha}{\beta} - \frac{p^r}{\beta} & \text{if } p^r \leq \frac{p^d}{\theta} - \frac{\alpha(1 - \theta)}{\theta} \end{cases} \] (13)

Again taking into account corner outcomes the reaction functions are:

\[ p^d(p^r) = \begin{cases} \alpha(1 - \theta) + \theta p^r & \text{if } p^r \leq \frac{\hat{c}^d - \alpha(1 - \theta)}{\theta} \\ \frac{\alpha(1 - \theta) + \theta p^r + \hat{c}^d}{2} & \text{if } \frac{\hat{c}^d - \alpha(1 - \theta)}{\theta} \leq p^r \leq \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^d}{2 - \theta^2} \\ \frac{p^r}{\theta} - \frac{\alpha(1 - \theta)}{\theta} & \text{if } \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^d}{2 - \theta^2} \leq p^r \leq \alpha(1 - \theta) + \frac{(\alpha + \hat{c}^d)\theta}{2} \\ \frac{\alpha + \hat{c}^d}{2} & \text{if } p^r \geq \alpha(1 - \theta) + \frac{(\alpha + \hat{c}^d)\theta}{2} \end{cases} \] (14)

\[ p^r(p^d) = \begin{cases} \alpha(1 - \theta) + \theta p^d & \text{if } p^d \leq \frac{\hat{c}^r - \alpha(1 - \theta)}{\theta} \\ \frac{\alpha(1 - \theta) + \theta p^d + \hat{c}^r}{2} & \text{if } \frac{\hat{c}^r - \alpha(1 - \theta)}{\theta} \leq p^d \leq \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^r}{2 - \theta^2} \\ \frac{p^d}{\theta} - \frac{\alpha(1 - \theta)}{\theta} & \text{if } \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^r}{2 - \theta^2} \leq p^d \leq \alpha(1 - \theta) + \frac{(\alpha + \hat{c}^r)\theta}{2} \\ \frac{\alpha + \hat{c}^r}{2} & \text{if } p^d \geq \alpha(1 - \theta) + \frac{(\alpha + \hat{c}^r)\theta}{2}, \end{cases} \] (15)

where \( \hat{c}^d = c^d + a - \lambda(a - c^u) \) and \( \hat{c}^r = c^r + a + s \) are marginal costs when the affiliate and the rival, respectively, use monopoly pricing (in which the affiliate’s effective marginal cost does not include \((1 - \theta)\) since the rival is foreclosed).

A typical reaction curve of the rival is pictured in Figure 1. The first part of the reaction curve \( p^i(p^i) = \alpha(1 - \theta) + \theta p^i \) is the region where firm \( i \) does not produce and
firm \( j \) serves the whole market. Actually, firm \( i \)'s reaction consists of the whole region \( p^i(p^j) \geq \alpha(1 - \theta) + \theta p^j \) pictured as the shaded area in Figure 1. The second part of the reaction curve \( p^i(p^j) = \frac{\alpha(1 - \theta) + \theta p^j + \tilde{c}^i}{2} \) is the region where firms \( i \) and \( j \) produce and price according to the first order conditions. The third and fourth parts of this reaction curve, \( p^i(p^j) = \frac{p^j}{\theta} - \frac{\alpha(1 - \theta)}{\theta} \) and \( p^i(p^j) = \frac{\alpha + \tilde{c}^i}{2} \) respectively, are the regions where firm \( i \) forecloses; firm \( i \) uses monopoly pricing in the latter case.

![Figure 1: Rival's Reaction Curve.](image)

Note that the first parts of the two reaction curves cannot intersect, because that would imply marginal costs are so high that both firms produce zero in equilibrium.
Similarly, the third parts of the two reaction curves cannot intersect because that would imply both firms price in a way that they both foreclose each other. The possible intersections of these reaction curves give us three different types of equilibria which are examined in detail below. Readers need to keep in mind that these reaction curves are derived when \( 0 < \theta < 1 \). Equilibria when \( \theta \) takes on extreme values need special attention and are examined later on.

### 3.2.1 Interior Equilibrium

For \( 0 < \theta < 1 \) equilibrium prices and quantities are derived from the first order conditions:

\[
p^{*i} = \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^j + 2 \hat{c}^i}{4 - \theta^2},
\]

and

\[
q^{*i} = \frac{\alpha(1 - \theta)(2 + \theta) - (2 - \theta^2) \hat{c}^i + \theta \hat{c}^j}{\beta(4 - \theta^2)(1 - \theta^2)},
\]

where \( i, j = r, d \) \((i \neq j)\). This corresponds to the region where the second portions of the reaction curves intersect. A typical interior equilibrium is pictured in Figure 2. However, for \( \theta \) large enough and \( c^r \) and \( c^d \) sufficiently different from each other it is possible for either the rival or the affiliate to foreclose the market.

### 3.2.2 Market Foreclosure (deterrence or blockade)

Suppose \( 0 < \theta < 1 \). Then firm \( j \) serves the whole market if

\[
\hat{c}^i \geq \frac{\alpha(1 - \theta)(2 + \theta) + \theta \hat{c}^j}{2 - \theta^2}.
\]
Given this, the low-cost firm $j$ “deters”\textsuperscript{12} by choosing

$$p^{*j} = \bar{c} - \frac{\alpha(1 - \theta)}{\theta}, \quad q^{*j} = \frac{\alpha - \bar{c}}{\gamma},$$

and firm $i$ prices at $\bar{c}$ when

$$\bar{c} < \alpha(1 - \theta) + \theta \frac{\alpha + \bar{c}}{2}.\quad (20)$$

The low-cost firm $j$ “blockades” by choosing the monopoly point

$$p^{*j} = \frac{\alpha + \bar{c}}{2}, \quad q^{*j} = \frac{\alpha - \bar{c}}{2\beta}.$$  

\textsuperscript{12}Even though market participation is not explicitly modeled as requiring incurrance of a sunk cost we borrow the “deterrence” and “blockade” terminology for ease of exposition.
and firm \( i \) prices at or above \( \bar{c}^i \) when

\[
\bar{c}^i \geq \alpha(1 - \theta) + \theta \frac{\alpha + \bar{c}^j}{2}.
\] (22)

Condition (18) is a threshold point between the interior and market foreclosure equilibria. The converse of (18) would imply that firm \( i \) always produces. Typical deterrence and blockade outcomes are pictured in Figure 3 and 4.

![Figure 3: Deterrence by Firm \( r \).](image)

### 3.2.3 Local Monopolies

When \( \theta = 0 \) or \( \theta = 1 \) reaction curves (14) and (15) are not well-defined. When \( \theta = 0 \) the products are not substitutes and both the rival and the affiliate face the monopoly
inverse demand function $p^i(q^i) = \alpha - \beta q^i$, with equilibrium

$$p^*i = \frac{\alpha + \tilde{c}^i}{2}, \quad q^*i = \frac{\alpha - \tilde{c}^i}{2\beta}. \quad (23)$$

### 3.2.4 Pure Bertrand Competition

When $\theta = 1$ the products are perfect substitutes and a firm with a lower cost supplies the whole market. If $\hat{c}^i < \hat{c}^j$, then

$$q^{*j} = 0, \quad q^*i = \max \left\{ \frac{\alpha - \hat{c}^j}{\beta}, \frac{\alpha - \tilde{c}^i}{2\beta} \right\} \quad (24)$$

$$p^{*j} = \hat{c}^j, \quad p^*i = \min \left\{ \hat{c}^j, \frac{\alpha + \tilde{c}^i}{2} \right\}. \quad (25)$$
3.3 First Best

The regulator can achieve the first best in a limited number of cases, but usually
the regulator faces a trade-off between sabotage deterrence and efficient production.
This trade-off is explored in the later sections. Before doing so it is necessary to
identify those cases in which the regulator is able to achieve the first best. We start
by characterizing the first best.

The first observation is that the first best should be sabotage-free. Sabotage is
a socially costly activity because it adds production costs $sq^r$ for the rival and adds
direct costs $K(s)$ for the IP without adding any gross surplus, as is evident from the
aggregate welfare function (9). Recall that in the game tree the IP observes $(a, \lambda)$
set by the regulator and then chooses the level of sabotage which is then followed by
the pricing decisions of the affiliate and the rival. In some cases it is possible for the
regulator to manipulate the downstream equilibrium to induce the IP to choose the
zero level of sabotage while also inducing downstream firms to produce output levels
that achieve productive efficiency.

Definition (derived in the Appendix). Suppose $c^i < c^j$ for $i, j = r, d (i \neq j)$. If

$$\theta < \frac{\alpha - (c^j + c^u)}{\alpha - (c^i + c^u)}$$

then the first best is

$$p^j = c^j + c^u, \quad q^j = \frac{\alpha(1 - \theta) + \theta(c^j + c^u) - (c^j + c^u)}{\beta(1 - \theta^2)} \quad (26)$$

$$p^i = c^i + c^u, \quad q^i = \frac{\alpha(1 - \theta) + \theta(c^j + c^u) - (c^i + c^u)}{\beta(1 - \theta^2)} \quad (27)$$
If $\theta \geq \frac{\alpha - (c^j + c^u)}{\alpha - (c^i + c^u)}$ then the first best is

$$q^j = 0, \quad p^j \geq \alpha(1 - \theta) + \theta(c^i + c^u)$$  \hspace{1cm} (28)$$

$$p^i = c^i + c^u, \quad q^i = \frac{\alpha - (c^i + c^u)}{\beta}. \hspace{1cm} (29)$$

In all cases $s = 0$ in the first best.

Condition $\theta = \frac{\alpha - (c^j + c^u)}{\alpha - (c^i + c^u)}$ is a threshold point that defines whether the high-cost firm should produce in the first best. This ratio measures the size of the market for the low-cost firm relative to the size of the market for the high-cost firm. If $\theta$ is below this relative market size measure the regulator would like to have the high-cost firm supplying the market because the products are sufficiently different compared to the cost difference to justify offering both products; whereas for $\theta$ above this relative market size measure only the low-cost firm should supply as products sold by the two firms are close substitutes compared to the cost difference. That is why when $\theta = 1$ only the low-cost firm should supply and when $\theta = 0$ both firms should supply. Note that the threshold degenerates to $\theta = 1$ if marginal costs are the same, for then there is no trade off between productive efficiency and product variety.

The regulator’s task is to choose $(a, \lambda)$ to achieve productive efficiency downstream as described in the first best definition while also inducing the IP to engage in zero sabotage if possible. Differentiating (7) with respect to $s$ yields:

$$\frac{\partial \pi^{IP}}{\partial s} = (a - c^i) \left( \frac{\partial q^r}{\partial s} + \frac{\partial q^d}{\partial s} \right) + (p^d - c^d - a) \frac{\partial q^d}{\partial s} + \frac{\partial p^d}{\partial s} q^d - K'(s). \hspace{1cm} (30)$$

It is assumed throughout that the convexity of $K$ is sufficient to guarantee strict concavity of $\pi^{IP}$ in $s$ and that the foreclosure level of sabotage is not optimal. Since
the first increment of sabotage is costless to the IP,

\[
\frac{\partial \pi_{IP}}{\partial s} \bigg|_{s=0} = (a - c^u) \left( \frac{\partial q^r}{\partial s} \bigg|_{s=0} + \frac{\partial q^d}{\partial s} \bigg|_{s=0} \right) + (p^d|_{s=0} - c^d - a) \frac{\partial q^d}{\partial s} \bigg|_{s=0} + \frac{\partial p^d}{\partial s} \bigg|_{s=0} q^d|_{s=0}.
\] (31)

To achieve the first best the regulator must choose \((a, \lambda)\) such that (31) is non positive and the equilibrium prices and quantities are as specified in the definition of the first best. Each of the following propositions is proved by identifying which \((a, \lambda)\) value(s) induce the right prices and quantities in equilibrium assuming \(s = 0\), and then checking whether (31) is non positive at these value(s) of \((a, \lambda)\).

**Proposition 1.** Suppose \(\theta = 0\). Then the first best is not achievable regardless of which firm is efficient.

When \(\theta = 0\) the two downstream firms are local monopolies and they use monopoly pricing as in (23). The regulator would like to achieve marginal cost pricing and thus sets the access charge below cost in order to offset the double margin, turning the access markup \((a - c^u)\) negative. The IP’s profits consist of access revenues and affiliate’s profits. The affiliate’s price and quantity do not depend on \(s\) from (23). However, the IP is incurring an access deficit since access is priced below its cost and thus chooses to sabotage in order to reduce the rival’s output and hence the access deficit.

**Proposition 2.** Suppose \(\theta = 1\). Then the first best is not achievable when the downstream affiliate is at least as efficient as the rival. Setting \(a - c^u = c^r - c^d\) may achieve the first best when the rival is more efficient, depending on \(K(s)\) and the
rival’s relative cost advantage \((\lambda \text{ is irrelevant in this case})\).

When \(\theta = 1\) the two downstream firms are perfect competitors so the lowest cost firm serves the market. With equal marginal costs, both firms use marginal cost pricing and earn zero profits. In this case the regulator would like to set the access charge equal to its cost. At this access charge the IP receives no access revenues and no downstream profits. However an arbitrarily small level of sabotage will foreclose the rival, thereby enabling positive downstream profits for the affiliate, and is almost free to the IP since \(K'(0) = 0\). Hence the IP will sabotage when the regulator tries to induce productive efficiency.

Essentially the same argument applies when the downstream affiliate is strictly more efficient than the rival. In this case the affiliate will foreclose the rival and will either match the rival’s effective marginal cost or use monopoly pricing. The regulator can only achieve productive efficiency by choosing the access price to equate the rival’s effective marginal cost (i.e., the affiliate’s price, because this choice of access price drives the rival’s effective marginal cost below the affiliate’s monopoly price) with the rival’s true cost \(c'\). However, the IP receives no access revenues since the rival is foreclosed, and can increase the rival’s effective cost (and hence the affiliate’s price and downstream profit) by engaging in sabotage. At least a small amount of sabotage is therefore profitable for the IP since the first increment of sabotage is costless.

The proof of the case when the rival is strictly more efficient is more complicated. With zero sabotage the downstream equilibrium will have the rival serving the whole market. This aligns with the regulator’s objective, and the regulator can use the
access charge to bring the rival’s price to the socially efficient level. In this case the regulator would like to set the access charge below cost. So the parent’s profits will only consist of access revenues from the rival (the affiliate is undercut), which are negative. A small amount of sabotage given the regulator’s chosen access charge only decreases the IP’s profits because the sabotage is costly and from (25) the rival prices at the affiliate’s marginal cost which is independent of $s$. However, if sabotage exceeds the difference in marginal costs $c^d - c^r$ the rival is induced to exit the market and the affiliate takes over. Further increases in sabotage allow the affiliate to charge a higher price and earn higher downstream profits. At very high levels of $s$ it might even be possible for the affiliate to use monopoly pricing. If the affiliate’s marginal cost is sufficiently close to the rival’s, then a small increase in $s$ will tip the market in the affiliate’s favor while sabotage costs are relatively low and thus the IP will engage in a finite amount of sabotage. However, if $K(s)$ sufficiently convex and rival’s relative efficiency is large, the sabotage cost incurred when the IP tries to foreclose the rival is larger than the profit the IP can enjoy as the sole downstream producer, and thus the IP will not engage in sabotage. Hence the regulator can achieve the first best when $\theta = 1$ and $c^r < c^d$ provided $K(s)$ is sufficiently convex and the downstream cost difference is large enough to render unprofitable the finite increment of $s$ necessary to foreclose the rival; otherwise the first best is not achievable.

**Proposition 3.** Suppose $0 < \theta < 1$ and $c^r \geq c^d$. Then the first best is not achievable.

If $\theta$ is small the first best requires that both firms produce with prices $p^r = c^r + c^u$ and $p^d = c^d + c^u$. It is straightforward to show that there is no value of $(a, \lambda)$ with
\[ \lambda \in [0, 1] \] that simultaneously equates the interior equilibrium prices to these costs unless \( c^d = c^r \). The value of \( a \) that achieves this is below \( c^u \) when \( c^d = c^r \), which creates an incentive for at least a small amount of sabotage, hence the first best is not achievable.

If \( \theta \) is large the first best requires that the affiliate produces and the rival does not with the affiliate charging \( p^d = c^d + c^u \). The downstream equilibrium entails the affiliate either blockading or deterring the rival. As shown in the Appendix, there is no feasible value of \((a, \lambda)\) that achieves productive efficiency when the affiliate blockades. The regulator may be able to achieve productive efficiency when the affiliate deters. In this case the first best requires access to be priced below its cost. However, the parent can increase its downstream profits by engaging in sabotage and hence increasing the rival’s effective marginal cost (i.e., the affiliate’s price) and will do so since the first increment of sabotage is free.

**Proposition 4.** Suppose \( c^d > c^r \). If \( 0 < \theta < 3 \sqrt{\alpha - (c^d + c^u)} \alpha - (c^r + c^u) \) then the first best is not achievable. If \( 3 \sqrt{\alpha - (c^d + c^u)} \alpha - (c^r + c^u) \leq \theta < 1 \) then choosing \((a, \lambda)\) to satisfy

\[
\lambda = \frac{c^d + a - \alpha(1 - \theta) - \theta(c^r + c^u)}{(a - c^u)(1 - \theta)}
\]

may achieve the first best, depending on \( K(s) \) and the rival’s relative cost advantage.

When \( \theta < \frac{\alpha - (c^d + c^u)}{\alpha - (c^r + c^u)} \) (this implies that \( \theta < 3 \sqrt{\alpha - (c^d + c^u)} \alpha - (c^r + c^u) \)), the regulator would like to have both firms supplying the market and charging their respective marginal costs plus the cost of access according to the definition of the first best. This is achieved by setting the access charge below its cost. However, at the regulator’s chosen \((a, \lambda)\) the IP incurs an access deficit and thus would like to reduce it by
increasing sabotage. In addition the IP receives higher downstream profits when it sabotages by allowing its affiliate to charge a higher price.

When \( \theta > \frac{\alpha - (c^d + c^u)}{\alpha - (c^r + c^a)} \) the regulator would like the rival to serve the whole market charging its marginal cost plus the cost of access. There are feasible values of \((a, \lambda)\) that accomplish this only when \( \theta \) is high enough, specifically, when \( \theta \geq \sqrt{\frac{\alpha - (c^d + c^u)}{\alpha - (c^r + c^a)}} \) and the rival deters the affiliate by pricing at the affiliate’s effective marginal cost. To achieve productive efficiency the regulator needs to set the access charge below its cost. In this case the parent’s profits consist of only access revenues from the rival, which are negative. The IP could reduce the access deficit by sabotaging the rival but the rival is matching the affiliate’s marginal cost, deterring it from “entry” and is thus unresponsive to a small amount of sabotage. A “large enough” level of sabotage can reduce the rival’s relative cost advantage so much that the affiliate starts producing downstream, in which case the parent’s downstream profits as well as sabotage costs \( K(s) \) increase. The level of sabotage required for the affiliate to “enter” the market depends on the relative cost difference. Therefore, if the rival holds a relatively small cost advantage and sabotage costs do not increase sharply, the IP will engage in sabotage; otherwise the IP will not engage in sabotage.

In summary, the regulator can achieve the first best when firms are sufficiently close substitutes (including the pure Bertrand case), provided the direct cost of the finite increment of sabotage that would either foreclose the rival or allow the affiliate to “enter” the market is sufficiently high. The remaining cases, when the regulator faces a real trade-off between sabotage and productive efficiency, are examined in the next section.
3.4 Second Best with Interior Downstream Equilibrium

Collectively, Propositions 1-4 give an exhaustive characterization of when the first best is and is not attainable, and identify the vertical control and access price policies that achieve the first best when it is attainable. What remains is to study the regulator’s optimal policies when the first best is not attainable. From Propositions 1-4, there are three such situations:

1. When firms are local monopolies \( (\theta = 0) \).

2. When firms are equally efficient or the downstream affiliate is the efficient producer.

3. When products are not close substitutes and the rival firm is the efficient producer.

All three cases are quite complicated. Most interest centers on the case with differentiated but competing products and regulatory policies that are not driven by a presumption that one firm is more efficient than the other. Thus we assume \( 0 < \theta < 1 \) and equally efficient firms \( (c^r = c^d \equiv c) \). We also assume that both the rival and affiliate firms produce positive quantities in downstream equilibrium. Later we will derive conditions that guarantee participation by both firms. In this case the downstream equilibrium is given by (16) and (17).

Before looking at the regulator’s problem in the first stage of the game tree, we must investigate the access monopolist’s choice of sabotage given the downstream equilibrium determined by the last stage of the game. Setting (30) to zero defines an
interior optimal sabotage choice \( s^\star(a, \lambda) \). It has been assumed that the convexity of \( K \) is sufficient to satisfy the second order condition, so \( \frac{\partial^2 \pi_{IP}}{\partial s^2} < 0 \). Differentiating (30) and assuming the downstream equilibrium is given by (16) and (17) (interior equilibrium prices and quantities) yields the comparative statics of an interior optimum for \( s \) as:

\[
\frac{\partial s^\star}{\partial a} = \frac{(1 - \theta)(-8(1 + \theta) + \theta^3(1 - \lambda))}{D(4 - \theta^2)\partial^2 \pi_{IP} / \partial s^2} = -8(1 + \theta) + \theta^3(1 - \lambda) < 0 \quad (32)
\]

\[
\frac{\partial s^\star}{\partial \lambda} = \frac{\theta^3(1 - \theta)}{D(4 - \theta^2)\partial^2 \pi_{IP} / \partial s^2}(a - c^u) = -(a - c^u), \quad (33)
\]

where \( D = \beta(1 - \theta^2)(4 - \theta^2) \).

**Proposition 5.** Suppose \( 0 < \theta < 1 \). Then, at any interior equilibrium for the sabotage choice: (i) Sabotage is decreasing in the access price, (ii) Sabotage is increasing in vertical control when access is priced below cost and vice versa, and (iii) Vertical control has no effect on sabotage when access is priced at cost.

Item (i) formalizes the intuition that the input monopolist’s temptation to sabotage can be diminished by making upstream production more profitable. When access is priced below cost, an increase in vertical control increases the effective marginal cost of the downstream affiliate (see the definition of \( \hat{c}^d \) following (11)), thereby shifting the equilibrium output mix toward the rival and increasing the IP’s losses from unprofitable input sales, whence a stronger incentive to diminish the rival’s output via sabotage. Item (iii) is at odds with some contemporary policies, for example in telecommunications, that attempt to price access at marginal cost while also attempt-
ing to deter non-price discrimination by imposing restrictions on vertical control.\textsuperscript{13}

The regulator seeks to maximize the welfare function (9). Letting \( c = c^d = c^r \) be the common downstream marginal cost, and differentiating (9) while accounting for the resulting changes in the optimal levels of sabotage and the downstream quantities, yields:

\[
\frac{\partial W}{\partial a} = (p^d - c - c^u) \frac{\partial q^d}{\partial a} + (p^r - c - c^u) \frac{\partial q^r}{\partial a} - s \frac{\partial q^r}{\partial a} + \frac{\partial s}{\partial a} \Psi \quad (34)
\]

\[
\frac{\partial W}{\partial \lambda} = (p^d - c - c^u) \frac{\partial q^d}{\partial \lambda} + (p^r - c - c^u) \frac{\partial q^r}{\partial \lambda} - s \frac{\partial q^r}{\partial \lambda} + \frac{\partial s}{\partial \lambda} \Psi, \quad (35)
\]

where

\[
\Psi = (p^d - c - c^u) \frac{\partial q^d}{\partial s} + (p^r - c - c^u) \frac{\partial q^r}{\partial s} - s \frac{\partial q^r}{\partial s} - q^r - K'(s) \quad (36)
\]

is a multiplier that reflects the effect on welfare of an increment in sabotage. As might be expected since sabotage is a socially costly activity:

**Lemma.** \( \Psi \leq 0 \).

The comparative statics of the downstream equilibrium quantities in (34) and (35) are:

\[
\frac{\partial q^d}{\partial a} = -\frac{(1 - \theta)(2 + \theta - \lambda(2 - \theta^2))}{D} < 0, \quad \frac{\partial q^r}{\partial a} = -\frac{(1 - \theta)(2 + \theta(1 + \lambda))}{D} < 0 \quad (37)
\]

\[
\frac{\partial q^d}{\partial \lambda} = \frac{(1 - \theta)(2 - \theta^2)(a - c^u)}{D} = s (a - c^u), \quad \frac{\partial q^r}{\partial \lambda} = -\frac{(1 - \theta)\theta(a - c^u)}{D} = -(a - \Psi) \quad (38)
\]

\[
\frac{\partial q^d}{\partial s} = \frac{\theta}{D} > 0, \quad \frac{\partial q^r}{\partial s} = -\frac{(2 - \theta^2)}{D} < 0. \quad (39)
\]

It is assumed hereinafter that \( W \) is strictly concave in \( a \) (this is assured in the special case of \( K \) considered below if \( K \) is sufficiently convex).

\textsuperscript{13}See the CALLS proposal adopted in FCC (2000) and Section 272(b) of the US Telecommunications Act of 1996.
Equation (34) shows that there are two effects of sabotage that cause the regulator to depart from inducing efficient downstream prices \( p^d = p^r = c + c^u \) when setting the access price. First, a decrease in the access price causes a sabotage-related increase in production costs of the rival when there is sabotage, in the amount \( s \frac{\partial q^r}{\partial a} \). Second, a decrease in the access price causes an increase in sabotage that directly diminishes welfare by \( \Psi \frac{\partial s}{\partial a} \). Hence the last two terms in (34) are nonnegative. These extra costs cause the regulator to set the access price higher than would be optimal in the absence of sabotage, resulting in equilibrium downstream prices above the efficient level.

It is difficult to give more characteristics of the regulator’s optimum without more assumptions. An explicit solution for the optimal policy can be obtained when the sabotage cost function takes the specific form \( K(s) = ms^2 \) for some cost parameter \( m > 0 \). For convenience and without loss of generality assume \( m = \frac{\eta \theta^2}{D(4 - \theta^2)} \) for some parameter \( \eta \). The second order condition for \( s \) requires \( \eta > 1 \). With this specification, setting (30) to zero and substituting from the downstream equilibrium as needed yields

\[
s^* = \frac{2\theta(\alpha - c - c^u)(1 - \theta)(2 + \theta) - (a - c^u)(1 - \theta)(8 + 8\theta - \theta^3(1 - \lambda))}{2\theta^2(\eta - 1)}. \tag{40}
\]

As one can see, optimal sabotage by the parent is positive if and only if \( a - c^u < \frac{2\theta(2 + \theta)(\alpha - c - c^u)}{8 + 8\theta - \theta^3(1 - \lambda)} \). In some cases it might be optimal for the regulator to set the access charge so high that sabotage is eliminated, at the welfare cost of distorting the downstream equilibrium prices further above the efficient level.

When the presence and severity of sabotage induces the regulator to price access above cost, the regulator can lessen the impact of a high access charge on down-
stream prices by allowing full vertical control ($\lambda = 1$), which minimizes the affiliate’s effective marginal cost $\hat{c}_d = c + a - \lambda(a - c_u)(1 - \theta)$ given the positive access margin. Similarly, when access is priced below cost the regulator induces the maximum output-expanding effect of the low access charge by inducing the affiliate to ignore the effect expanded output has on the parent’s profits, by fully restricting vertical control ($\lambda = 0$), which again minimizes the affiliate’s effective marginal cost given the negative access margin. This ability to manipulate the affiliate via the vertical control parameter is lost when access is priced at marginal cost; if the regulator priced access at marginal cost, a finite improvement in welfare could be obtained by perturbing the access price a small amount (which has a small effect on welfare) and then moving vertical control in the welfare-improving direction.

These observations lead to a complete characterization of the welfare optimal regulatory policy. Setting (34) to zero, substituting for equilibrium levels of sabotage and downstream prices, and evaluating at $\lambda = 0$ and $\lambda = 1$ yields:

$$a^* - c^u|_{\lambda=0} = 2(\alpha - c - c^u)(1 - \theta)\frac{n(0, \eta, \theta)}{d(0, \eta, \theta)}$$  \[ (41) \]

$$a^* - c^u|_{\lambda=1} = -(\alpha - c - c^u)(1 - \theta)\theta(2 + \theta)^2 \frac{n(1, \eta, \theta)}{d(1, \eta, \theta)}$$  \[ (42) \]

where $n(\lambda, \eta, \theta)$ and $d(\lambda, \eta, \theta)$ are polynomials in $(\lambda, \eta, \theta)$. Equations (41) and (42) give an explicit solution for the optimal access markup as a function of the sabotage cost parameter $\eta$ and the degree of competition $\theta$ under each of the two possible equilibrium vertical control regimes, $\lambda = 0$ and $\lambda = 1$, respectively. The second order condition $\frac{\partial^2 W}{\partial a^2} < 0$ for an interior solution requires that the sabotage cost parameter $\eta$ be large enough to ensure $d(\lambda, \eta, \theta) > 0$. Positive equilibrium quantities also require
that \( \eta \) be sufficiently large. Let \( \bar{\eta} \) be the lower bound that ensures second order conditions for \( s^* \) and \( a^* \), and positive equilibrium quantities. Then, for \( \eta \geq \bar{\eta} \),

\[
a^* - c^{u|\lambda=0} s = n(0, \eta, \theta) \tag{43}
\]

\[
a^* - c^{u|\lambda=1} s = -n(1, \eta, \theta). \tag{44}
\]

Hence the aforementioned welfare-enhancing effects of regulating vertical control are obtained when \( \lambda = 0 \) only if \( n(0, \eta, \theta) \) is negative. Similarly, \( \lambda = 1 \) is potentially optimal only if \( n(1, \eta, \theta) \) is negative.

\( n(\lambda, \eta, \theta) \) is quadratic in \( \eta \) and the roots of \( n \) always lies on opposite sides of \( \bar{\eta} \). Moreover, \( n(0, \eta, \theta) \) is strictly concave in \( \eta \) and \( n(1, \eta, \theta) \) is strictly convex in \( \eta \). Hence (41) is relevant only if \( \eta \) exceeds the larger root of \( n(0, \eta, \theta) \) and (42) is relevant only if \( \eta \) lies between \( \bar{\eta} \) and the larger root of \( n(1, \eta, \theta) \). Let \( \bar{n}(\lambda, \theta) \) denote the larger root of \( n(\lambda, \eta, \theta) \). We have:

**Proposition 6.** Suppose the downstream firms are equally efficient \((c^d = c^r = c)\) and \(0 < \theta < 1\). Suppose further that sabotage costs are given by \( K(s) = \frac{\eta \theta^2}{D(4-\theta^2)} s^2 \) for some \( \eta > \eta \). Then there exists a critical level of sabotage cost \( \tilde{\eta} \in (\bar{n}(0, \theta), \bar{n}(1, \theta)) \) such that full vertical control is optimal \((\lambda^* = 1)\) and the optimal access margin is positive and given by (42) for \( \eta \leq \tilde{\eta} \); and complete restriction of vertical control is optimal \((\lambda^* = 0)\) and the optimal access margin is negative and given by (41) for \( \eta \geq \tilde{\eta} \). In particular, pricing access at marginal cost is never optimal.

Hence, depending on the cost parameters and degree of competition, it may be optimal to price access below marginal cost and fully restrict vertical control, or it
may be optimal to price access above marginal cost and allow full vertical control. The regulator would like to set $a^* < c^u$ to induce output expansion, but this may create more sabotage than it is worth in welfare terms. Access must be priced above marginal cost in order to deter sabotage when sabotage is not very costly to the saboteur ($\eta \leq \hat{\eta}$). When sabotage is more costly ($\eta \geq \hat{\eta}$) the regulator can induce more efficient output levels by pricing access below marginal cost. If sabotage considerations cause the regulator to price access above marginal cost then it is optimal to allow full vertical control because this places the most weight on $c^u$ rather than $a^*$ in the IA’s objective, thereby minimizing effective downstream costs. Alternatively, if sabotage costs are high then the output-expanding benefit of pricing access below marginal cost exceeds the welfare cost of sabotage. In this case it is optimal to fully restrict vertical control because this places the most weight on $a^*$ rather than $c^u$ in the IA’s objective, again minimizing effective downstream costs and inducing the maximal downstream output for the particular access price chosen. It is never optimal in this setting to price access at marginal cost. Doing so neutralizes the regulator’s ability to induce output expansion through manipulation of vertical control.

The foregoing discussion included no explicit consideration of whether the optimal choice of sabotage is positive or is the corner solution at zero. One might expect that the equilibrium level of sabotage decreases as sabotage costs increase and that sabotage reaches the corner solution at zero for very high levels of sabotage cost. Interestingly, this is not true in general. To understand when a corner solution for sabotage occurs, we must decompose the total change in sabotage into the partial effect of a change in the access charge $a$ and the partial (direct) effect of a change in
sabotage cost $\eta$:

$$\frac{ds^*}{d\eta} = \frac{\partial s^* \partial a^*}{\partial \eta} + \frac{\partial s^*}{\partial \eta}. \quad (45)$$

From (40), $\frac{\partial s^*}{\partial a^*}$ and $\frac{\partial s^*}{\partial \eta}$ are unambiguously negative (when $s^*$ is positive). However, $\frac{\partial a^*}{\partial \eta}$ is negative at least for some values of $\eta$ (but it can be be shown by example that it is not always negative). Ambiguity in the response of sabotage to an increase in sabotage cost arises because the regulator may decrease the access price fast enough to offset the direct effect ($\frac{\partial s^*}{\partial \eta}$) of the cost increase. For low levels of sabotage cost the regulator resorts to high access charges as a way of curtailing sabotage. The regulator may set the access charge high enough so that it completely eliminates sabotage even though sabotage cost is very low.

This can be directly seen from equation (40). It is clear from (40) that sabotage is positive when the access margin is negative (recall $\eta \geq 1$). Hence the $\lambda^* = 0$ regime always has positive sabotage in equilibrium. When $\lambda^* = 1$, $a^* - c^*$ from (42) can be substituted into (40) to obtain

$$s^* = k(\eta, \theta), \quad (46)$$

where $k(\eta, \theta)$ is linear and increasing in $\eta$. Therefore starting from the point where sabotage cost is very high, the regulator prices access below cost and the IP chooses a positive level of sabotage. As sabotage cost falls, the regulator might price access sufficiently above cost to ensure that the IP chooses zero sabotage. This threshold value of $\eta$ at which sabotage becomes zero, denoted by $\tilde{\eta}(\theta)$, varies with $\theta$. It can be shown by numerical examples that, depending on the magnitude of $\theta$, the IP might engage in zero sabotage whenever access is priced above cost (Figure 5), sabotage...
might be positive despite a positive access margin when the sabotage cost parameter takes on medium values and then turn zero when sabotage becomes very cheap (Figure 6), or sabotage might be always positive (Figure 7). In any case, $s^\star$ is always increasing at $\hat{\eta}$ because, from (40), $s^\star$ is strictly larger when the access margin is negative than when it is positive.\textsuperscript{14}

Figure 5: Optimal Access Charge, Vertical Control and Sabotage when $\theta = 0.2$.

![Figure 5](image)

Figure 6: Optimal Access Charge, Vertical Control and Sabotage when $\theta = 0.7$.

![Figure 6](image)

One interesting observation is that the optimal access charge $a^\star$ is constant for all $\eta < \tilde{\eta}(\theta)$. This is because, when sabotage is cheap, the only reason the regulator prices access above cost is to deter the IP from engaging in sabotage. When sabotage is zero there is no reason for further increases in the access charge; such increases only

\textsuperscript{14}All three of these examples are for general demand and marginal cost parameters $\alpha - c - cu$ and $\beta$. Results shown in Figures 5-7 only depend on the $(\eta, \theta)$ parameter space.
hurt downstream efficiency. Therefore the regulator leaves the optimal access charge unchanged once sabotage cost falls below $\tilde{\eta}(\theta)$.

A simple numerical example gives an indication of the magnitudes involved. Suppose $\alpha-c-c^u = 1$, $\beta = 0.3$, and $\theta = 0.3$. Then the first best upstream access mark-up is $a^*-c^u = -0.7$ and the first best welfare level is $W = 2.56$. Figure 8 shows the second best equilibrium outcomes as functions of the sabotage cost parameter. The discontinuities in the graphs clearly display the switch from full vertical control and positive access margins to zero vertical control and negative access margins at the critical level of sabotage cost $\tilde{\eta}$.

The level of sabotage is quite low when sabotage costs are low because the regulator is aggressively trying to counter the parent’s incentives by pricing access high. Sabotage levels jump up drastically as the regulator switches to the full vertical restriction regime by pricing access below cost. Not shown in this graph, sabotage levels decrease monotonically and approach zero as sabotage costs grow large.

Access margins fall rapidly as the regulator is able to rely more on sabotage costs for sabotage deterrence. The upper curves in the last graph show the output produced by the affiliate. As shown here downstream output levels are increasing fast,
consistent with rapidly falling access charges. Welfare is increasing as the drastic fall in access charges more than offsets increases in sabotage when sabotage costs are in the medium range. Welfare approaches the first-best level as sabotage costs grow large. Note, however, that at the relatively large sabotage costs depicted in the graphs (relative to the demand-cost margin)\(^\text{15}\) the possibility of sabotage has severe welfare consequences since welfare is still only 82\% of the first best level.

### 3.5 Summary

This is the first formal study of restriction on vertical control, distinct from vertical ownership, as a policy tool. Restricting vertical control appears to be a useful weapon in some settings. It gives the policy maker a new way of inducing output-expansion

\(^{15}\)When \(\eta = 140\) the marginal cost of a unit of sabotage at \(s^*\) is 0.32, which is about third of the demand-cost margin.
and can thereby complement access pricing policy when pricing policy alone is inadequate because of potential for non-price discrimination. Manipulation of vertical control can be beneficial in inducing prices closer to the first best in two settings. First, if products are close substitutes and the rival firm is more efficient than the affiliate, the regulator would like the rival to serve the whole market and price at marginal cost. The regulator can achieve this by setting the access charge below cost and allowing for partial vertical control. Doing so brings the rival’s price to the first-best level and at the same time keeps the affiliate out of the market. Second, if the downstream firms have identical costs but differentiated products, then for any access price that balances sabotage deterrence with output-expansion the regulator can induce maximal output-expansion by minimizing effective downstream costs through the choice of vertical control. The cost minimum is obtained by allowing a high degree of vertical control when access is priced above marginal cost, and by severely restricting vertical control when access is priced below marginal cost.

Sabotage deterrence is the reason it may be optimal to price access above marginal cost. If the regulator is able to influence costs of sabotage by monitoring and penalties, then the regulator can possibly set sabotage costs high enough to make restrictions on vertical control ($\lambda^* = 0$) and access pricing below marginal cost ($a^* < c^u$) the optimal policy. Such monitoring and penalties as specified in Section 272 of the Act and pursued by the FCC,\textsuperscript{16} accompanied by restrictions on vertical control as required by Section 272 of the Telecommunications Act of 1996, increase welfare\textsuperscript{17} given that the

\textsuperscript{16}For example, see the penalties imposed on BellSouth and Verizon in the first essay, pg. 38.
\textsuperscript{17}See Figure 8.
cost of monitoring is not too high. However, a strong separation between the parent and the affiliate, as applied to the Verizon and BellSouth Section 272 affiliates,\textsuperscript{18} should include, as Proposition 6 suggests, access prices below marginal cost rather than the marginal cost pricing of access embraced by the FCC (FCC, 2000). Moreover, the FCC recently has removed certain structural and separation requirements.\textsuperscript{19} The results of the model prescribe corner solutions for the vertical control parameter, that is, either a full vertical separation or a full vertical control. Therefore, this type of policy pursued by the FCC seems to be at odds with the main results of this model.

\textsuperscript{18}See the first essay, pg. 39.
\textsuperscript{19}See FCC’s revision on OI&M sharing prohibition, pg. 40.
Figure 9: Game Tree
3.6 Appendix 1

Definition of First Best. Differentiating (9) with \( s = 0 \) and setting it to zero yields:

\[
\frac{\partial W}{\partial q^i} = \alpha - \beta q^i - \gamma q^j - (c^i + c^u) = 0 \quad i, j = d, r.
\] (47)

The first best values of \( q^i \) are found from the above expression:

\[
q^i = \frac{\alpha(1 - \theta) + \theta(c^j + c^u) - (c^j + c^u)}{\beta(1 - \theta^2)}.
\] (48)

This is positive iff

\[
\theta < \frac{\alpha - (c^i + c^u)}{\alpha - (c^j + c^u)}. \tag{49}
\]

If \( c^i < c^j \) then (49) always holds. If \( c^i > c^j \) and \( \theta \geq \frac{\alpha - (c^j + c^u)}{\alpha - (c^j + c^u)} \) then \( q^j = 0 \) and \( q^i \) is found from (48). First best prices are found from the inverse demand functions.

Proof of Proposition 1. Suppose \( \theta = 0 \). Downstream prices are given by (23). The regulator would like to achieve zero sabotage as well as productive efficiency by pricing at \( p^d = c^d + c^u \) and \( p^r = c^r + a \). If the parent does not sabotage, setting \( a = c^r + 2c^u - \alpha \) and \( \lambda = \frac{c^r - c^d}{c^r + c^u - \alpha} \) is required to equate (23) with these first-best prices. Then \( (a - c^u) = c^r + c^u - \alpha < 0 \).\(^{20}\) Now we must check whether the IP will indeed choose \( s = 0 \) given the outcome downstream and the regulator’s chosen \((a, \lambda)\).

The IP’s profits are:

\[
\pi^{IP} = (a - c^u)(q^r + q^d) + (p^d - c^d - a)q^d - K(s). \tag{50}
\]

As seen from (23) and the definition of \( \tilde{c}^i \), \( s \) only affects \( q^r \). Thus

\[
\left. \frac{\partial \pi^{IP}}{\partial s} \right|_{s=0} = -\frac{a - c^u}{2\beta} > 0, \tag{51}
\]

so the IP will choose a positive level of sabotage when the regulator tries to induce first best retail prices. The first best is not achievable.

Proof of Proposition 2. Suppose \( \theta = 1 \). The first best requires that there be no sabotage. Assuming \( s = 0 \), the \( \theta = 1 \) condition implies that the effective downstream marginal costs are \( \tilde{c}^d = c^d + a \) and \( \tilde{c}^r = c^r + a \). There are three cases:

Case 1: \( c^d = c^r = c \). The downstream market is pure Bertrand competition with equal marginal costs, so the rival and the affiliate both price at the common effective marginal cost and split the market:

\[
p^{d*} = p^{r*} = c + a, \quad q^{r*d} = q^{r*r} = \frac{\alpha - c - a}{2\beta}. \tag{52}
\]

In order to achieve efficiency, the regulator must set \( a = c^u \) and hope that the IP does not sabotage. The parent’s downstream and upstream profits are both zero in this case. However, with \( a = c^u \), if the parent does sabotage then the rival drops from the

\(^{20}\)If \( c^r > c^d \) then \( \lambda < 0 \) and the regulator cannot achieve productive efficiency downstream.
Market and the affiliate’s Bertrand equilibrium price is the rival’s effective marginal cost, \( p^d = c + c^a + s \), and quantity is \( q^d = \frac{\alpha - c - c^u - s}{\beta} \). The parent’s profit in this case is

\[
\pi_{IP}|_{s>0} = \pi^n + \pi^d = (p^d - c - c^u)q^d - K(s) = s \frac{\alpha - c - c^u - s}{\beta} - K(s).
\] (53)

Since \( \alpha - c - c^u \) is strictly positive and \( K'(s) \) is arbitrarily small for \( s \) small, a small increase in \( s \) starting from zero pays off for the parent:

\[
\frac{\partial \pi_{IP}}{\partial s} = \frac{\alpha - c - c^u - 2s}{s} - K'(s) > 0.
\] (54)

So the first best is not achievable.

**Case 2:** \( c^d < c^r \). In this case the affiliate serves the whole market and either price matches the rival’s marginal cost or blockades the affiliate as in (25). To achieve productive efficiency the regulator would like \( p^d = c^d + c^u + s \) and \( p^r \geq c^d + c^u \). If the parent does not sabotage, the regulator can only achieve the first best pricing when the affiliate prices (deters) at \( p^d = c^r + a \). In this case the regulator must set \( a = c^d + c^u - c^r \) to make the affiliate’s price first-best, and then \((a - c^u) = c^d - c^r < 0\). It can be verified that \( c^r + a < \frac{\alpha + c^d + a - \lambda(a - c^u)}{2} \) so the affiliate does not blockade when the regulator chooses \( a \) in this way. Now we must check the parent’s incentives to sabotage. The IP’s profits in this setting are:

\[
\pi_{IP} = q^d(p^d - c^d - c^u) - K(s) = s \frac{\alpha - c^d - c^u - s}{\beta} - K(s).
\] (55)

Thus:

\[
\frac{\partial \pi_{IP}}{\partial s} \bigg|_{s=0} = \frac{\alpha - c^d - c^u}{\beta} > 0,
\] (56)

and the first best is not achievable.

**Case 3:** \( c^d > c^r \). If the parent does not sabotage then the rival serves the whole market and either deters or blockades the affiliate. Just as in case 2, the regulator can only achieve productive efficiency when the rival deters with \( p^r = c^d + a \). To achieve this the regulator must set \( a = c^r + c^u - c^d \) \((a - c^u) = c^r - c^d < 0\). Now we must check the parent’s incentives to sabotage.

The IP’s profits require careful examination. If sabotage \( s \) exceeds \((c^d - c^r)\) then the rival will drop from the market and the affiliate will serve the whole market. If \( s \) is even higher the affiliate will be able to blockade the rival. Consequently, the parent’s modified profit function is:

\[
\pi_{IP} = \begin{cases} 
(a - c^u) \frac{\alpha - c^d - a}{\beta} - K(s) & \text{if } s \leq \underline{s} = c^d - c^r \\
\frac{a - c^r - a - s}{\beta} (c^r + a + s - c^d - c^u) - K(s) & \text{if } \underline{s} < s \leq \bar{s} \\
\frac{a - c^d - a + \lambda(a - c^u)}{2\beta} (c^d + a + \lambda(a - c^u) - c^d - c^u) - K(s) & \text{if } s > \bar{s}
\end{cases}
\] (57)

where \( \bar{s} = \frac{\alpha + c^d - 2c^r - a - \lambda(a - c^u)}{2} \). The second part of the profit function is the affiliate’s profit when it deters the rival by matching the rival’s marginal cost. The third part is the affiliate’s profit when it is using the monopoly price from (25). Using the values for \( a, \underline{s} \) and \( \bar{s} \) we get the following: \( \pi_{IP}|_{s\leq\underline{s}} = (c^r - c^d) \frac{\alpha - c^r - c^u}{\beta} - \frac{\lambda(a - c^u)}{2} \).
Proof of Proposition 3. Suppose $0 < \theta < 1$ and $c^r \geq c^d$. There are two cases depending on the intensity of competition and the cost parameters.

Case 1: Suppose $\theta < \frac{\alpha - c^r - c^u}{\alpha - c^d - c^u}$, or $c^r + c^u < \theta(c^d + c^u) + \alpha(1 - \theta)$. According to the definition of first best the regulator would like both firms serving the market, pricing and producing according to (26) and (27): $p^r = c^r + c^u$ and $p^d = c^d + c^u$. The downstream equilibrium prices when both firms produce are given in (16). Setting these expressions for $p^r$ and $p^d$ equal to $c^r + c^u$ and $c^d + c^u$, respectively, (and imposing $s = 0$ as required for the first best) yields a regulatory policy of $a = c^u = c^r + c^d - \theta(c^d + c^u) - \alpha(1 - \theta) < 0$ and $\lambda = \frac{(c^r - c^d)(1 + \theta)}{(a - c^u)(1 - \theta)}$. This policy is infeasible when $c^r > c^d$ because then $\lambda < 0$.

When $c^d = c^r = c$ then $\lambda = 0$, so we must check whether the parent chooses zero sabotage. The parent’s profit function is:

$$
\pi^{IP} = (a - c^u)(q^r + q^d) + (p^d - c^d - a)q^d - K(s).
$$

(58)

Substituting in the equilibrium prices and quantities and taking into account that the first best requires $\lambda = 0$ gives us

$$
\pi^{IP} = \frac{(a - c^u)}{\beta(1 + \theta)(2 - \theta)}(2\alpha - 2(c + a) - s) +
\frac{(1 - \theta)(2 + \theta)(\alpha - c - a) + \theta s)^2}{\beta(1 - \theta^2)(4 - \theta^2)^2} - K(s).
$$

(59)

The derivative evaluated at $s = 0$ is:

$$
\frac{\partial \pi^{IP}}{\partial s} \bigg|_{s=0} = -\frac{a - c^u}{\beta(1 + \theta)(2 - \theta)} + \frac{2\theta(1 - \theta)(2 + \theta)(\alpha - c - a)}{\beta(1 - \theta^2)(4 - \theta^2)^2} > 0.
$$

(60)

The first term is positive since $a < c^u$ is required for the first best and the second term is positive as well since $\alpha - c - c^u > 0$ and $a < c^u$. Thus the first best is not achievable.

Case 2: Suppose $\theta \geq \frac{\alpha - c^r - c^u}{\alpha - c^d - c^u}$, or $c^r + c^u \geq \theta(c^d + c^u) + \alpha(1 - \theta)$ (note that $\theta < 1$ implies $c^r > c^d$ in this case). Then the the first best requires that the affiliate serve the whole market with prices at $p^r \geq \alpha(1 - \theta) + \theta(c^d + c^u)$ and $p^d = c^d + c^u$. If the parent does not sabotage there are two possibilities downstream: the affiliate either deters or blockades.

First consider the blockade. In this case the downstream equilibrium entails $p^r \geq c^r + a$ and $p^d = \frac{\alpha + c^d + a - \lambda(a - c^u)}{2}$. To make the affiliate’s equilibrium price be first best the regulator must choose $(a, \lambda)$ to satisfy $\lambda(a - c^u) = \alpha - c^d - c^u + a - c^u$. The
policy must also satisfy the necessary inequality (22) for the blockade. Substituting for \( \lambda \) and simplifying:

\[
 a - c^u > \alpha(1 - \theta) + \theta(c^d + c^u) - c^r - c^u. \tag{61}
\]

At this point the sign of \( a - c^u \) is still indeterminate. First observe that \( a \neq c^u \), since this would imply \( \alpha - c^d - c^u = 0 \). Suppose \( a - c^u < 0 \). We need to make sure that \( \lambda \) is positive, that is, \( \alpha - c^d - c^u + a - c^u < 0 \). However, \( \alpha - c^d - c^u + a - c^u > \alpha - c^d - c^u + \alpha(1 - \theta) + \theta(c^d + c^u) - c^r - c^u = \alpha - c^r - c^d + (1 - \theta)(\alpha - c^d - c^u) > 0 \).

This implies that \( \lambda \) is infeasible. Now suppose \( a - c^u > 0 \). We need to make sure that \( \lambda < 1 \), that is, \( \alpha - c^d - c^u + a - c^u < a - c^u \). However, \( \alpha - c^d - c^u > 0 \). Thus \( \lambda \) is again infeasible.

Now consider the case when the affiliate deters. The downstream equilibrium prices are \( p^d = c^r + a \) and \( p^d = c^r + a - \frac{\alpha(1 - \theta)}{\theta} \). Setting \( a = \alpha(1 - \theta) + \theta(c^d + c^u) - c^r \) (note that \( a - c^u < 0 \)) is required to achieve the desired pricing of \( p^d = c^d + c^u \) and \( p^d = c^r + c^u \).

The IP’s profit function is:

\[
\pi^{IP} = (p^d - c^d - c^u)q^d - K(s) = \left( \frac{c^r + a + s - \alpha(1 - \theta)}{\theta} - c^d - c^u \right) \frac{\alpha - c^r - a - s}{\gamma} - K(s). \tag{62}
\]

The derivative evaluated at \( s = 0 \) and at \( a = \alpha(1 - \theta) + \theta(c^d + c^u) - c^r \) is:

\[
\left. \frac{\partial \pi^{IP}}{\partial s} \right|_{s=0} = \frac{\alpha - c^d - c^u}{\gamma} > 0. \tag{63}
\]

Thus first best is not achievable.

**Proof of Proposition 4.** Suppose \( 0 < \theta < 1 \) and \( c^d > c^r \). There are two cases depending on the intensity of competition and the cost parameters.

**Case 1.** Suppose \( \theta < \frac{\alpha - (c^d + c^u)}{\alpha - (c^r + c^u)} \), or \( c^d + c^u < \theta(c^r + c^u) + \alpha(1 - \theta) \). In this case the first best requires that both firms serve the market charging \( p^d = c^r + c^u \) and \( p^d = c^d + c^u \). Downstream prices for the interior equilibrium are given by (16). If the parent does not sabotage, to match the first best and downstream prices the regulator must set \( a = 2c^a + c^r - \theta(c^r + c^u) - \alpha(1 - \theta) \) (note that \( a - c^u = c^a + c^r - \theta(c^d + c^u) - \alpha(1 - \theta) < 0 \) and \( \lambda = \frac{(1 + \theta)(c^r - c^d)}{2(a + c^u)(1 - \theta)} > 0 \).

Now we must check whether the parent does indeed choose zero sabotage at the regulator’s chosen \((a, \lambda)\). Since both firms produce downstream, the parent’s profit function is:

\[
\pi^{IP} = (a - c^u)(q^r + q^d) + (p^d - c^d - a)q^d - K(s). \tag{64}
\]

Downstream equilibrium quantities and prices are found in (16) and (17). After some simplification,

\[
\pi^{IP} = \frac{(a - c^u)}{\beta(1 + \theta)(2 - \theta)} (2\alpha - c^r - c^d)
+ \frac{1}{\beta(1 - \theta^2)(4 - \theta^2)} \left( \frac{\alpha(1 - \theta)(2 + \theta) + \theta c^r + 2c^d}{4 - \theta^2} - c^d - a \right) 
\ast (\alpha(1 - \theta)(2 + \theta) - (2 - \theta^2)c^d + \theta c^r) - K(s). \tag{65}
\]
The derivative evaluated at \( s = 0 \) is:

\[
\frac{\partial \pi^P}{\partial s} \bigg|_{s=0} = -\frac{a - c^u}{\beta(1 + \theta)(2 - \theta)} \\
+ \frac{\theta}{\beta(1 - \theta^2)(4 - \theta^2)^2} (2\alpha(1 - \theta)(2 + \theta) + \theta^2c^d + 2\theta c^r - (4 - \theta^2)(c^d + a)) \\
= \frac{1}{\beta(1 - \theta^2)(4 - \theta^2)} ((a - c^u)(1 - \theta)(\theta - 2 - \theta) + 2\theta(p^d - c^d - a)) > 0.
\]

The sign follows because \( a - c^u < 0 \) from above, and \( p^d - c^d - a > 0 \) given the chosen \((\alpha, \lambda)\). Thus, first best is not achievable.

**Case 2.** Suppose \( \theta \geq \frac{\alpha - (c^d + c^u)}{\alpha - (c^r + c^u)} \), or \( c^d + c^u > \theta(c^r + c^u) + \alpha(1 - \theta) \). In this case the first best requires that the rival serve the whole market with both firms charging prices as specified in (28) and (29): \( p^d \geq \alpha(1 - \theta) + \theta(c^r + c^u) \) and \( p^r = c^r + c^u \). The downstream equilibrium entails the rival either deterring the affiliate or blockading it, with no sabotage for the first best.

First consider the blockade. If the rival blockades then \( p^d \geq c^d + a - \lambda(a - c^u)(1 - \theta) \) and \( p^r = \frac{\alpha + c^r + a}{2} \). To match the first best price for the rival the regulator must set \( a = c^r + 2c^u - \alpha \) (note that \( a - c^u = c^r + c^u - \alpha < 0 \)). At this access charge the necessary inequality (22) for the blockade, that is, \( c^d + a - \lambda(a - c^u)(1 - \theta) \geq \alpha(1 - \theta) + \theta^2(\alpha + c^r + a) \), cannot hold. After simplification this condition is

\[
\lambda > \frac{2c^d - \theta c^r - \alpha(2 - \theta) + a(2 - \theta)}{2(a - c^u)(1 - \theta)}.
\]

However \( \frac{2c^d - \theta c^r - \alpha(2 - \theta) + a(2 - \theta)}{2(a - c^u)(1 - \theta)} > 1 \) implying that \( \lambda > 1 \). Thus the regulator cannot achieve the first best in this case.

The regulator may be able to achieve the first best when the rival deters the affiliate. In this case downstream equilibrium prices are \( p^d = c^d + a - \lambda(a - c^u)(1 - \theta) \) and \( p^r = \frac{c^d + a - \lambda(a - c^u)(1 - \theta) - \alpha(1 - \theta)}{\theta} \) from (19). The regulator must match those prices with first best prices \( p^d \geq \alpha(1 - \theta) + \theta(c^r + c^u) \) and \( p^r = c^r + c^u \) given that the parent does not sabotage. \( \lambda = \frac{c^d + a - \alpha(1 - \theta) - \theta(c^r + c^u)}{(a - c^u)(1 - \theta)} \) is both necessary and sufficient for the first best prices to be deterrence equilibrium prices, provided this value of \( \lambda \) is in \([0, 1]\), the affiliate doesn’t produce in equilibrium, and the rival’s price is below the monopoly level. The latter two conditions are:

\[
\hat{c}^d \geq \frac{\alpha(1 - \theta)(2 + \theta) + \theta c^r}{2 - \theta^2},
\]

\[
\hat{c}^d < \alpha(1 - \theta) + \theta \frac{c^r}{2}.
\]

Together equations (67) and (68) imply that \( c^r + c^u - \alpha < a - c^u < (1 - \theta^2)(c^r + c^u - \alpha) \). Hence the access charge is set below cost. Furthermore, \( 0 \leq \lambda \leq 1 \) implies

\[
\theta \left( -\frac{\alpha - c^r - c^u}{\alpha - c^r - c^u} \right) \leq a - c^u \leq (c^r + c^u - \alpha) \left( \theta - \frac{\alpha - c^r - c^u}{\alpha - c^r - c^u} \right).
\]

Since \( c^r + c^u - \alpha <
\[ \frac{c^r + c^u - \alpha}{\theta} \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right), \] the effective lower bound for \( a - c^u \) is

\[ \frac{c^r + c^u - \alpha}{\theta} \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \leq a - c^u. \] (69)

Both upper bounds of \( a - c^u \) may be relevant, depending on \( \theta \). Hence

\[ a - c^u \leq \min \left\{ (1 - \theta^2)(c^r + c^u - \alpha), (c^r + c^u - \alpha) \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \right\}. \] (70)

The inequality (70) requires more careful examination. When \( \theta = \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \), then

\[ (1 - \theta^2)(c^r + c^u - \alpha) < (c^r + c^u - \alpha) \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \] and when \( \theta = 1 \) then \( (c^r + c^u - \alpha) \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) < (1 - \theta^2)(c^r + c^u - \alpha) \). Moreover, the first bound is increasing in \( \theta \) and the second bound is decreasing in \( \theta \). Thus there is some threshold value of \( \theta \), say \( \bar{\theta} \), where those two expressions are equal and for \( \theta < \bar{\theta} \) the effective upper bound is \( (1 - \theta^2)(c^r + c^u - \alpha) \). However, when \( \theta = \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \) the lower bound \( \frac{c^r + c^u - \alpha}{\theta} \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \) is zero and the upper bound \( (1 - \theta^2)(c^r + c^u - \alpha) \) is strictly negative and thus the interval for \( a - c^u \) becomes degenerate. The effective upper bound \( (1 - \theta^2)(c^r + c^u - \alpha) \) is increasing in \( \theta \) and the lower bound \( \frac{c^r + c^u - \alpha}{\theta} \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \) is decreasing in \( \theta \), and they cross at \( \theta = \frac{3\sqrt{\alpha - c^d - c^u}}{\alpha - c^r - c^u} \). Hence the \( a - c^u \) interval is non-degenerate for \( \theta \) larger this cube root (the other potential upper bound in (70) is always above the lower bound). To summarize, the necessary and sufficient conditions for the regulator to achieve the productive efficiency downstream are:

\[ \theta \geq \frac{3\sqrt{\alpha - c^d - c^u}}{\alpha - c^r - c^u}; \] (71)

\[ \lambda = \frac{c^d + a - \alpha(1 - \theta) - \theta(c^r + c^u)}{(a - c^u)(1 - \theta)}, \] (72)

\[ \frac{c^r + c^u - \alpha}{\theta} \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \leq a - c^u, \] (73)

\[ a - c^u \leq \min \left\{ (1 - \theta^2)(c^r + c^u - \alpha), (c^r + c^u - \alpha) \left( \theta - \frac{\alpha - c^d - c^u}{\alpha - c^r - c^u} \right) \right\}. \] (74)

The regulator is free to choose any value of \( a - c^u \) that satisfies (73) and (74) (and there are such values given (71)) provided the corresponding \( \lambda \) is set according to (72).

Now we must check that the parent indeed does not sabotage given the regulator’s chosen \((a, \lambda)\). The parent’s profits are:

\[ \pi^{IP} = (a - c^u)q^r - K(s) = (a - c^u) \frac{\alpha - (c^d + a - \lambda(a - c^u)(1 - \theta))}{\gamma} - K(s). \] (75)

Plugging in the regulator’s chosen \( \lambda \) and simplifying yields:

\[ \pi^{IP} = (a - c^u) \frac{\alpha - c^r - c^u}{\beta} - K(s). \] (76)
This is strictly decreasing in $s$, so the parent will not engage in a small amount of sabotage.

However, the IP can increase sabotage to the level where the rival’s effective cost advantage diminishes enough for the affiliate to start producing in the downstream equilibrium. At this point, the downstream equilibrium is given by (16) and (17) and the IP’s profit is:

$$\pi^{IP} = (a - c^u)(q^r + q^d) + (p^d - c^d - a)q^d - K(s).$$

(77)

The parent’s downstream profit $(p^d - c^d - a)q^d$ is increasing in $s$ and the downstream aggregate quantity $q^r + q^d$ is decreasing in $s$. Thus, aside from sabotage costs $K(s)$, the IP gains from sabotage once sabotage is high enough to make the downstream affiliate viable (remember that $a - c^a < 0$). As seen from (67), $s > (1 - \theta^2)(c^r + c^u - \alpha) - (a - c^u)$ is required for the affiliate to participate in the downstream market. This $s$ is positive at the regulator’s chosen $(a, \lambda)$. So the key question is whether (76) evaluated at $s = 0$ exceeds the maximum of (77) over $s$ subject to the constraint $s \geq (1 - \theta^2)(c^r + c^u - \alpha) - (a - c^u)$. If so, there will be no sabotage and the first best is achievable. If not, sabotage will be positive and the first best is not achievable. Which outcome occurs depends on the specific functional form for $K(s)$ (specifically, how quickly $K(s)$ increases), on $\theta$, and on the size of the rival’s cost advantage $c^d - c^r$ (i.e. the size of the sabotage threshold $(1 - \theta^2)(c^r + c^u - \alpha) - (a - c^u)$).

The sabotage threshold approaches zero as $\theta \to 1$ or $c^r \to c^d$ at the regulator’s choice of $a - c^a$, hence the first best is unachievable for any given $K$ provided $\theta$ is “high enough” or $c^r - c^d$ is “low enough.” On the other hand, if $K(s)$ is convex enough, the two marginal costs are sufficiently different, and $\theta$ is not too close to one then the IP will not engage in sabotage.

**Proof of Lemma.** Let $U^*(p^r, p^d) = \max(q^r, q^d)U(q^r, q^d) - p^d q^d - p^r q^r$ be the indirect utility function. Now rewrite the welfare objective using $U^*(p^r, p^d)$ and the downstream equilibrium profit functions:

$$W(a, \lambda) = U^*(\hat{p}^r(s^*(a, \lambda), a, \lambda), \hat{p}^d(s^*(a, \lambda), a, \lambda)) + \hat{\pi}^{IP^*}(a, \lambda) + \hat{\pi}^r(s^*(a, \lambda), a, \lambda),$$

(78)

where the circumflex denotes downstream equilibrium values:

$$\hat{\pi}^r(s^*(a, \lambda), a, \lambda) = [\hat{p}^r(s^*(a, \lambda), a, \lambda) - c^r - a - s^*(a, \lambda)] \hat{q}^r(s^*(a, \lambda), a, \lambda)$$

(79)

$$\hat{\pi}^{IP^*}(a, \lambda) = \hat{\pi}^{IP}(s^*(a, \lambda), a, \lambda)$$

$$= [\hat{p}^d(s^*(a, \lambda), a, \lambda) - c - c^a] \hat{q}^d(s^*(a, \lambda), a, \lambda)$$

$$+ (a - c^a)\hat{q}^r(s^*(a, \lambda), a, \lambda) - K(s^*(a, \lambda)).$$

(80)

Differentiating (78) while accounting for the resulting changes in the optimal level of sabotage and the downstream quantities and prices yields:

$$\frac{\partial W}{\partial a} = U^*_1(\hat{p}^r_1 \frac{\partial s^*}{\partial a} + \hat{p}^r_2) + U^*_2(\hat{p}^d_2 \frac{\partial s^*}{\partial a} + \hat{p}^d_2) + \hat{\pi}^{IP^*}_1 + \hat{\pi}^{IP^*}_2 + \hat{\pi}^r$$

$$= [U^*_1 \hat{p}^r_1 + U^*_2 \hat{p}^r_2 + \hat{\pi}^{IP^*}_1] \frac{\partial s^*}{\partial a} + U^*_2 \hat{p}^d_2 + \hat{\pi}^{IP^*}_1 + \hat{\pi}^r$$

$$= \Psi \frac{\partial s^*}{\partial a} + U^*_1 \hat{p}^r_2 + U^*_2 \hat{p}^d_2 + \hat{\pi}^{IP^*}_1 + \hat{\pi}^r.$$
It is easy to see from (81) that \( \Psi = U^*_1 \dot{p}_1^r + U^*_2 \dot{p}_1^d + \dot{\pi}_1^r < 0 \), since \( U^*_1, U^*_2 \) and \( \dot{\pi}_1^r \) are negative and \( \dot{p}_1^r, \dot{p}_1^d \) are positive.

**Proof of Proposition 6.** Rewrite (35) using (38) as:

\[
\frac{\partial W}{\partial \lambda} = (p^d - c - c^u)(1 - \theta)(2 - \theta^2)(a - c^u) - (p^r - c - c^u - s)(1 - \theta)(a - c^u) + \frac{\partial s}{\partial \lambda} \Psi \\
= \frac{(1 - \theta)(a - c^u)}{D} \Gamma + \frac{\partial s}{\partial \lambda} \Psi,
\]

where \( \Gamma = (p^d - c - c^u)(2 - \theta^2) - (p^r - c - c^u) \theta + \theta s \). We will show first that \( a - c^u \) always has the same sign as \( \frac{\partial W}{\partial \lambda} \), establishing that \( \lambda^* = 0 \) if \( a^* - c^u < 0 \) and \( \lambda^* = 1 \) if \( a^* - c^u > 0 \). The last term \( \frac{\partial s}{\partial \lambda} \Psi \) always takes on the same sign as \( a - c^u \), since \( \Psi \leq 0 \) and \( \frac{\partial s}{\partial \lambda} = - (a - c^u) \) (or \( \frac{\partial s}{\partial \lambda} = 0 \) at the corner \( s^* = 0 \)), thus we omit it from further analysis. What remains to show is that \( \Gamma \) is always positive. Substituting for the interior equilibrium values of \( p^r \) and \( p^d \) and simplifying reveals that \( \Gamma \) is linear in \( \lambda \) and:

\[
\Gamma|_{\lambda=1} = \frac{1}{4 - \theta^2} [(\alpha - c - c^u)(1 - \theta)^2(2 + \theta)^2 + 4 \theta(a - c^u)(1 - \theta^2) + 2 \theta s(2 - \theta^2)]
\]

\[
\Gamma|_{\lambda=0} = \frac{1}{4 - \theta^2} [(\alpha - c - c^u)(1 - \theta)^2(2 + \theta)^2 + (a - c^u)(1 - \theta)(2 + \theta)^2 + 2 \theta s(2 - \theta^2)].
\]

If \( a - c^u > 0 \) then (83) and (84) are clearly positive, therefore \( \Gamma > 0 \ \forall \ \lambda \in [0, 1] \).

If \( a - c^u < 0 \) the second term inside the square brackets in (83) and (84) turns negative thus we must show that the first term dominates the second in both cases. Recall from Case 1 of Proposition 3 that, if there were no sabotage, the optimal regulatory policy would be \( \lambda = 0 \) and \( a - c^u = -(\alpha - c - c^u)(1 - \theta) \). Since the last two terms in (34) are nonnegative and the welfare function is concave in \( \theta \) under the stated assumptions, we know that the possibility of sabotage causes the optimal access charge to be no lower than the first best level. Thus:

\[
\Gamma|_{\lambda=0} \geq \frac{(1 - \theta)(2 + \theta)^2}{4 - \theta^2} \left[ (\alpha - c - c^u)(1 - \theta) - (\alpha - c - c^u)(1 - \theta) + \frac{2 \theta s(2 - \theta^2)}{(2 + \theta)^2(1 - \theta)} \right] \\
= \frac{2 \theta s(2 - \theta^2)}{4 - \theta^2} \geq 0.
\]

For the \( \lambda = 1 \) case when \( a - c^u < 0 \), if there were no sabotage and the regulator could not choose \( \lambda \) then the optimal access price would satisfy

\[
\frac{\partial W}{\partial a} = (p^d - c - c^u) \frac{\partial q^d}{\partial a} + (p^r - c - c^u) \frac{\partial q^r}{\partial a} = 0.
\]

Solving for this optimal access price yields \( a - c^u = -(\alpha - c - c^u) \frac{(1 - \theta)(2 + \theta)^2}{5 \theta^2 + 4} \). Again, since the regulator must set the optimal access charge no lower when sabotage is
possible compared to when there is no sabotage, we have:

\[
\Gamma|_{\lambda=1} \geq \frac{(1 - \theta)^2(2 + \theta)^2}{4 - \theta^2} \left[ (\alpha - c - c^u) - (\alpha - c - c^u) \frac{4\theta(1 + \theta)}{5\theta^2 + 4} + \frac{2\theta s(2 - \theta^2)}{(1 - \theta)^2(2 + \theta)^2} \right]
\]

\[
= \frac{(1 - \theta)^2(2 + \theta)^2}{4 - \theta^2} \left[ (\alpha - c - c^u) \left( 1 - \frac{4\theta(1 + \theta)}{5\theta^2 + 4} \right) + \frac{2\theta s(2 - \theta^2)}{(1 - \theta)^2(2 + \theta)^2} \right]
\]

\[
= \frac{(1 - \theta)^2(2 + \theta)^2}{4 - \theta^2} \left[ (\alpha - c - c^u) \frac{(2 - \theta)^2}{5\theta^2 + 4} + \frac{2\theta s(2 - \theta^2)}{(1 - \theta)^2(2 + \theta)^2} \right] > 0,
\]

(87)

Therefore \( \Gamma > 0 \ \forall \ \lambda \in (0, 1) \) when \( a - c^u < 0 \) (since \( \Gamma \) is linear).

Next we show that the regulator will never choose \( a - c^u = 0 \). Differentiate (34) with respect to \( \lambda \):

\[
\frac{\partial^2 W}{\partial a \partial \lambda} = \frac{\partial p^d}{\partial \lambda} \frac{\partial q^d}{\partial a} + (p^d - c - c^u) \frac{\partial^2 q^d}{\partial a \partial \lambda} + \left( \frac{\partial p^r}{\partial \lambda} - \frac{\partial s}{\partial \lambda} \right) \frac{\partial q^r}{\partial a} + (p^r - c - c^u - s) \frac{\partial^2 q^r}{\partial a \partial \lambda} + \frac{\partial^2 s}{\partial a \partial \lambda} \Psi + \frac{\partial s}{\partial a} \frac{\partial \Psi}{\partial \lambda},
\]

(88)

where

\[
\frac{\partial \Psi}{\partial \lambda} = \frac{\partial p^d}{\partial \lambda} \frac{\partial q^d}{\partial s} + (\partial p^r - \partial s) \frac{\partial q^r}{\partial s} \frac{\partial q^r}{\partial \lambda} - K''(s) \frac{\partial s}{\partial \lambda}.
\]

(89)

Using the downstream equilibrium prices, (32), (33), (37), (38) and (39), if \( a = c^u \) then \( \frac{\partial p^d}{\partial \lambda} = \frac{\partial p^r}{\partial \lambda} = \frac{\partial s}{\partial \lambda} = \frac{\partial q^r}{\partial \lambda} = 0 \). Therefore, after simplifying

\[
\frac{\partial^2 W}{\partial a \partial \lambda} \bigg|_{a=c^u} = \frac{(p^d - c - c^u)(2 - \theta^2)(1 - \theta)}{D} - (p^r - c - c^u - s) \frac{\theta(1 - \theta)}{D} + \frac{\partial^2 s}{\partial a \partial \lambda} \Psi \\
\leq \frac{1 - \theta}{D(4 - \theta^2)}(\alpha - c - c^u)(1 - \theta)^2(2 + \theta)^2 + 2\theta s(2 - \theta^2) > 0,
\]

(90)

since \( \frac{\partial^2 s}{\partial a \partial \lambda} \) (from (40)) and \( \Psi \) are both non-positive. Equation (90) shows that \( a = c^u \) cannot be optimal. If \( \frac{\partial W}{\partial a} \) were zero at \( a = c^u \), a change in \( \lambda \) would have no effect on \( W \) (since \( \frac{\partial W}{\partial \lambda} \equiv a - c^u \)) but such a change would make \( \frac{\partial^2 W}{\partial a \partial \lambda} \) nonzero (since \( \frac{\partial^2 W}{\partial a \partial \lambda} > 0 \)).

So, changing \( a \) in the same direction as \( \lambda \) then raises \( W \). Hence, the optimum is either \( a - c^u > 0 \) or \( a - c^u < 0 \).

Finally, we sketch why the \((\lambda^* = 1, a^* > c^u)\) regime occurs when \( \eta \in (\eta, \hat{\eta}] \) and the \((\lambda^* = 0, a^* < c^u)\) regime occurs when \( \eta \geq \hat{\eta} \). It can be shown that \( \tilde{\eta}(0, \theta) > \hat{\eta}(1, \theta) \) for all \( \theta \in (0, 1) \). Since the regulator uses the \( \lambda = 0 \) regime for \( \eta > \tilde{\eta}(0, \theta) \) and the \( \lambda = 1 \) regime for \( \eta < \hat{\eta}(1, \theta) \) there is a region between \( \tilde{\eta}(0, \theta) \) and \( \hat{\eta}(1, \theta) \) where either regime could be optimal. For \( \eta \in (\tilde{\eta}(0, \theta), \hat{\eta}(1, \theta)) \), the choice of \( \lambda \) is determined by a direct comparison of welfare. It is straightforward but tedious to substitute for downstream equilibrium quantities from (16), sabotage from (40) and optimal access charges from (41) and (42) into the welfare expression to obtain

\[
W|_{\lambda=0} = \frac{-(\alpha - c - c^u)^2 \Phi(\eta, \theta)}{2\beta(1 + \theta)d(0, \eta, \theta)}
\]

(91)

\[
W|_{\lambda=1} = \frac{(\alpha - c - c^u)^2 \Pi(\eta, \theta)}{2\beta(1 + \theta)d(1, \eta, \theta)},
\]

(92)
where $\Phi(\eta, \theta)$ and $\Pi(\eta, \theta)$ are second order polynomials in $\eta$. Hence

$$W|_{\lambda=0} - W|_{\lambda=1} = - \left[ \frac{\Phi(\eta, \theta)}{d(0, \eta, \theta)} + \frac{\Pi(\eta, \theta)}{d(1, \eta, \theta)} \right].$$

(93)

It can be verified that this expression is negative at $\eta = \bar{\eta}(0, \theta)$ and positive at $\eta = \bar{\eta}(1, \theta)$. Therefore by the intermediate value theorem there is at least one root of (93) on $\eta \in (\bar{\eta}(0, \theta), \bar{\eta}(1, \theta))$. Moreover, it is possible to show that the derivative of (93) is positive for all $\eta \in (\bar{\eta}(0, \theta), \bar{\eta}(1, \theta))$. Thus the root is unique on this interval.
Many network industries have an upstream monopolist that sells an essential input to downstream firms. Examples include electricity markets where a firm owning transmission lines sells access to generating companies, telecommunications where a local operator sells access to a competitive long distance market or to other communications providers such as wireless firms or providers of high speed internet services,\(^1\) cable telephony where a local cable monopolist sells access to firms providing long distance and local voice services,\(^2\) and software markets where Microsoft provides a key resource, the Windows operating system, while also competing with other firms for other software components (media players, for example) that seek compatibility with Windows.

The access offered to downstream firms by an upstream monopolist consists of two parts, an access charge and quality of access. Often the upstream monopolist is regulated in terms of the access charge while the downstream market is deemed sufficiently competitive and is therefore unregulated. There is a large literature on access charges and the regulation thereof to optimize social welfare (Armstrong et al. 1996; Laffont and Tirole 1990 and 1994; Bustos and Galetovic 2007; Reiffen 1998; Vickers 1995; Weisman 1995 and 1998; Weisman and Kang 2001). In an unregulated

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1 Digital Subscriber Line (DSL) is a family of technologies that provide digital data transmission over the wires of a local telephone network. See [http://en.wikipedia.org/wiki/DSL](http://en.wikipedia.org/wiki/DSL).

2 Voice Over Internet Protocol (VOIP) is a recent technology, where voice is carried through the internet. See [http://en.wikipedia.org/wiki/Voip](http://en.wikipedia.org/wiki/Voip).
market, quality of access probably would not be a concern as the upstream monopolist could extract monopoly profits via access charges. Even with regulated access charges an unintegrated upstream monopolist still would probably not want to degrade access quality since doing so may be costly and does not generate additional revenues for the monopolist.

However, access price regulation may create incentives to degrade the quality of access when the upstream monopolist is affiliated with one of the downstream competitors and thus receiving profits from retail markets. Absent the ability to extract monopoly profits via access pricing, the upstream monopolist may degrade the quality of access to its downstream rivals to increase its own retail profits and possibly foreclosure its rivals. This type of non-price discrimination by an upstream monopolist has been labeled “sabotage” in the literature. The first essay provides documentation that such sabotage occurs in the US energy and telecommunications industries. The literature agrees that sabotage is a socially costly activity, therefore there may be a need for regulation of access quality along with regulation of access prices.

The literature on sabotage has focused on theoretical possibilities of when access quality degradation may or may not occur. The upstream monopolist’s incentives to sabotage vary as relative efficiencies of the downstream affiliate and rival change as well as with the degree of competition. Although it is well-established that it may be possible to manipulate regulated access charges in order to decrease sabotage

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3Various Orders and quality monitoring requirements issued by the FCC and the FERC to eradicate such quality discrimination also indicates that regulators agree that sabotage is a real concern. For example, see “Notice of Inquiry into Alleged Anticompetitive Practices Related to Marketing Affiliates of Interstate Pipelines,” pg. 9.
and thereby enhance overall welfare (Ordover, Sykes, and Willig 1985; Economides 1998; Sibley and Weisman (SW) 1998; Mandy 2000; Mandy and Sappington 2007), there have been few attempts to derive welfare-optimal regulatory policies for a vertically integrated upstream monopoly when the upstream monopolist can sabotage its downstream rivals.

The present paper fills this gap in the literature and also extends results derived in Chikhladze and Mandy (2009) by bringing the study of optimal regulatory policies for a vertically integrated upstream monopolist to a setting that may involve sabotage. Existing regulatory policies have long acknowledged the tension between access price regulation designed to encourage efficiency downstream and the potential that such regulation may encourage sabotage. Policies intended to maximize welfare and deter sabotage in network industries include marginal cost pricing of access, restrictions on vertical control between the monopolist and its downstream subsidiary, nondiscrimination requirements, performance monitoring of input quality, penalties for violations of nondiscrimination requirements, and limitations on the tools employed by regulators.4 “Vertical control” in this setting means the extent to which the upstream

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4 All of these policies are present in contemporary telecommunications regulation. On May 31, 2000 the US Federal Communications Commission (FCC) adopted the proposal of the Coalition for Affordable Local and Long Distance Service (CALLS) to rapidly move access charges toward the marginal cost of supplying access (FCC, 2000). Section 272 of the Telecommunications Act of 1996 restricts the vertical control a Bell company can exert over its long distance affiliate by requiring that the affiliate operate independently and maintain separate books from the Bell operating company; have separate officers, directors, and employees; have separate credit arrangements; and conduct all transactions with the parent company at arm’s length. This section also requires that the Bell company not discriminate in the provision of services between its affiliate and other suppliers of long distance. To enforce nondiscrimination, the FCC has required substantial performance monitoring agreements and pre-specified fines for violations as a condition of a Bell company’s entry into long-distance markets (for example, see FCC 1999). Regulatory tools are limited, however. Price discrimination and Baron-Myerson (1982) style incentive mechanisms are rarely used in practice, despite their established theoretical advantages.
monopolist can align the objective of its downstream affiliate with the objective of the overall firm. Despite the explicit vertical control policies used in practice, formal modeling of vertical control as a policy parameter has attracted little attention in the literature (Chikhladze and Mandy (2009), Hoffler and Kranz (2007)).

We depart from Chikhladze and Mandy (2009) by studying the incentives for sabotage and welfare-optimal access price and vertical control policies when the downstream market is competitive rather than oligopolistic. The regulator sets a nondiscriminatory uniform access price and a level of vertical control. Limited internal control is due to external restrictions imposed by the regulator on the organization of the firm, not because of partial ownership or agency problems. The access price and vertical control policies modeled here are representative of the tools used under the US Telecommunications Act of 1996 to regulate local network access for long-distance suppliers once a Bell company enters the long-distance market, and are not far removed from policies used by the US Federal Energy Regulatory Commission (FERC) to regulate the relationship between electric generation and transmission.\footnote{FERC does not currently require “corporate” or “structural” unbundling of transmission and generation services of vertically integrated providers in electricity markets. FERC Order No. 890 (Docket Nos. AD05-17-000 and RM05-25-000) only requires “functional” unbundling. That is, FERC requires that employees engaged in transmission functions operate separately from employees of energy affiliates and marketing affiliates. However, several members of the industry have urged FERC to take more decisive steps toward corporate unbundling (FERC 2007).}

The nondiscriminatory uniform access price and vertical control parameters comprise a limited but realistic regulatory toolbox.

We find that the regulator may be able to achieve the first best welfare outcome when the entry cost of the competitive firms is large enough. In this limiting case the downstream affiliate of the upstream monopolist is itself a monopoly. The regulator
prices access below its marginal cost to overcome the “double margin” problem and restricts vertical control so that the downstream affiliate will respond to the low access price. The upstream monopolist does not engage in sabotage in this setting because the rivals are foreclosed even without sabotage.

More generally, we find a high access charge is needed to diminish incentives for sabotage, whereas a low access price is used to stimulate production. The regulator’s choice of vertical control policy parameter depends on the relative efficiency of the downstream affiliate and the optimal access charge used. At high access charges, an increase in vertical control shifts the downstream production mix in favor of the affiliate but at the same time increases sabotage by the integrated parent. A decrease in vertical control has similar effects on welfare when low access charge is used. If the downstream affiliate is very efficient, then welfare gains from shifting the downstream production mix toward the affiliate exceed the cost of higher sabotage. Therefore, the regulator would like to allow full vertical control when a high access charge is used and the regulator would like to fully restrict vertical control when a low access charge is used. If the downstream affiliate is not very efficient then the regulator chooses the degree of vertical control to balance sabotage deterrence versus optimal downstream production.

We are able to construct numerical examples that show each of the policy choices described above can be optimal. If the access monopolist’s sabotage cost increases relatively slowly with the level of sabotage then it is welfare-optimal to price access above marginal cost. On the other hand, if sabotage cost increases relatively rapidly with the level of sabotage then it is welfare-optimal to price access below marginal
cost. The latter provides greater inducement to increase downstream output when the access monopolist’s cost of sabotage can be more heavily relied upon to control the level of sabotage. When the downstream affiliate is very efficient, then the regulator will either fully restrict vertical control if low access charge is used or allow full vertical control if high access charge is used. When the downstream affiliate is not very efficient, then the intermediate level of vertical control is used to balance sabotage deterrence and improved downstream efficiency.

As in Chikhladze and Mandy (2009), our results formally verify a conjecture that has appeared in the literature (see, for example, Laffont and Tirole 2000, Chapter 4), that it is sometimes optimal to price access above marginal cost in order to deter sabotage. We also continue to find that, pricing access at marginal cost is never optimal.

Section 1 presents the model and Section 2 derives the downstream equilibrium. Section 3 identifies the situations in which the regulator can achieve the first best and the policies that do so. Then section 4 studies the second best. Section 5 concludes.

4.1 Model

The downstream market consists of a dominant firm and a competitive fringe that sell a homogeneous product facing an inverse aggregate demand function \( P(D) \).\(^6\) We make the standard assumption that the downstream technology is fixed coefficients, that is, one unit of access sold by the upstream monopolist is needed to produce one unit of downstream output by the dominant firm or by a representative competitive

\(^6\)This type of downstream market structure may be appropriate for the US natural gas and electricity industries where goods are homogeneous and downstream markets are characterized by large numbers of traders that buy and sell the respective commodities.
A representative competitive firm has the following cost structure:

\[ C(q^f) = (1 + s)c(q^f) + aq^f + (1 + \theta s)F \]  

(1)

where \( c(q^f) \) is a variable cost of production with \( c'(q^f), c''(q^f) > 0 \) and \( c(0) = 0 \), and \( F \) is a fixed cost that a competitive firm must incur when it enters the market after observing the access charge, \( a \), set by the regulator, and degree of sabotage, \( s \), chosen by the upstream monopolist. The parameter \( \theta \geq 0 \) captures the possibility of sabotage influencing entry and variable costs differently. The dominant downstream firm can blockade or deter entry by the competitive fringe as \( F \) will be sunk when the dominant firm and the fringe play the quantity game in the last stages of the game. The size of \( F \) will ultimately determine the measure of the competitive fringe, denoted as \( n \).

Once measure \( n \) of competitive firms enter the market and observe the quantity chosen by the dominant downstream firm they will each choose an optimal quantity to maximize the following profit function, taking the market price \( P \) as given:

\[ \pi^f = Pq^f - C(q^f). \]  

(2)

The dominant downstream firm has a constant marginal cost due its dominant position, denoted by \( c^d \geq 0 \). Let \( c^u \) denote the marginal cost of providing access for

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7 For example, ignoring energy losses, one unit of electric power (MW) at the distribution network requires one unit of electric power to be wheeled from the generator through the transmission network. Even taking into account energy losses, the relationship between the electric power from the transmission network to the distribution network that delivers it to the end users is fixed.

8 As noted regulators do not generally use discriminatory access charges. Also, if discriminatory access charges were used then an integrated monopolist would probably not have incentives to sabotage, leaving unexplained the examples of sabotage in the survey essay.

9 For example, in energy industries a transmission company or a pipeline may deny or delay requests for capacity on its network by the non-affiliate shippers, and then once access is granted unexpectedly interrupt services or re-route energy to different network paths that would increase variable costs of production of non-affiliated shippers.
the upstream monopolist and $K(s)$ the cost to the upstream monopolist of engaging in $s$ units of sabotage. We assume $K(0) = K'(0) = 0$ and $K''(s) > 0$ for $s > 0$, so the cost of the first increment of sabotage is zero but sabotage costs are strictly increasing and strictly convex in the degree of sabotage.\(^{10}\) Let $Q = nq^f$ denote the aggregate quantity produced by the fringe. Then profit functions for the dominant downstream firm and the upstream monopolist are:

$$
\pi^d = [P(q^d + Q) - c^d - a]q^d
$$

$$
\pi^u = (a - c^u)(q^d + Q) - K(s).
$$

We assume throughout that any upstream viability constraint for the incumbent can be met with non-distorting transfers, so upstream fixed costs are ignored and the marginal cost of access may even exceed the access price (i.e., $a < c^u$ is a feasible regulatory policy).

A new innovation in this model is the explicit parameterization of vertical control as a policy tool. We use the vertical control parameter $\lambda \in [0, 1]$ to measure the degree of influence exercised by the upstream monopolist over the choices of its downstream affiliate. Letting $IA$ denote “Integrated Affiliate” and $IP$ denote “Integrated Parent,”

\(^{10}\)There is no consensus in the literature about costs of sabotage. According to Weisman (1998) direct costs of sabotage include increased likelihood of error of inadvertently sabotaging the affiliate’s own facilities and a decrease in operating efficiency when the integrated parent creates at least two different sets of operating practices. Mandy (2000) points out that costs of sabotage may include the likelihood of getting caught coupled with the penalties imposed if caught. In practice regulators monitor input quality and impose penalties for violations of nondiscrimination requirements as found in the survey essay. As the likelihood of getting caught is likely very low for small levels of sabotage, and increases thereafter, this can provide one foundation for the structure of $K$ assumed herein. Another evidence that sabotage generally is costly is the fact that we found examples of partial sabotage (Panhandle in the natural gas industry and Idaho Power in electricity industry) in the survey essay. We would expect no sabotage or full foreclosure of non-affiliated rivals if sabotage were costless.
we specify their objectives as

\[ \pi^{IP} = \pi^u + \pi^d \]  

(5)

\[ \pi^{IA} = (1 - \lambda)\pi^d + \lambda \pi^{IP} = \pi^d + \lambda \pi^u. \]  

(6)

If \( \lambda = 0 \) (zero vertical control) the affiliate maximizes only its own profit \( \pi^d \), while if \( \lambda = 1 \) (full vertical control) the affiliate maximizes the profit of its upstream parent. Note that this vertical control specification is not the usual agency approach to modeling separation of ownership and control. The IP has full information in our model, but is still unable to perfectly control the IA (when \( \lambda < 1 \)) because of legal restrictions on the control mechanisms that can be used (for example, the restrictions that are imposed by Section 272 of the Telecommunications Act of 1996, and the various rules promulgated by the FCC to implement this legislation, or the independent functioning requirements set in Order 497 by FERC).

Aggregate welfare is a sum of consumer surplus and profits of the upstream monopolist, the dominant affiliate and the competitive fringe:

\[ W = CS + \pi^u + \pi^d + n\pi^f \]

\[ = \int_{0}^{q^d+Q} P(x)dx - n[(1 + s)c(q^f) + c^u q^f + (1 + \theta s)F] - [c^d + c^u]q^d - K(s). \]  

(7)

The timing of the game is as follows. In the first stage, the regulator announces the access charge and the vertical control policy \((a, \lambda)\) to maximize \( W \). This is observed by the IP, IA and the fringe. In the second stage, the upstream monopolist chooses the level of sabotage \( s \) to maximize \( \pi^{IP} \) and offers access at the regulated charge. This is observed by the downstream affiliate and the fringe. In the third stage, \( n \)
measure of competitive firms make entry decisions and incur an entry cost $F$. In
the fourth stage, the dominant affiliate chooses the production level $q^d$ to maximize
$\pi^I_A$ anticipating a reaction from the fringe. In the fifth stage, the competitive firms
observe $q^d$ and choose $q^f$ to maximize $\pi^f$ taking the market price as given.\footnote{See Figure 10.} We seek
to determine the regulator’s optimal policy given the subgame perfect equilibrium in
the upstream and downstream markets and to study the regulator’s ability to control
sabotage while also seeking to maximize surplus from production, using only the
limited tools $(\alpha, \lambda)$.

4.2 Downstream Equilibrium

The first order condition for a representative competitive firm based on equation (2)
is

$$P = (1 + s)c'(q^f) + a. \quad (8)$$

Substituting (3) and (4) into (6) yields $\pi^I_A = (P(q^d + Q) - c^d - a)q^d + \lambda(a - 
\alpha)(q^d + Q) - \lambda K(s)$. The IA recognizes the market-clearing condition that $P(q^d + Q)$
must equal the price $P$ in (8). Making this substitution and differentiating (8) yields

$$\frac{\partial Q}{\partial q^d} = n\frac{\partial q^f}{\partial q^d} = \frac{-nP'(q^d + Q)}{nP'(q^d + Q) - (1 + s)c''(q^f)} < 0. \quad (9)$$

Hence the IA’s first order condition is:

$$P'(q^d + Q) \left(1 + \frac{\partial Q}{\partial q^d}\right) q^d + P(q^d + Q) = c^d + a - \lambda(a - \alpha) \left(1 + \frac{\partial Q}{\partial q^d}\right). \quad (10)$$
Rewriting (10) yields:

\[
P(q^d + Q) - q^d \frac{P'(q^d + Q)(1 + s)c''(q^f)}{nP'(q^d + Q) - (1 + s)c''(q^f)} = c^{d} + a + \lambda (a - c^{u}) \frac{(1 + s)c''(q^f)}{nP'(q^d + Q) - (1 + s)c''(q^f)}.
\]

(11)

The right hand side of (11) is the “effective” marginal cost of the IA which says that nonzero vertical control and a positive access margin decrease the perceived marginal cost of the IA, because an increase in the IA’s quantity increases upstream profit when the access margin is positive, and \( \lambda > 0 \) means the IA cares about upstream profit. Interpreted this way, (11) becomes the familiar condition that marginal revenue equals marginal cost, where marginal revenue on the left side is based on the standard residual demand in a dominant firm / competitive fringe model. Together, equations (8) and (11) define interior equilibrium values \( q^f(n, s, a, \lambda) \) and \( q^d(n, s, a, \lambda) \) in the retail market.

Next we must consider the entry stage when \( n \) measure of competitive firms enter the market. The equilibrium condition that gives an interior value of \( n \) is:

\[
\pi^f = P(q^d + nq^f)q^f - (1 + s)c(q^f) - aq^f - (1 + \theta s)F = 0.
\]

(12)

Equation (12) together with equations (8) and (11) define interior equilibrium values \( n^*(s, a, \lambda), q^f(s, a, \lambda) \) and \( q^d(s, a, \lambda) \).

**Proposition 1.** In an interior downstream equilibrium: i) a representative competitive firm operates at the efficient scale that does not depend on the access charge or the degree of vertical control, and ii) the market equilibrium price is determined by the minimum of a representative competitive firm’s average cost and does not depend on the degree of vertical control.
Equation (12) can be stated as the familiar condition that market equilibrium price is determined by the minimum of each fringe firms’ average cost:

\[ P^\star = \frac{(1 + s)c(q_f^f)}{q_f^f} + a + \frac{(1 + \theta s)F}{q_f^f}. \]  

(13)

Equation (13) coupled with the fringe’s first order condition (8) yields:

\[ (1 + s)c'(q_f^f)q_f^f - (1 + s)c(q_f^f) - (1 + \theta s)F = 0. \]  

(14)

Equation (14) determines the interior equilibrium value of an individual fringe firm’s output, denoted as \( q^\star_f(s) \), which is solely only a function of \( s \) and does not depend on \( a \) or \( \lambda \). Substituting this into (11) reveals that the equilibrium price, denoted as \( P^\star(s,a) \), does not depend on \( \lambda \) or \( n \). This is an important result. The fact that the equilibrium market price is pegged by the minimum of the fringe average cost is a main reason some of the results shown hereafter are different from the duopoly model.

Given \( q^\star_f(s) \) and \( P^\star(s,a) \), (11) determines \( n^\star(s,a,\lambda) \), the equilibrium measure of fringe. Then \( P(q_d^d + n^\star q_f^f) = P^\star(s,a) \) determines \( q^\star_d(s,a,\lambda) \), the equilibrium output of the IA.

Before considering comparative statics we make assumptions about the demand function and the variable cost structure of the fringe. These assumptions are mainly needed to make derivations simpler and not much is lost by abandoning the general case. We assume hereinafter that the inverse demand function is linear, \( P(q_d^d + Q) = \alpha - \beta(q_d^d + Q) \), and the fringe’s variable cost is quadratic, \( c(q_f^f) = (q_f^f)^2 \). In order to have a meaningful problem we also assume that the downstream dominant firm is always viable regardless of the regulatory choice of \( \lambda \). This means the downstream firm’s marginal cost must be below the minimum of the fringe’s average cost: \( c^d < 2\sqrt{F} \).
Proposition 2. Suppose the market inverse demand is $P(q^d + Q) = \alpha - \beta(q^d + Q)$, the fringe’s variable cost is $c(q^f) = (q^f)^2$, and $c^d < 2\sqrt{F}$. Then, in an interior downstream equilibrium:

i) market price is $P^*(s, a) = a + 2\sqrt{(1+s)(1+\theta s)F}$, which is independent of both vertical control and the size of the fringe and is increasing in both sabotage and access charge; and

ii) individual fringe output is $q^f(s) = \sqrt{\frac{(1+\theta s)F}{1+s}}$ which is independent of vertical control, the size of the fringe, and the access charge; and is increasing in sabotage for $\theta > 1$, decreasing in sabotage for $0 \leq \theta < 1$ and does not depend on sabotage for $\theta = 1$.

A unit increase in the access charge increases the market equilibrium price by one unit. Also, the relationship between $q^f$ and $s$ depends on $\theta$, since $\theta$ captures the fact that sabotage influences variable and entry costs differently. Essentially, if sabotage increases entry costs more than variable cost ($\theta > 1$), the average cost shifts by a larger amount than marginal cost. Given that $q^f$ is determined by the intersection of the average cost and the marginal cost, each competitive firm produces more.

Proposition 3. Suppose the market inverse demand is $P(q^d + Q) = \alpha - \beta(q^d + Q)$, the fringe’s variable cost is $c(q^f) = (q^f)^2$, and $c^d < 2\sqrt{F}$. Then, in an interior downstream equilibrium: i) $\frac{\partial q^d}{\partial x} = a - c^d$, ii) $\frac{\partial n^*}{\partial x} = -(a - c^d)$, iii) the IA’s output $q^{*d}$ is increasing in sabotage but the effect of the access charge on $q^{*d}$ is ambiguous, iv) the fringe size $n^*$ is decreasing in sabotage when $\theta \geq 1$ and is always decreasing in the access charge, and v) total fringe output, $Q^* = n^*q^{sf}$, is decreasing in both
sabotage and the access charge.

Proposition 3 reveals several interesting properties. Items (i) and (ii) state that the downstream affiliate’s output and the size of fringe move in opposite directions when the degree of vertical control changes. In fact, since the market price and individual fringe output do not depend on $\lambda$, changes in $q^d$ and $Q$ (due to changes in $n$) exactly offset each other.

In item (iii) the fact that the IA’s output is increasing in sabotage is unsurprising. The ambiguous effect of the access charge on the IA’s output is a little puzzling, however, as we might expect a higher access charge to favor the IA except when vertical control is zero. A more careful examination of the IA’s output, as derived in the appendix, shows that there is a critical value $\lambda_c \in (0, 1)$ such that $q^d$ is decreasing in $a$ when $\lambda < \lambda_c$ and increasing in $a$ when $\lambda > \lambda_c$. With sufficiently “low” zero vertical control the IA “ignores” upstream profits and puts more weight on the effect higher access charges have on its downstream cost of production. With sufficiently “high” vertical control the IA “ignores” the access charge and puts more emphasis on the upstream cost of production. Additionally, since the products are perfect substitutes, a higher access charge causes a decrease in total downstream production regardless of its composition. Therefore, in this case the IA benefits from its increased production at a higher market price.

The effect of sabotage on the number of entrants in item (iv) is only ambiguous when $0 \leq \theta < 1$. Since Proposition 1 states that the market price is increasing in sabotage and the IA’s production increases with sabotage, implying the total fringe
output must be decreasing in sabotage, this ambiguity only arises when individual competitive firms produce less with higher sabotage, which according to Proposition 2 happens only when $0 \leq \theta < 1$.

Item (v) is straightforward. Since individual fringe output does not depend on the access charge and the number of competitive firms is decreasing in access charge, total fringe output must be decreasing in the access charge. Also, according to Proposition 1 the market price is increasing in sabotage and given that the IA’s production increases with sabotage, total fringe output must be decreasing in sabotage.

### 4.3 First Best

It is possible for the regulator to achieve the first best, but usually and in the interesting cases the regulator faces a trade-off between sabotage deterrence and efficient production. This trade-off is explored in section 4. Before doing so it is necessary to identify those cases in which the regulator is able to achieve the first best. We start by characterizing the first best.

The first observation is that the first best should be sabotage-free. Sabotage is a socially costly activity because it adds variable and entry costs for the fringe and adds direct costs $K(s)$ for the IP without adding any gross surplus. Recall that in the game tree the IP observes $(a, \lambda)$ set by the regulator and then chooses the level of sabotage which is then followed by the downstream interaction between the affiliate and the fringe. We will show that it is possible for the regulator to manipulate the downstream equilibrium to induce the IP to choose the zero level of sabotage while also inducing downstream firms to produce output levels that achieve productive
efficiency.

**Definition.** The first best has the IA meeting the entire market demand, the fringe foreclosed and zero sabotage. In this case

\[ q^d = \frac{\alpha - c^d - c^u}{\beta}, \quad P = c^d + c^u. \]  

(15)

Since products are homogeneous and it has been assumed that the dominant firm is more efficient than the fringe \((c^d < 2\sqrt{F})\), the first best has only the IA producing positive quantity. The regulator would like to achieve the market price and quantity in (15), which are based on marginal costs of production, upstream and downstream.

**Proposition 4.** Suppose the market inverse demand is \(P(q^d + Q) = \alpha - \beta(q^d + Q)\), the fringe’s variable cost is \(c(q^f) = (q^f)^2\), and \(c^d < 2\sqrt{F}\). The first best is achievable when \(\alpha - c^u - 2\sqrt{F} \leq 0\). In this case the regulator can choose any \((a, \lambda)\) pair that satisfies the following:

\[ a - c^u = \frac{c^d + c^u - \alpha}{1 - \lambda}, \quad a - c^u \geq c^d - 2\sqrt{F}. \]  

(16)

In all cases, the access margin, \(a - c^u\), is negative and allowing full vertical is not optimal, so \(\lambda < 1\).

Since the first best has the fringe foreclosed the IA will set the monopoly price based on its effective marginal cost, \(p^m = \frac{\alpha + c^d + a - \lambda(a - c^u)}{2}\). The regulator would like to choose a policy \((a, \lambda)\) that induces the IA to choose efficient pricing while at the same time keeping the fringe out of market. The former requires the regulator to price access below cost to offset market power while the latter requires that the access
charge not to be “too low.” Hence the regulator strikes this balance by choosing $(a, \lambda)$ as specified in Proposition 4. The fact that full control is never optimal is easily seen from the IA’s monopoly price. With full vertical control $(\lambda = 1)$, the IA takes into account only the upstream marginal cost of production, $c^u$. Therefore the regulator loses the access charge as a policy tool. Also, the regulator’s ability to design an optimal first best policy depends on entry costs being sufficiently high. With “low” entry cost $F$ there is no feasible pair $(a, \lambda)$ that would achieve the first best by foreclosing the fringe. Finally, when the regulator chooses the access charge and vertical control as specified in Proposition 4, the IP has no incentives to sabotage since the fringe is foreclosed and sabotage does not directly affect the market price or quantity produced by the IA.

### 4.4 Second Best with Interior Downstream Equilibrium

Before looking at the regulator’s problem in the first stage of the game tree, we must investigate the access monopolist’s choice of sabotage given the interior downstream equilibrium determined in the last stages of the game. Differentiating (5) with respect to $s$ and setting it to zero defines an interior optimal sabotage choice $s^*(a, \lambda)$. Hereinafter we will assume that $K$ is sufficiently convex to satisfy the second order condition, $\frac{\partial^2 \pi_{IP}}{\partial s^2} < 0$. Differentiating the IP’s first order condition again and assuming an interior downstream equilibrium as described in Section 2 yields the comparative statics of an interior optimum for $s^*(a, \lambda)$ as:

\[
\frac{\partial s^*}{\partial a} = -\frac{\partial^2 \pi_{IP}}{\partial s \partial a} \frac{s}{\partial^2 \pi_{IP} / \partial s^2} > 0 \quad (17)
\]

\[
\frac{\partial s^*}{\partial \lambda} = -\frac{\partial^2 \pi_{IP}}{\partial s \partial \lambda} \frac{s}{\partial^2 \pi_{IP} / \partial s^2} = (a - c^u). \quad (18)
\]
Proposition 5. Suppose the market inverse demand is \( P(q^d + Q) = \alpha - \beta(q^d + Q) \), the fringe’s variable cost is \( c(q^f) = (q^f)^2 \), \( c^d < 2\sqrt{F} \) and the downstream equilibrium is interior. Then at any interior equilibrium for the sabotage choice: (i) sabotage is decreasing in the access price, (ii) sabotage is increasing in vertical control when access is priced above cost and vice versa, and (iii) vertical control has no effect on sabotage when access is priced at cost.

Item (i) formalizes the intuition that the input monopolist’s temptation to sabotage can be diminished by making upstream production more profitable. Item (iii) is at odds with some contemporary policies, for example in telecommunications, that attempt to price access at marginal cost while also attempting to deter non-price discrimination by imposing restrictions on vertical control.\(^{12}\) Item (ii) is in contrast with the result in Chikhladze and Mandy (2009), that states that sabotage is decreasing in vertical control when access is priced above cost and vice versa. The form of downstream competition matters for the effect of vertical control on sabotage. A more detailed examination of \( \frac{\partial^2 \pi^{IP}}{\partial s \partial \lambda} \) reveals that:

\[
\frac{\partial^2 \pi^{IP}}{\partial s \partial \lambda} = (P^* - c^d - c^u) \frac{\partial^2 q^{*d}}{\partial s \partial \lambda} + \frac{\partial q^{*d}}{\partial s} \frac{\partial P^*}{\partial \lambda} + (a - c^u) \frac{\partial^2 Q^*}{\partial s \partial \lambda} + \frac{\partial P^*}{\partial s} \frac{\partial q^{*d}}{\partial \lambda},
\]

where the second term is zero since the market price does not depend on \( \lambda \). In Chikhladze and Mandy (2009) this term is inversely related to \( (a - c^u) \) and dominates the expression. The price-taking fringe with entry pegs the price, thereby eliminating the regulator’s ability to push up price as a disincentive to sabotage (when \( a > c^u \)).

The regulator seeks to maximize the welfare function (7). Differentiating (7),

\(^{12}\)See the CALLS proposal adopted in FCC (2000) and Section 272(b) of the US Telecommunications Act of 1996.
while accounting for the resulting changes in the optimal levels of sabotage and the downstream quantities, yields:

\[
\frac{\partial W}{\partial a} = (P^* - c^d - c^u) \frac{\partial q^d}{\partial a} + (a - c^u) \frac{\partial Q^*}{\partial a} + \frac{\partial s^*}{\partial a} \Psi \tag{20}
\]

\[
\frac{\partial W}{\partial \lambda} = (P^* - c^d - c^u) \frac{\partial q^d}{\partial \lambda} + (a - c^u) \frac{\partial Q^*}{\partial \lambda} + \frac{\partial s^*}{\partial \lambda} \Psi,
\tag{21}
\]

where

\[
\Psi = (P^* - c^d - c^u) \frac{\partial q^d}{\partial s} + (a - c^u) \frac{\partial Q^*}{\partial s} - \frac{\partial P^*}{\partial s} Q^* - K'(s^*) \tag{22}
\]

is a multiplier that reflects the effect on welfare of an increment in sabotage. As might be expected since sabotage is a socially costly activity:

**Lemma.** $\Psi \leq 0$.

It is assumed hereinafter that $W$ is strictly concave in $a$. Equation (20) shows that there is a direct effect of sabotage that causes the regulator to depart from inducing the efficient downstream price $P = c^d + c^u$ when setting the access price. Since the last term in (20) is nonnegative, an infinitesimal decrease in the access price starting at $a = c^u$ and $p^* = c^d + c^u$ would cause no change in the first two terms but would cause an increase in sabotage that directly diminishes welfare by $\Psi \frac{\partial s^*}{\partial a}$. These extra costs cause the regulator to set the access price higher than would be optimal in the absence of sabotage, resulting in an equilibrium downstream price above the first best level.

The complementarity result between the degree of vertical control and access margin as derived in Chikhladze and Mandy (2009) does not hold here. In Chikhladze and Mandy (2009) the optimal level of vertical control is either zero or one, and the
regulator chooses a positive access margin \((a - c^u > 0)\) if and only if \(\lambda = 1\) and a negative access margin \((a - c^u < 0)\) if and only if \(\lambda = 0\). This is because \(\frac{\partial W}{\partial \lambda} \geq a - c^u\) in Chikhladze and Mandy (2009). In contrast, at an interior equilibrium of the model under consideration herein, (21) can be rewritten to obtain:

\[
\frac{\partial W}{\partial \lambda} = (P^* - c^d - a) \frac{\partial q^{**d}}{\partial \lambda} + \frac{\partial s^*}{\partial \lambda} \Psi.
\]

(23)

The sign of (23) generally is not known as the IA’s quantity \(q^{*d}\) and optimal sabotage \(s^*\) move in the same direction when the degree of vertical control \(\lambda\) changes, while \(\Psi\) is non-positive and the margin \(P^* - c^d - a\) is non-negative. In Chikhladze and Mandy (2009) \(q^{*d}\) and \(s^*\) move in opposite directions because \(\frac{\partial s^*}{\partial \lambda} = -(a - c^u)\), in contrast to (18). Therefore, if the regulator chooses a positive access margin under Bertrand competition, then it is optimal to increase the degree of vertical control as doing so both promotes downstream efficiency and reduced the sabotage by the upstream parent. Here, under price-taking, if the regulator chooses a positive access margin then increasing the degree of vertical control improves productive efficiency but increases sabotage by the upstream parent.

However, as in Chikhladze and Mandy (2009), pricing access at cost is still not optimal. To see this consider equations (20) and (21). When access is priced at cost, then the dominant affiliate’s quantity \(q^{*d}\) and sabotage \(s^*\) by the IP are unaffected by changes in vertical control, therefore (21) is zero and (20) becomes:

\[
\left. \frac{\partial W}{\partial a} \right|_{a = c^u} = (P^* - c^d - a) \frac{\partial q^{*d}}{\partial a} + \frac{\partial s^*}{\partial a} \Psi.
\]

(24)

Since the last term and the downstream profit margin \(P^* - c^d - a\) are positive, this expression is zero only for unique \(\lambda_c \in [0, 1]\) (see proof of Proposition 3 in Appendix).
At this \( \lambda \), a small change in \( \lambda \) has no effect on welfare since \( \frac{\partial W}{\partial \lambda} = 0 \) but would make \( \frac{\partial W}{\partial a} \) nonzero. Then the regulator could change \( a \) in the appropriate direction to raise welfare. Hence the optimum is either \( a - c^a > 0 \) or \( a - c^a < 0 \). This result is at odds with some of the contemporary policies.\(^{13}\)

Generally, the regulator faces a trade-off when choosing the optimal degree of vertical control. Given the access margin, the optimal degree of vertical control must strike a balance between downstream efficiency and control of sabotage, as reflected in (23). For example, if the regulator were to choose a positive access margin then increase in the degree of vertical control does not directly affect the market quantity produced. However, a change in the degree of vertical control indirectly decreases the market quantity through an increase in sabotage. At the same time higher sabotage shifts production to the more efficient downstream affiliate. Conversely, if a negative access margin were chosen, an increase in the degree of vertical control decreases sabotage, which increases total market quantity produced, but at the same time shifts downstream production toward the less efficient fringe. In summary, a balance between welfare gains in downstream efficiency and welfare gains from reduced sabotage determines the optimal degree of sabotage.

On the other hand, the upstream monopolist’s cost of sabotage influences the regulator’s choice of access charge. The regulator would like to lower the access charge to induce output expansion but this may create more sabotage than it is worth in welfare terms. When sabotage is not very costly to the saboteur the regulator would like to increase the access charge in order to deter sabotage. Alternatively, if sabotage

\(^{13}\)For example, see FCC 2000.
costs are high then the regulator can use this as a “natural” deterrent to sabotage, and decrease the access charge to induce output expansion.

Generally, almost any combination of access price and vertical control can be optimal (except \( a = c^u \)), depending on model parameters. Figures 11-15 present examples showing equilibrium outcomes for sabotage, quantities and welfare as functions of the access margin \( a - c^u \) and the degree of vertical control \( \lambda \).\textsuperscript{14} The monotonicity of sabotage in the access charge as well as in the degree of vertical control promised by Proposition 5 is apparent in each example. These examples are constructed to show the diversity of possible equilibria. Figures 11-12 show that it may be optimal for the regulator to price access below marginal cost and fully restrict vertical control, or it may be optimal to price access above marginal cost and allow full vertical control. Figure 13 shows that it may indeed be optimal for the regulator to choose some intermediate degree of vertical control.

In Figure 11 the downstream affiliate is very efficient and sabotage is relatively costly. Here the optimal access margin is negative and the degree of vertical control is zero. With high sabotage costs the output-expanding benefit of pricing access below marginal cost exceeds the welfare cost of sabotage. Given the negative access margin and efficient downstream affiliate it is optimal to fully restrict vertical control to achieve the efficient downstream output mix.

Access must be priced above marginal cost in order to deter sabotage when sabotage is not very costly to the saboteur as shown in Figure 12. Given this positive

\textsuperscript{14}These examples are constructed using the same quadratic sabotage cost function \( K(s) = ms^2 \) as in Chikhladze and Mandy (2009). Also \( \alpha = 2.95, \beta = 0.2, c^u = 0.6, \theta = 1 \) and \( F = 0.09 \) in each of these examples.
access margin and very efficient downstream affiliate it is optimal to allow full vertical
control again to achieve the efficient downstream output mix. There is another interest-
esting feature worth noting in this figure. For access margins \( a - c^u = 0.6 \) or higher
(not shown in the figure) the fringe is foreclosed. At this point the optimal level of
sabotage for the IP is the corner outcome of zero sabotage. This is because at this
high access charge a positive level of sabotage will neither increase access revenues nor
shift production in favor of the IP’s downstream affiliate since the fringe is foreclosed.

Figure 13 presents equilibrium outcomes when the downstream affiliate is rela-
tively “inefficient” and sabotage is not costly. In this case, an intermediate degree
of vertical control \( \lambda = 0.4 \) is chosen since the cost advantage of the affiliate is not
so large. A further increase in \( \lambda \) would increase both the quantity produced by the
downstream affiliate and sabotage. The gain in welfare in terms of changing the
downstream mix in favor of the affiliate is offset by the higher level of sabotage. Ad-
ditionally, at the optimal access margin and degree of vertical control the IP chooses
not to sabotage. This is because higher sabotage would shift the downstream mix in
favor of the affiliate but would also decrease the total market quantity. At a higher
level of sabotage the IP would incur a loss in access revenues that offsets a gain in the
downstream production. Figures 14 and 15 show it is possible to have interior equilib-
rium outcomes for both sabotage and the downstream quantities for the intermediate
levels of the affiliate’s relative efficiency and for low costs of sabotage.
4.5 Summary

This paper examines restrictions on vertical control as a policy tool when the downstream market is competitive. As in Chikhladze and Mandy (2009), restricting vertical control gives the policy maker a new way of inducing output-expansion and can thereby complement access pricing policy when pricing policy alone is inadequate because of potential for non-price discrimination. Some of the results derived here are consistent with the results derived by Chikhladze and Mandy (2009) under differentiated Bertrand duopoly. Mainly, these results are: i) the regulator can discourage sabotage by increasing the access charge above cost, ii) vertical control is sterile when access is priced at cost, and iii) cost of sabotage (along with the downstream affiliate’s relative efficiency) determines the regulator’s choice of optimal policy. There are some important differences, however, when the downstream market is competitive. Vertical control has the opposite effect on sabotage because the downstream price is pegged, and a general complementarity between the optimal access charge and the degree of vertical control is not present. It may be optimal for the regulator to choose some intermediate level of vertical control depending on cost differences between the downstream affiliate and the fringe, and cost of sabotage for the IP.

Similar to the second essay, the regulator can use penalties\(^\text{15}\) to raise the cost of sabotage which in turn allows the regulator to price access below cost and hence increase welfare.\(^\text{16}\) These kind of penalties are optimal given that the administrative cost of imposing such penalties are not “too high.” In natural gas and electricity

\(^{15}\text{For example, see penalties imposed on Transco (pg. 15), Oasis (pg. 17) and Cleco (pg. 27).}\)

\(^{16}\text{See Figures 11 and 12.}\)
markets the FERC has traditionally pursued weaker separation policies than the FCC has pursued in telecommunications.\textsuperscript{17} The theory alone cannot determine whether high or low access charges should be used for this vertical control policy, as the exact optimal policy under price-taking requires numerical simulations. Moreover, the FERC has recently been strengthening separation requirements as a general policy\textsuperscript{18} but in some cases stopped short of requiring a complete corporate divorce between the integrated monopolist and the affiliate. Based on the results of this essay, we cannot definitely rationalize the FERC’s policy of strong vertical separation, because whether this type of policy is optimal generally depends on the access charges used as well as on the relative efficiency of the affiliated company.

\textsuperscript{17}See independent functioning requirements of Order 497, pg. 13.
\textsuperscript{18}See Order 2004, pg. 18 and Order No. 890, pg. 30.
4.6 Appendix 2

Proof of Proposition 1. See the main text.

Proof of Proposition 2. Given the fringe’s variable cost structure \(c(q^f) = (q^f)^2\), the interior equilibrium values of market price and individual fringe output from (13) and (14) are:

\[
q^f(s) = \sqrt{\frac{(1 + \theta s)F}{1 + s}} \quad P^*(s, a) = 2\sqrt{(1 + s)(1 + \theta s)F} + a. \tag{25}
\]

\(P^*(s, a)\) is clearly increasing in both \(s\) and \(a\). Since \(\frac{\partial q^f}{\partial s} = \sqrt{\frac{(1+s)F}{1+\theta s}} \frac{-\theta - 1}{2(1+s)^2}\), \(q^f\) is increasing in sabotage when \(\theta > 1\), decreasing when \(\theta < 1\) and unchanged when \(\theta = 1\).

Proof of Proposition 3. Given \(P^*(s, a)\) and \(q^f(s)\) in (25), we can use (11) and the market clearing condition \(P^*(s, a) = \alpha - \beta(q^* + Q^*)\) to solve for the IA’s output and the measure of the fringe:

\[
n^*(s, a, \lambda) = \frac{2(1 + s)(\alpha - a - \lambda(a - c^d))}{\beta(4\sqrt{(1 + s)(1 + \theta s)F - c^d})} - \frac{2(1 + s)}{\beta}, \tag{26}
\]

\[
q^d(s, a, \lambda) = \frac{(\alpha - a)(2\sqrt{(1 + s)(1 + \theta s)F} - c^d) + \lambda(a - c^u)2\sqrt{(1 + s)(1 + \theta s)F}}{\beta(4\sqrt{(1 + s)(1 + \theta s)F - c^d})}. \tag{27}
\]

Notice that in an interior equilibrium, \(\alpha - a - \lambda(a - c^u)\) must be positive in (26). Differentiating (26) and (27) yields:

\[
\frac{\partial q^d}{\partial s} = \frac{c^d(\alpha - a - \lambda(a - c^u))(1 + \theta + 2\theta s)F}{\beta(4\sqrt{(1 + s)(1 + \theta s)F - c^d})^2} > 0, \tag{28}
\]

\[
\frac{\partial q^d}{\partial a} = \frac{c^d - 2\sqrt{(1 + \theta s)(1 + s)F(1 - \lambda)}}{\beta(4\sqrt{(1 + \theta s)(1 + s)F - c^d})}, \tag{29}
\]

\[
\frac{\partial n^*}{\partial a} = -\frac{2(1 + s)(1 + \lambda)}{\beta(4\sqrt{(1 + \theta s)(1 + s)F - c^d})} < 0, \tag{30}
\]

\[
\frac{\partial q^d}{\partial \lambda} = \frac{(a - c^u)2\sqrt{(1 + \theta s)(1 + s)F}}{\beta(4\sqrt{(1 + \theta s)(1 + s)F - c^d})} \leq a - c^u, \tag{31}
\]

\[
\frac{\partial n^*}{\partial \lambda} = -\frac{2(1 + s)(a - c^u)}{\beta(4\sqrt{(1 + \theta s)(1 + s)F - c^d})} \leq -(a - c^u). \tag{32}
\]

From (29) there is a critical value \(\lambda_c = \frac{2\sqrt{(1+\theta s)(1+s)F-c^d}}{2\sqrt{(1+\theta s)(1+s)F}}\) such that \(\frac{\partial q^d}{\partial a} < 0\) when \(\lambda < \lambda_c\), \(\frac{\partial q^d}{\partial a} > 0\) when \(\lambda > \lambda_c\) and \(\frac{\partial q^d}{\partial a} = 0\) when \(\lambda = \lambda_c\).

Rewrite the expression for \(n^*\) as \(n^* = \frac{a - P^* - \beta q^d}{\beta q^d}\). Then

\[
\frac{\partial n^*}{\partial s} = \frac{\left(-\frac{\partial P^*}{\partial s} - \beta \frac{\partial q^d}{\partial s}\right)q^f - \frac{\partial q^f}{\partial s}(\alpha - P^* - \beta q^d)}{\beta(q^f)^2} \tag{33}
\]
Since the first term in parenthesis is negative and the second term in parenthesis is negative, the above expression has a negative sign when $\frac{\partial q^*}{\partial s} \geq 0 \Leftrightarrow \theta \geq 1$.

**Proof of Proposition 4.** Assuming the IP does not sabotage, the market interior equilibrium price is $P^* = 2\sqrt{F} + a$. The regulator must choose $(a, \lambda)$ so that the fringe does not participate and the IA charges the efficient price $P = c^d + c^u$. Given that the fringe does not participate, the IA will use monopoly pricing, that is, $p^m = \frac{a+c^d+a-\lambda(a-c^u)}{2}$. Therefore, $\frac{a+c^d+a-\lambda(a-c^u)}{2} = c^d + c^u$ implies $a - c^u = \frac{c^d+c^u-\alpha}{1-\lambda}$. Given that feasible $\lambda \in [0, 1)$ can be chosen and the demand parameter is large enough to cover marginal costs of production, $c^d$ and $c^u$, the access margin $a - c^u$ is always negative.

Also, in order to keep the fringe foreclosed $a$ must be set sufficiently high, that is, $c^d + c^u \leq 2\sqrt{F} + a \Rightarrow a - c^u \geq c^d - 2\sqrt{F}$. Combining this with the efficient pricing requirement implies that

$$\lambda \leq \frac{\alpha - 2\sqrt{F} - c^u}{c^d - 2\sqrt{F}}. \quad (34)$$

Since the denominator of the above expression is negative, the necessary condition for feasible $\lambda$ is that $\alpha - 2\sqrt{F} - c^u$ be negative. Given that this necessary condition is satisfied, viability of the integrated firm implies that right side of the above expression is bounded above by 1.

Lastly, full vertical control ($\lambda = 1$) is never optimal since the regulator then loses the access charge as a policy tool and cannot achieve downstream efficiency, as seen from the $p^m$ expression above.

Also, given that the necessary condition is satisfied and optimal $(a, \lambda)$ are chosen according to (16), the IP does not sabotage because sabotage is costly and does nothing when the fringe is foreclosed by high prices.

**Proof of Lemma.** Define $K'(s^*)$ from the IP’s first order condition as:

$$\frac{\partial \pi^{IP}}{\partial s} = (P^* - c^d - c^u)\frac{\partial q^*}{\partial s} + (a - c^u)\frac{\partial Q^*}{\partial s} + q^*d\frac{\partial P^*}{\partial s} - K'(s) = 0 \quad (35)$$

$$K'(s^*) = (P^* - c^d - c^u)\frac{\partial q^*}{\partial s} + (a - c^u)\frac{\partial Q^*}{\partial s} + q^*d\frac{\partial P^*}{\partial s}. \quad (36)$$

Substitute (36) into (22) to get

$$\Psi = -(Q^* + q^*d)\frac{\partial P^*}{\partial s} < 0. \quad (37)$$

**Proof of Proposition 5.** Differentiating (35) with respect to $a$ yields:

$$\frac{\partial^2 \pi^{IP}}{\partial s \partial a} = \frac{\partial^2 q^*}{\partial s \partial a}(P^* - c^d - a) + \frac{\partial P^*}{\partial s}(\frac{\partial q^*}{\partial a} - \frac{1}{\beta}), \quad (38)$$

where

$$\frac{\partial^2 q^*}{\partial s \partial a} = \frac{-c^d(1 + \lambda)(1 + \theta + 2\theta s)F}{\beta \sqrt{(1 + \theta s)(1 + s)F(4\sqrt{(1 + \theta s)(1 + s)F} - c^d)^2}} < 0 \quad (39)$$
from (28) and
\[
\frac{\partial q^* d}{\partial a} - \frac{1}{\beta} = \frac{2c^d - 2\sqrt{(1 + s)(1 + \theta s)}F(3 - \lambda)}{\beta(4\sqrt{(1 + \theta s)(1 + s)}F - c^d)} < 0
\] (40)
for \( \lambda \in [0, 1] \). Therefore (38) is negative.

Simplifying (19) yields:
\[
\frac{\partial^2 \pi^{IP}}{\partial s \partial \lambda} = (P^* - c^d - a) \frac{\partial^2 q^* d}{\partial s \partial \lambda} + \frac{\partial P^*}{\partial s} \frac{\partial q^* d}{\partial \lambda}.
\] (41)

Using \( \frac{\partial^2 q^* d}{\partial s \partial \lambda} = \frac{-c^d(a - c^u)(1 + \theta + 2\theta s)F}{\beta \sqrt{(1 + \theta s)(1 + s)}F(4\sqrt{(1 + \theta s)(1 + s)}F - c^d)^2} \) (derived from (28)) and (31) yields:
\[
\frac{\partial^2 \pi^{IP}}{\partial s \partial \lambda} = \frac{\sqrt{F}(1 + \theta + 2\theta s)(a - c^u)(4\sqrt{(1 + \theta s)(1 + s)}F(2\sqrt{(1 + \theta s)(1 + s)}F - c^d) + (c^d)^2)}{\beta \sqrt{(1 + \theta s)(1 + s)}F(4\sqrt{(1 + \theta s)(1 + s)}F - c^d)^2}
\]
\[
\overset{=} {=} a - c^u
\] (42)
Figure 10: Game Tree.
Figure 11: Equilibrium Outcomes when $m = 150$ and $c^d = 0.1$. 

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Figure 12: Equilibrium Outcomes when $m = 5$ and $c^d = 0.1$.  

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Figure 13: Equilibrium Outcomes when $m = 5$ and $c^d = 0.58$. 

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Figure 15: Equilibrium Outcomes when $m = 4$ and $c^d = 0.45$. 

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References


VITA

George Chikhladze was born in Kutaisi, Georgia in 1978. He graduated with BA in Economics from the University of Missouri in 2000 and he received MA in Economics and MS in Mathematics from the University of Missouri in 2003. In 2004 he started his doctoral studies in Economics at the University of Missouri.

As a graduate student George Chikhladze worked as a teaching assistant for Dr. Harstad, Dr. Podgursky, Dr. Haslag. George has been leading independent sections of intermediate microeconomics for over a year. His research interests include microeconomic theory, industrial organization and regulation.