Revista de Análisis Económico, Vol. 16, Nº 2, pp. 77-107 (Diciembre 2001)

THE ROLE OF INFORMATIONAL RENTS: NETWORK UTILITIES AND VERTICAL STRUCTURE*

EDUARDO SAAVEDRA**
Universidad Alberto Hurtado

Abstract

This paper presents a theoretical assessment of the efficiency implications of alternative vertical structures in an industry characterized by a natural monopoly, vertically related to potentially competitive markets (network utilities). Based on the incomplete contracts and asymmetric information paradigm, I show that the monopoly's informational rents vary according to the vertical structure of the industry. This, in turn changes the relative advantages of these alternative structures in terms of their allocative and productive inefficiencies. The main policy conclusion of this paper is that the existence of conglomerates in network industries matters. This paper's contribution is that its exploration of the issue does not assume that monopolies behave in an uncompetitive fashion toward their rivals, as is common in the literature on this subject. This paper, therefore, offers an economic rationale for vertical separation.

* I am grateful to Kaushik Basu, David Easley, Robert Masson, Eduardo Zambrano, and seminar participants at Universidad Alberto Hurtado (ILADES), Universidad de Concepción, and LACEA/Rio de Janeiro 2000 for helpful comments on earlier versions of this article. I also thank to two anonymous referees of this journal. Any remaining errors in this paper are mine.
** Programa de Postgrado en Economía, ILADES/Georgetown University. E-mail: saavedra@uahurtado.cl

I. Introduction

Many public enterprises were privatized in developed and developing countries in the 80's and 90's. From both the empirical and theoretical points of view, it is clear that privatizing public firms in competitive sectors may increase social welfare. This outcome is not clear, however, when privatizing public monopolies. While some studies found empirical support for this practice (e.g., Galal, *et al*., 1994, Levy and Spiller, 1996; and Newbery, 1997), from a theoretical point of view the best choice in terms of ownership and control is still ambiguous, particularly when considering network utilities.

Taking privatization as a given, this paper compares the *welfare implications* of two different market (vertical) structures, *liberalization* and *vertical separation*, in an industry with naturally monopolistic characteristics. It may be useful to begin with some definitions.

Liberalization is a market structure in which any firm is free to enter the competitive market, including the monopoly.

Vertical separation is a market structure in which the monopoly is not allowed to produce in any related market.

In studying the welfare implications of the alternative structures, I define **welfare** as the net social surplus.

The model suggests that these two forms of market structure have markedly different effects on the allocative and productive efficiency of the industry. It therefore supports vertical separation of competitive and monopolistic activities by privately owned entities. This result, however, is not based on noncompetitive assumptions concerning the monopoly's behavior. As a matter of fact, the model's action arises from the informational rents that the monopoly achieves because of its better knowledge about its cost function and technological parameters, compared to that of the regulator's.[1]

The fact that the design of a vertical structure matters is not new on the literature about utility regulation. Most of the work already done shows us that the trade-off comes from a basic externality that is reduced or eliminated by a vertically integrated monopoly. For further references see Spengler (1950), Tirole (1988), and Perry (1989) on the double mark-up effect, and Williamson (1985), Joskow (1985) and Grossmann and Hart (1986) on the Hold-Up effect. These examples illustrate the pros of vertical integration. The cons of vertical integration have always been demonstrated assuming noncompetitive practices on the part of the monopoly. Some references in this regard are Armstrong, Cowan, and Vickers (1994), Vickers (1995), Tirole (1988), Díaz and Soto (2000), Galetovic (2000), and Saavedra (2001).

The literature on applied contract theory provides me with the theoretical support to suit my problem. In particular, in the subject of utility ownership, the literature tells us that ownership is irrelevant and liberalization Pareto dominates any other market structure. This result is true where fully contingent contracts can be written at the moment of choosing the best institutional arrangement for the network utility. Williamson (1985) states that where transaction costs are zero, the government can write a full contingent contract that causes public firms to function very like private ones. Moreover, a public firm may outperform private firms when externalities are present. Therefore, under complete contracting a public firm can be at least as good as a private firm, from the point of view of social welfare. On the other hand, Sappington and Stiglitz (1987) show the converse in their Fundamental Theorem of Privatization. Whenever possible, the government may write out a full contingent contract specifying the whole life of a firm after being privatized. Thus, from society's perspective a private firm can be at least as good as a public firm.[2]

However, when the government cannot write complete contracts (for example, when there are unforseen contingencies) we no longer have conclusive results regarding whether private or public monopolies are more efficient.[3] For example, Shapiro and Willig (1990) suggest that privatization changes the firm's incentive structure, with private ownership reducing the incentives of government's officials to pursue their own agenda, making it less efficient than public ownership in the allocation of resources. Laffont and Tirole (1991) show that a private monopoly is productively efficient but conflicts in the agenda of the principals, a regulator and shareholders, leads to low-powered incentive schemes. Schmidt (1990) and (1996), whose framework I follow closely, shows a trade-off between a private monopoly, which may produce at lower costs, and a public monopoly, which always produces Pareto optimal allocations. Finally, Laffont (1995) suggests that there is a trade-off between the lower costs of low-powered incentive schemes under privatization and the expectations of rent appropriation under public ownership.

Many other issues need to be taken into account, however, when analyzing privatization in developing countries.[4] For example, at the very least, a suitable, incentive-oriented regulatory framework requires well prepared regulators, and clear, enforceable laws and regulations. Indeed, most of these characteristics are missing in developing countries. Moreover, as mentioned, other factors affect the allocative efficiency of private monopolies, as long as they are allowed to carry out potentially competitive activities. Although the latter is not exclusive to developing countries,[5] its adverse implications are exacerbated by regulator's incompetence, ambiguities in the regulatory framework, and the lack of institutions able to enforce contracts. These conditions justify using the incomplete contracting approach in this paper.

This paper's main contribution to the literature on privatization and incomplete contracts using optimal mechanism design is to introduce a network utility industry into the analysis. Most of the literature has assumed a monopoly unrelated to other potentially competitive markets. Such a setting is far from reality, because natural monopolies are tipically networks that is, they are vertically related to competitive activities. For example, the telecommunications sector usually has a natural monopoly on local telephone services, which provide access to wireless and long distance telephone service, cable TV, and Internet; the electric sector has natural monopolies in transmission and distribution, but generation and retail segments of the industry are potentially competitive; pipelines may be de-signed to be open carriers to distributors; track activity in railroads is a natural monopoly, but passenger and freight markets are potentially competitive; finally, in the water and sewage industry, distribution and collection are natural monopolies, whereas water supply and sewage treatment and disposal may become competitive markets. Therefore, a framework consistent with actual practice provides an economic rationale for some commonly observed institutional arrangements in several regulated industries.

This result highlights the importance of strenghtening regulatory and antitrust institutions in developing countries. This paper shows that there is no hard and fast rules when it comes to the question of vertical integration versus separation. Regulatory or anti-trust agencies must, therefore, be able to carry out their own analysis at the moment of studying a specific case of vertical integration. For instance, whether or not the monopoly preys on or discriminates against its rivals, society may be better off with a vertically separated industry. The converse is also true; even if noncompetitive practices are reported, society may be better off with a vertically integrated monopoly.

This paper is organized as follows. The basic model of two vertically related markets, one of which is a natural monopoly and the other a competitive market, is presented in the next section. In section III, I assume that the government has chosen to liberalize the industry, which was previously sold to a private interest in a competitive bidding process. I analyze the vertically separated structure of the industry in section IV and compare these alternatives in this section. A simple example that highlights the main findings of this paper is provided in section V. Finally, section VI concludes.

II. The Model

There are two vertically related goods. A natural monopoly upstream produces y units of an intermediate good. This good is only used as input in the downstream industry. This monopoly may also produce x_m units of the downstream good using a decreasing return to scale technology. Let us assume, without loss of generality, that both y and x_m are produced by an integrated monopoly.

Technologies used by the monopoly are not common knowledge, however. The owner knows more, for example, about the efficiency of technological processes inside the firm. Accordingly, total costs of the monopoly, unknown to outsiders, are $k(\theta) \cdot y + C(x_m, \theta)$, where $\theta \in \{\underline{\theta}, \overline{\theta}\}$ is an adverse selection parameter that summarizes the efficiency level of the firm. Nonetheless, the support of θ is common knowledge.[6]

Let us assume the existence of important sunk costs that justify the assumption of there being one firm (monopoly) producing the upstream good. These costs, however, are less than the social value of the final good, x, for any $x > 0$. They become irrelevant, however, when analyzing differences in payoffs of the alternative institutional arrangements. Thus, I take it out of the parties' payoffs.

Assume that $C(x_m, \theta)$ is strictly increasing and convex in x_m, for all x_m. Convexity of $C(x_m, \theta)$ is consistent with a strictly increasing and concave production function when the monopoly produces the downstream good. This, in turn, implies that the derived demand for the input from the monopoly itself is a strictly increasing and convex function of x_m. That is, $y = \varphi\,(x_m, \theta)$, such that $\varphi' > 0$ and $\varphi'' > 0$. For simplicity, let us write it as $\varphi(x_m)$. In addition, assume that $k(\underline{\theta}) < k(\overline{\theta})$, $C(x_m, \underline{\theta}) < C(x_m, \overline{\theta})$, and $C'(x_m, \underline{\theta}) < C'(x_m, \overline{\theta})$, for all x_m. The last condition is the Spence-Mirrlees condition (single crossing condition).[7]

An important assumption in the model is that only the owner of the monopoly observes the adverse selection parameter, θ. Since the monopoly is private, the government is unable to observe θ and must elicit the true information by solving a mechanism design problem. Let us assume that before θ is realized by the monopoly owner, she may invest effort e in cost-reducing activities. The higher the value of e, the more likely the firm will be efficient. Let $q(e)$ be the probability of obtaining $\underline{\theta}$. In order to obtain interior solutions, assume that, for all e 0, $q(e)$ is strictly increasing and concave, $\lim_{e \to 0} q_e(e) = \infty$, $\lim_{e \to \infty} q_e(e) = 0$, and $0 < q(e) < 1$.

There is a potential competitive fringe downstream. If the fringe enters, it produces x_f units of the downstream good, using a linear technology. The fringe's marginal cost is constant, c, and common knowledge[8]. The monopoly charges an access price a for each unit of its intermediate good sold to the fringe and this access price may be regulated. As usual in practice, in order to avoid market foreclosure, I assume that the monopoly cannot refuse to sell any required inputs by the fringe (open access).

Therefore, total production of the input is equal to its total derived demand, that is $y = \varphi\,(x_m) + x_f$. From now on I use $\left[\varphi(x_m) + x_f\right]$ instead of y, so I denote $k(\theta) \cdot \left[\varphi(x_m) + x_f\right]$ as the upstream cost function of producing $\left[\varphi(x_m) + x_f\right]$ units of the intermediate good.

I assume that the downstream activity produces a social benefit of $v(x_m + x_f)$. Let $v(\cdot)$ be strictly increasing and concave, satisfying Inada Conditions, and $v(0) = 0$. Assume income effects are negligible. Thus $v'(x_m + x_f) = P(x_m + x_f)$ corresponds to the inverse demand function for the final good. Moreover, market equilibrium implies zero profit to the fringe $\left(P(x_m + x_f) = c + a\right)$.

The structure of these related markets allows us to analyze the efficiency advantages and pitfalls of vertical separation versus full liberalization of the industry.

Let us assume that the government sells the monopoly at time zero and charges a price z to the winner of a competitive bidding process. In equilibrium, this price drives the new monopoly owner to her expected reservation utility (for simplicity's sake, I'll assume this utility to be zero).

Let us consider a case where the regulator determines cost reimbursement rules. The government gets revenue from this monopoly activity and pays to the monopoly owner a transfer $T(\theta)$ in period 4. The government determines transfers using a menu of contracts set in period 3, before production takes place (period 4) and just after the monopoly owner realizes θ (period 2). Since a direct mechanism requires the menu of contracts to be contingent on observable variables, transfers are fixed contingent to the monopoly production, y and x_m. Thus, each contract is a transfer-production pair $\left\{T(x_m(\theta), x_f(\theta)), (x_m(\theta), x_f(\theta))\right\}$, for each $\theta \in \left\{\underline{\theta}, \overline{\theta}\right\}$, which induces truth-telling.

Figure 1, below, indicates the timing of actions in this model.

FIGURE 1

0	1	2	3	4
– Privatization – Contract • fixes e (when contractible)	– Investment in efforts	– θ realized by the monopoly owner	– Government sets menu of contracts $\{T(x_m, x_f), (x_m, x_f)\}$	– Production takes place – Payments – Payoff realized

All players are risk neutral and there is no discounting. Table 1 presents player's payoffs for market structure, which are realized in period 2 (by definition, each competitive firm in the fringe obtains zero profits).

TABLE 1

	Government (V)	Monopolist (U)
lib:	$v(x_m + x_f) + z - T(\theta) - c \cdot x_f$	$-z + T(\theta) - k(\theta) \cdot \left[\varphi(x_m) + x_f\right] - C(x_m, \theta) - e$
sep:	$v(x_f) + z - T(\theta) - c \cdot x_f$	$-z + T(\theta) - k(\theta) \cdot x_f - e$

Note: These abbreviations work as follows: *lib* means liberalization and *sep* means vertical separation.

III. Liberalization of the Downstream Market

3.1 First best allocations

In the benchmark of this market structure I assume that the contract signed by the parties is complete, in the sense that it specifies relevant variables contingent to the states of nature. Proposition 1 characterizes the first best production and allocations.

Proposition 1. *Under full contracting there is a unique vector of allocations, access price, and a level of cost reducing activities* $(x_m^*(\theta), x_f^*(\theta),\ a^*(\theta), e^*)$*, for each* $\theta \in \{\underline{\theta}, \overline{\theta}\}$*, which is optimal from society's point of view. Furthermore, the monopoly owner gets zero ex-post payments. Thus, the next five equations fully characterize the first best:*

$$P\left(x_m^*(\theta) + x_f^*(\theta)\right) = k(\theta) \cdot \varphi'(x_m^*(\theta)) + C'(x_m^*(\theta), \theta) \tag{1}$$

$$P(x_m^*(\theta) + x_f^*(\theta)) = k(\theta) + c \tag{2}$$

$$a*(\theta) = k(\theta) \tag{3}$$

$$q_e(e^*) \cdot \left[W^*(\underline{\theta}) - W^*(\overline{\theta})\right] = 1 \tag{4}$$

$$U = 0 \tag{5}$$

where $W*(\theta)$ *corresponds to the ex-post net social benefit of producing* $x_m^*(\theta) + x_f^*(\theta)$ *units of the final good, for each* $\theta \in \{\underline{\theta}, \overline{\theta}\}$ *that is:*

$$W*(\theta) \equiv v(x_m^*(\theta) + x_f^*(\theta)) - k(\theta) \cdot \left[\varphi(x_m^*(\theta)) + x_f^*(\theta)\right]$$

$$-C(x_m^*(\theta), \theta) - c \cdot x_f^*(\theta)$$

Proof. See Appendix A.

Remark 1. *An interesting result is that under complete contracting the access price is not an issue, because any deviation from the optimal price would be severely punished since third parties may verify any variable.*

In period 0, the government's expected payoff under full contracting and liberalization of the industry is equal to:

$$V^* = q(e^*) \cdot W^*(\underline{\theta}) + \left[1 - q(e^*)\right] \cdot W^*(\overline{\theta}) - e^* \tag{6}$$

3.2 Noncontractible allocations

Long term contracts in general are not feasible, however. Since the technological parameter is only realized in period 2, the time zero contract cannot specify contingent efforts, production, or transfers. In addition, the government cannot commit to never appropriating rents from cost-reducing activities. Therefore, optimal allocation of resources would not be achieved.

The monopoly owner realizes θ in period 2. This technological parameter is unknown to the government, however. Thus the government must design a revelation mechanism to elicit the true value of θ. It is standard that the asymmetric information on θ allows efficient firms to obtain profits. The monopolist, therefore, has an incentive to invest in cost-reducing activities. Proposition 2, below, characterizes second-best production and transfers. The result is well known in the literature[9]. It is characterized by "no-distortion-and-informational-rents-on-the-top" and "underproduction-and-no-rents-at-the-bottom". Therefore, the private monopoly is allocatively inefficient because it produces less than the first best level.

Let $\hat{e}$ be the government's equilibrium belief regarding the action taken by the monopolist in cost-reducing activities (below I show that this belief is a single mass point). Let us assume that the government believes the costs are low with probability $\hat{q} \equiv q(\hat{e})$. Informational rents of the efficient monopolist are equal to $R^U(\hat{e})$ in the upstream market and $R^D(\hat{e})$ in the downstream market, where

$$R^U(\hat{e}) \equiv \left[k(\overline{\theta}) - k(\underline{\theta})\right] \cdot \left[\varphi(x_m(\overline{\theta},\hat{e})) + x_f(\overline{\theta},\hat{e})\right]$$

$$R^D(\hat{e}) \equiv C(x_m(\overline{\theta},\hat{e}),\overline{\theta}) - C(x_m(\overline{\theta},\hat{e}),\underline{\theta})$$

The government's problem in period 3 can be expressed as the problem of a central planner choosing $\left\{x_m(\underline{\theta},\hat{e}), x_f(\underline{\theta},\hat{e}), x_m(\overline{\theta},\hat{e}), x_f(\overline{\theta},\hat{e})\right\}$.[10] That is,

$$\begin{aligned}
Max \quad & \Big\{\hat{q} \cdot \Big[v(x_m(\underline{\theta},\hat{e}) + x_f(\underline{\theta},\hat{e})) - k(\underline{\theta}) \cdot (\varphi(x_m(\underline{\theta},\hat{e})) + x_f(\underline{\theta},\hat{e}) \\
& -C(x_m(\underline{\theta},\hat{e}),\underline{\theta}) - c \cdot x_f(\underline{\theta},\hat{e}) - \underline{U}\Big] \\
& + (1-\hat{q}) \cdot \Big[v(x_m(\overline{\theta},\hat{e}) + x_f(\overline{\theta},\hat{e})) - k(\overline{\theta}) \cdot (\varphi(x_m(\overline{\theta},\hat{e})) + x_f(\overline{\theta},\hat{e})) \\
& -C(x_m(\overline{\theta},\hat{e}),\overline{\theta}) - c \cdot x_f(\overline{\theta},\hat{e}) - \overline{U}\Big] \\
& - \hat{e}\Big\}
\end{aligned}$$

subject to individual rationality (IR's) and incentive compatibility (IC's) constraints (nomenclature is standard):

$$\text{IR}(\underline{\theta}) : \underline{U} \geq 0$$

$$\text{IR}(\overline{\theta}) : \overline{U} \geq 0$$

$$\text{IC}(\underline{\theta}) : \underline{U} \geq U(\overline{\theta} / \underline{\theta})$$

$$\text{IC}(\overline{\theta}) : \overline{U} \geq U(\underline{\theta} / \overline{\theta})$$

Let $x_j^{lib}(\underline{\theta})$ and $x_j^{lib}(\overline{\theta})$, for $j = \{m, f\}$, be the solution to the government's problem.

Proposition 2. *An interior solution to the government's problem is fully characterized by:*

$$\begin{pmatrix} \overline{U} \\ \underline{U} \end{pmatrix} = \begin{pmatrix} 0 \\ R^U(\hat{e}) + R^D(\hat{e}) \end{pmatrix} \tag{7}$$

$$\begin{pmatrix} x_m^{lib}(\underline{\theta}) \\ x_f^{lib}(\underline{\theta}) \end{pmatrix} = \begin{pmatrix} x_m^*(\underline{\theta}) \\ x_f^*(\underline{\theta}) \end{pmatrix} \tag{8}$$

$$\begin{pmatrix} x_m^{lib}(\overline{\theta}) \\ x_f^{lib}(\overline{\theta}) \end{pmatrix} < \begin{pmatrix} x_m^*(\overline{\theta}) \\ x_f^*(\overline{\theta}) \end{pmatrix} \tag{9}$$

Proof. See Appendix A.

Distortion when the monopoly is inefficient is the cost of private ownership in this model. Underproduction also affects the access price that the monopolist charges to the fringe for using its intermediate good, usually a network facility. As expected, the optimal access price represents the shadow costs to the monopolist for providing its input to competitors[11]. The access price charged by the efficient monopoly is similar to that resulting from complete contracting. Otherwise, the competitive market would not be cleared.

$$a^{lib}(\underline{\theta}) = a^*(\underline{\theta}) = k(\underline{\theta})$$

However, when the monopoly is inefficient, this price is higher than the first best access price.

$$a^{lib}(\overline{\theta}) = k(\overline{\theta}) + \frac{\hat{q}}{1-\hat{q}} \cdot \left[R_{x_f}^U(\hat{e}) \right]$$

$$> a^*(\overline{\theta}) = k(\overline{\theta})$$

The latter inequality is because $R_{x_f}^U(\hat{e}) > 0$ by the single crossing property and monotonicity on $C(x_m, \theta)$ and $\varphi(x_m, \theta)$. The first term in $a^{lib}(\overline{\theta})$ is the direct marginal cost to the monopoly of providing access to the fringe. The second term is the monopolist's opportunity cost in terms of lower informational rents.

Since I have assumed cost reimbursement rules, the government makes a transfer to the owner of the monopoly that covers opportunity costs. Let $T^{lib}(\theta)$ be such transfers, for $\theta \in \{\underline{\theta}, \overline{\theta}\}$. Notice that the government is using a truth-telling mechanism, thus it is fine to use $T^{lib}(\theta)$ instead of $T^{lib}\left(x_m^{lib}(\theta), x_f^{lib}(\theta)\right)$. Therefore,

$$T^{lib}(\underline{\theta}) = k(\underline{\theta}) \cdot \left[\varphi\left(x_m^{lib}(\underline{\theta})\right) + x_f^{lib}(\underline{\theta})\right] + \left[C\left(x_m^{lib}(\underline{\theta}), \underline{\theta}\right)\right] + \left[R^U(\hat{e}) + R^D(\hat{e})\right]$$

$$T^{lib}(\overline{\theta}) = k(\overline{\theta}) \cdot \left[\varphi\left(x_m^{lib}(\overline{\theta})\right) + x_f^{lib}(\overline{\theta})\right] + \left[C\left(x_m^{lib}(\overline{\theta}), \overline{\theta}\right)\right]$$

The above discussion tells us that the firm is granted total freedom in choosing the access price. However, the revelation principle ensures the firm will choose the second best level, $a^{lib}(\theta)$, for $\theta \in \{\underline{\theta}, \overline{\theta}\}$. Such a result is a direct consequence of the common network assumption in the model, as noted by Laffont and Tirole (1993), chapter 5. Under this assumption, the monopoly cannot charge an excessive access price to the fringe in order to deter entry in the downstream market. By doing so, the monopoly would increase its market share in the downstream industry with a higher x_m, but it would reveal a predatory practice to the government. The government knows that a higher access price means higher marginal costs for x_m too, which is inconsistent with raising x_m.[12]

Both, the monopolist and the regulator know what will happen after the firm undertakes investments in cost reducing activities. The next proposition tells us that the monopolist invests less than the optimal e^*.

Proposition 3. *The monopoly owner invests $e^{lib}(\hat{e})$, which is her best response to the government's belief that she invests $\hat{e}$, and 0 < $e^{lib}(\hat{e}) < e^*$. Furthermore, a unique rational expectations equilibrium $e^{lib}(\hat{e}) = \hat{e}$ exists, determined by:*

$$q_e(e^{lib}(\hat{e})) \cdot \left[R^U(e^{lib}(\hat{e})) + R^D(e^{lib}(\hat{e}))\right] = 1 \tag{10}$$

Proof. See Appendix A.

Let $e^{lib} \equiv e^{lib}(\hat{e})$ represent the unique rational expectation equilibrium solving the monopolist problem above. In period zero, the government drives the monopoly owner to her expected reservation utility, which we have assumed equals zero. Therefore,

$$z^{lib} = q(e^{lib}) \cdot \left[R^U(e^{lib}) + R^D(e^{lib})\right] - e^{lib}$$

It turns out that the government's expected payoff is equal to:

$$V^{lib} = q(e^{lib}) \cdot W^*(\underline{\theta}) + \left[1 - q(e^{lib})\right] \cdot W^{lib}(\bar{\theta}) - e^{lib} \tag{11}$$

when the ex-post social surplus at $\bar{\theta}$ is below $W^*(\bar{\theta})$ and defined by:

$$W^{lib}(\bar{\theta}) \equiv v\left(x_m^{lib}(\bar{\theta}) + x_f^{lib}(\bar{\theta})\right) - k(\bar{\theta}) \cdot \left[\varphi\left((x_m^{lib}(\bar{\theta})\right) + x_f^{lib}(\bar{\theta})\right]$$

$$-C\left(x_m^{lib}(\bar{\theta}) + x_f^{lib}(\bar{\theta}), \bar{\theta}\right) - c \cdot x_f^{lib}(\bar{\theta})$$

IV. Vertical Separation of the Monopoly

Most of the discussion in privately owned utility is whether or not to vertically separate the monopolistic activity from potentially competitive industries. If prevented from owning a firm in competitive markets, the monopoly owner cannot use her informational rents to expand market power into other markets. I provide an economic rationale for this position[13].

Let us now consider the case where the monopoly is vertically separated and cannot produce the downstream good. The US government adopted this structure for the telecommunication sector, when it separated AT&T from its local network operators in 1984. Following the experience of the British privatization process, several developing countries, such as Argentina, organized the electric sector in this fashion too. Perhaps Chile is the most liberal in this regard. Most their utilities are functionally separated, but vertical ownership is not limited. From time to time and from industry to industry, however, the vertical integration-separation debate becomes an issue in Chile.

In most developing countries, people think that a vertically separated utility is the only way to accept privatization of these industries, otherwise the monopoly will use its market power against competitors by detering entry, discriminating or preying upon rivals, among other noncompetitive practices. In this case, however, I demonstrate that informational rents are less under this structure than in the liberalization structure. Thus, when reducing allocative inefficiencies is more important than increasing productive inefficiencies, it would be justifiable to vertically separate a network utility, as in the AT&T case. This result doesn't depend on assuming noncompetitive behavior on the part of the monopolist.

4.1 The benchmark

For each $\theta \in \left\{\underline{\theta}, \bar{\theta}\right\}$, the first best allocations are fully characterized by equations (12) to (15).

$$P\left(x_f^{**}(\theta)\right) = k(\theta) + c \tag{12}$$

$$a^{**}(\theta) = k(\theta) = a^*(\theta) \tag{13}$$

$$q_e(e^{**})\cdot\left[W^{**}(\underline{\theta})-W^{**}(\overline{\theta})\right]=1 \tag{14}$$

$$U = 0 \tag{15}$$

where $W^{**}(\theta)\equiv v\left(x_f^{**}(\theta)\right)-k(\theta)\cdot x_f^{**}(\theta)-c\cdot x_f^{**}(\theta)$.[14]

First of all, notice that equation (12) implies $x_f^{**}(\theta)=\varphi\left(x_m^{*}(\theta)\right)+x_f^{*}(\theta)$, equivalent to $y^{**}(\theta)=y^{*}(\theta)$, for each $\theta\in\left\{\underline{\theta},\overline{\theta}\right\}$. This result is not general, however. It comes from the fringe's constant marginal cost assumption in the downstream industry.

Let V^{**} be the expected value of the fully informed planner's problem in this case. Lemma 4 tells us that in a world where contingent contracts are feasible, the kind of ownership does not matter and, moreover, the common prejudice against integrated monopolies is incorrect. That is, in terms of efficiency, there are no economic reasons for opposing natural monopolies operating in related, competitive industries.

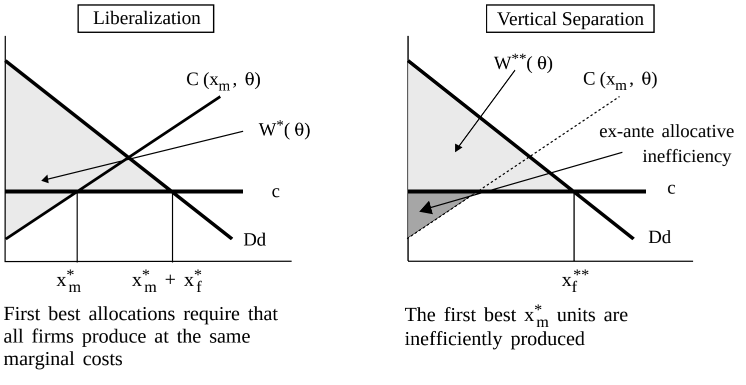
Lemma 1. *Under full contracting and competition in the downstream market, society is better off with an integrated monopoly than with a vertically separated monopoly.*

The proof is straightforward. The planner's problem under vertical separation at time zero has an additional constraint as compared to the planner's problem under liberalization. Since this constraint binds (notice our assumption about interior solutions), then $V^*(\theta)>V^{**}(\theta)$, for each $\theta\in\left\{\underline{\theta},\overline{\theta}\right\}$. Otherwise, a contradiction to the government's revealed preferences arises. This completes the proof ■

Figure 2 provides an explanation to Lemma 4 and the previous discussion.

FIGURE 2

WELFARE COSTS OF VERTICAL SEPARATION UNDER COMPLETE CONTRACTING



This result is standard in the literature. It tells us that we must assume incomplete contracting in order to achieve an economic rationale for vertical separation. Thus, as I show in the next section, this result doesn't necessarily hold when unforeseen contingencies prevent complete contracts.

4.2 The incomplete contracting approach under vertical separation

The owner of the private monopoly realizes θ in period 1. The government designs a mechanism to elicit truth-telling, but may give up some rents to the efficient firm. This informational rent, however, is less than the rent captured by the efficient firm under liberalization. Since those rents induce inefficient allocation of resources, the society would be better off under vertical separation than under vertical integration (liberalization).

Informational rents under vertical separation are defined as:

$$B(\hat{e}) \equiv \left[k(\overline{\theta}) - k(\underline{\theta})\right] \cdot x_f(\overline{\theta}, \hat{e})$$

As before, the second best allocations are fully characterized by equations (16) to (18).

$$\overline{U} = 0 \text{ and } \underline{U} = B(\hat{e}) \tag{16}$$

$$x_f^{sep}(\underline{\theta}) = x_f^{**}(\underline{\theta}) \tag{17}$$

$$x_f^{sep}(\overline{\theta}) < x_f^{**}(\overline{\theta}) \tag{18}$$

because $x_f^{sep}(\overline{\theta})$ satisfies:

$$P\left(x_f^{sep}(\overline{\theta})\right) = k(\overline{\theta}) + c + \frac{\hat{q}}{1-\hat{q}} \cdot \left[B'(\hat{e})\right]$$

and the last term of the righthand side is strictly positive because $B'(\hat{e}) \equiv \dfrac{\partial B(\hat{e})}{\partial x_f} > 0.$

The second-best access prices in equilibrium are equal to the marginal costs of providing access to the network (input). Therefore, when the monopoly is efficient:

$$a^{sep}(\underline{\theta}) = a^{**}(\underline{\theta})$$

Since (12) implies $y^{**}(\theta) = y^{*}(\theta),$ then

$$a^{sep}(\underline{\theta}) = a^{lib}(\underline{\theta})$$

too. That is, the access price charged by an efficient monopoly to potential competitors is the same, whatever the structure of the market chosen by the government.

In contrast, the access price charged by an inefficient monopoly is greater than the first best access price:

$$a^{sep}(\bar{\theta}) = k(\bar{\theta}) + \frac{\hat{q}}{1-\hat{q}} \cdot \left[B'(\hat{e})\right]$$

$$> a^{**}(\bar{\theta}) = k(\bar{\theta})$$

Moreover, the access price under vertical separation of the private monopoly is smaller than that of the inefficient type integrated monopoly operating in a competitive industry, $a^{sep}(\bar{\theta}) < a^{lib}(\bar{\theta})$. The reason is that vertical separation leads to smaller informational rents for the monopolist, which in turn shrinks the opportunity cost of providing access to the input.

Since the monopoly is not participating in the competitive industry, the government has to fix contingent (truth-telling) access prices in order to avoid abuse of monopoly power over competitors, i.e. the government cannot grant the monopoly any freedom in choosing prices under vertical separation. Accordingly, the government collects these revenues (we are using cost reimbursement rules), so that transfers are:

$$T^{sep}(\underline{\theta}) = k(\underline{\theta}) \cdot x_f^{sep}(\underline{\theta}) + \left[B(\hat{e})\right]$$

$$T^{sep}(\bar{\theta}) = k(\bar{\theta}) \cdot x_f^{sep}(\bar{\theta})$$

As with liberalization, (second-best) optimal cost-reducing activities are within the interval [0, e^{**}]. Since expected informational rents under vertical separation are smaller than under liberalization, cost-reducing activities under vertical separation are also smaller[15].

$$e^{sep} < e^{lib}$$

Hence, the adverse effect of vertical separation on social welfare is that divestiture is likely to reduce monopoly's efficiency.

Continuing backward, the government sells the upstream monopoly at:

$$z^{sep} = q(e^{sep}) \cdot \left[B\left(e^{sep}\right)\right] - e^{sep}$$

Therefore, the government's expected payoff at time zero is equal to:

$$V^{sep} = q(e^{sep}) \cdot W^{**}(\underline{\theta}) + \left[1 - q\left(e^{sep}\right)\right] \cdot W^{sep}(\overline{\theta}) - e^{sep} \tag{19}$$

where,

$$W^{sep}(\overline{\theta}) \equiv v\left(x_f^{lib}(\overline{\theta})\right) - k(\overline{\theta}) \cdot x_f^{sep}(\overline{\theta}) - c \cdot x_f^{sep}(\overline{\theta})$$

4.3 Analysis

We are interested in the trade-off resulting from the decision about whether to allow integrated monopolies to participate in competitive industries. In other words, the question is whether to design a liberalized or vertically separated industry.

When a monopoly produces efficiently, it generates more profits by operating in all markets, than if it is prevented from producing the final good. Integration, therefore, offers more incentives to invest in cost-reducing activities than vertical separation does. In contrast, a vertically separated, natural monopoly will allocate resources more efficiently than an integrated monopoly, which implies that the monopoly reduces underproduction in the inefficient state of nature.

The two types of inefficiencies (allocative and productive) come from the fact that the government cannot credibly commit to not appropriating some of the monopolist's rents produced by cost-reducing activities. Hence, the government's lack of commitment plays a crucial role in both inducing the agent to underinvest and, as a result, distorting production in period 4.

I summarize this discussion in the next proposition:

Proposition 4. *In terms of social benefits, vertical separation of a natural monopoly is preferable to total freedom to operate in vertically related markets (liberalization) if and only if:*

$$\begin{aligned} &\left\{q(e^{lib}) \cdot W^{*}(\underline{\theta}) - q(e^{sep}) \cdot W^{**}(\underline{\theta})\right\} \leq \\ &\qquad \left\{\left[1 - q(e^{sep})\right] \cdot W^{sep}(\overline{\theta}) - \left[1 - q(e^{lib})\right] \cdot W^{lib}(\overline{\theta})\right\} \\ &\qquad + \left[e^{lib} - e^{sep}\right] \end{aligned} \tag{20}$$

Proof. This result is straightforward. It comes from equations (11) and (19), after imposing V^{lib} V^{sep} ■

Remark 2. *The lefthand side in (20) represents the pros of liberalizing the competitive market. It corresponds to the net expected benefit of lower cost production to the integrated monopoly. The benefits of vertical separation are represented by the righthand side of (20). The first component corresponds to the gains expected from reducing the allocative inefficiency of the private monopoly. The* *second component on the righthand side of (20) measures the direct benefit to society, in terms of fewer resources spent in cost-reducing activities*[16].

Whether or not inequality (20) holds depends on specific calibrations of the industry structure (demand and cost functions) and the degree to which incentives push cost-reducing activities. The lefthand side and the last term of the right-hand side of this inequality are strictly positive because $e^{lib} > e^{sep}$ (see endnote 16) and $W^*(\underline{\theta}) > W^{**}(\underline{\theta})$, whereas the first term of the right-hand side of (20) could be positive if welfare distortions at inefficient firms are not too much higher under vertical separation than liberalization.

It is important to note that this inequality is useful as policy advice because it tells the policy maker how specific industry and country characteristics affect relative advantages of the alternative vertical structures studied in this article. For example, the weaker the incentive schemes, the deeper the productive inefficiency of a vertically separated monopoly. On the contrary, the more informational, transactional, and institutional constraints in the country, the more inefficient resources allocation will be due to regulation of a vertically integrated monopoly. Therefore, before fully liberalizing the industry, policy makers have to reduce informational constraints, improve enforceability, reduce legal ambiguities, and so on. In the interim, it is better to advance toward developing a privately owned industry with vertical separation of activities.

The next section provides a specific parametric example to illustrate this result.

V. A Simple Example: Linear Demand and Cost Functions

This section attempts to illustrate the trade-off between liberalization and vertical separation of a network utility. That is, whether to liberalize the downstream market or vertically separate the industry.

First of all, consider a gross consumer surplus as follows:

$$v(x_m + x_f) = A \cdot (x_m + x_f) - \frac{1}{2} \cdot (x_m + x_f)^2$$

which yields an inverse linear demand function for the downstream good:

$$P = A - (x_m + x_f)$$

Let the monopolist's cost function be:

$$\text{Upstream} \ : \ \theta \cdot \left[\delta \cdot (x_m)^2 + x_f \right]$$

$$\text{Downstream} \ : \ \alpha \cdot \theta \cdot (x_m)^2$$

where $\theta \in \{\underline{\theta}, \overline{\theta}\}$ is the asymmetric information parameter and α, δ are positive, constant numbers.

Thus, total costs are:

$$\theta \cdot (\delta + \alpha) \left[(x_m)^2 \right] + \theta \cdot x_f$$

and marginal costs are:

$$\text{respect to } x_m \ : \ 2 \cdot \theta \cdot (\alpha + \delta) \cdot x_m$$

$$\text{respect to } x_f \ : \ \theta$$

The competitive fringe shows constant marginal costs, c.

Assume that $q(e)$ takes the following form:

$$q(e) = \lambda + (1 - \lambda) \left[\frac{e}{\gamma + e} \right]^{\beta}$$

where λ is the probability of being an efficient monopolist when no investment is made in cost-reducing activities, γ is a positive parameter, and $\beta > 0$ such that $q(e)$ is strictly concave on e.

Despite linear demand and cost functions, the solution for each market design (first and second-best optimal allocations, net consumer surpluses, rents, and efforts) cannot be characterized by closed form solutions because of the non-linearity of $q(e)$ and the simultaneity of equations. Therefore, I use numerical analysis in these simulations.

- *A Case for Liberalization*. Let us assume that the Table 2 below contains the basic parameters of the industry.

TABLE 2

Parameter	A	c	α	δ	$\overline{\theta}$	$\underline{\theta}$	λ	γ	β
Value	50	1.0	0.20	0.20	0.25	0.10	0.60	60	0.90

Table 3 presents this industry's resulting simulated allocation of resources (see Table B.1 in Appendix B for more details).

TABLE 3

		Vertical Separation (*sep*) $\underline{\theta}$	Vertical Separation (*sep*) $\bar{\theta}$	Liberalization (*lib*) $\underline{\theta}$	Liberalization (*lib*) $\bar{\theta}$
First Best	V	1192.68		1198.78	
Second Best	**V**	**1192.57**		**1198.76**	
	e	.0015		.0064	
	$q(e)$	.6002		.6008	
	W	1195.51	1188.26	1203.17	1192.14
	Rents	7.28	0	8.43	0
	x_m	–	–	13.75	5.80
	x_f	48.90	48.52	35.15	42.73

- *A Case for Vertical Separation*. One of the main findings of this paper is that there exists an economic rationale for vertical separation under regulation and private ownership of the monopoly. I illustrate its feasibility by considering a more radical parameterization of the industry[17].
  Assume that industry parameters are those in Table 4 below:

TABLE 4

Parameter	A	c	α	δ	$\bar{\theta}$	$\underline{\theta}$	λ	γ	β
Value	200	1.0	0.20	0.20	0.50	0.10	0	100	0.90

that is, the competitive fringe of firms is very efficient in producing the final good (A increases from 50 to 200), $\bar{\theta}$ is now 400 percent higher than $\underline{\theta}$, and the probability $q(e)$ is not very responsive to changes in cost reducing activities ($\lambda = 0$ and $\gamma = 100$).

Under these parameters, vertical separation is preferable to liberalization, as shown in Table 5 below ($V^{sep} > V^{lib}$).

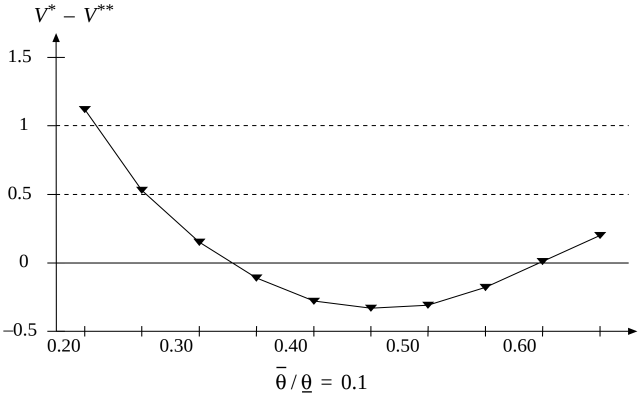
TABLE 5

		Vertical Separation (*sep*) $\underline{\theta}$	Vertical Separation (*sep*) $\bar{\theta}$	Liberalization (*lib*) $\underline{\theta}$	Liberalization (*lib*) $\bar{\theta}$
First Best	V	19701.44		19704.43	
Second Best	**V**	**19700.33**		**19700.02**	
	e	2.27		2.42	
	$q(e)$	.032		.034	
	W	19780.61	19699.98	19788.17	19699.98
	Rents	78.8	0	78.9	0
	x_m	–	–	13.75	3.74
	x_f	198.90	196.99	185.15	191.75

- *Illustrating the Trade-off.* Is it to society's advantage to divest the monopoly as the information between the regulator and the monopoly becomes more asymmetric (everything else constant)? The answer is ambiguous, as illustrated in Figure 3 below. As the difference between $\underline{\theta}$ and $\overline{\theta}$ becomes higher, the relative advantage of the liberalization decreases for small $\Delta\theta$'s. This trend is, however, reverted for values of $\overline{\theta}$ above 0.5.[18]

FIGURE 3

TRADE-OFF LIBERALIZATION VS. VERTICAL SEPARATION



In summary, $V^{sep} > V^{lib}$ is only true for values of $\overline{\theta}$ between 0.33 and 0.60 (or $\Delta\theta \in$ [0.33, 0.5]). Thus, for small amounts of asymmetric of information, society is better off liberalizing the industry.

VI. Conclusions and Further Research

The main purpose of this paper is to shed some light on the optimal design of a network utility. This article is better suited to developing countries, particularly in Latin America, where former public utilities are now privately owned and regulated (e.g. telecommunications, electricity, water and sewage, gas, railroads, etc.). It may be argued that, to some limited degree, the model is suitable for developed countries too. The point is that some underlying assumptions in the model apply better to developing countries, among them those involving incomplete contracts and enforceability problems[19].

The experience of recent privatizations in developing countries shows that these processes are not always successful. Their main shortcomings are basically three. The first problem is the existence of conglomerates in each privatized market – operating in different segments of the industry– using their informational advantages to hamper competition and extract rents from society. This produces an inefficient allocation of resources. The second shortcoming is the existence of regulatory frameworks that are both ambiguous and incomplete. Finally, developing countries lack institutions (e.g. regulators and a judiciary system) able to enforce contracts, improve the law (contracts), and encourage competition in potentially competitive industries[20].

The model used in this article took as given the last two shortcomings, emphasizing the fact that the monopoly is part of a network utility which provides services to potentially competitive markets. In this regard, two alternative market structures were studied and their relative productive and allocative efficiency compared.

The main result in terms of social welfare is that if the monopoly is suitably regulated, then no single vertical structure should dominate another, as Proposition 4 indicates. This conclusion supports the vertical separation of natural monopolistic activities from those that are potentially competitive. That is, the more asymmetric the information, the more ambiguous the regulatory framework, and the less reliable the institutions for enforcing contracts, the better it is to vertically separate the monopoly.

This result doesn't rely on noncompetitive assumptions on the part of the monopoly. The key concept is the simple fact that alternative market structures yield different informational rents. Moreover, these rents produce a trade-off because, on the one hand, they drive investments that reduce expected production costs and, on the other, the same informational rents produce social deadweight loss.

I finally work out an extremely simple example in order to illustrate my results. The simulations suggest that under normal parameterization of the industry, liberalization seems to be socially preferable. I show an extreme case in which the converse is also true, that is under radical parameterization of the industry, vertical separation becomes socially preferable.

Further research on this topic could proceed in several directions. One route is to consider network expansion with asymmetric marginal costs. That is, the monopoly incurs extra costs when providing its input to competitors. However, those costs are negligible when providing the intermediate good itself to produce the final good. In such a case, the regulator has more unknown parameters than instruments. This assumption may help in explaining many noncompetitive practices by the monopoly when integrated, such as discrimination, market foreclosure, and predatory behavior. In turn, it suggests that vertical separation of the private monopoly becomes much more desirable to society under network expansion than under common network, all else being constant.

Likewise, it may be useful to take as given a specific market design and analyze the efficiency implications of the other two shortcomings that I mentioned in the second paragraph of this section. For example, it may be interesting to study the consequences of the change from well prepared regulatory agencies to other that are less prepared. It may be easy to show that, for example, vertical separation becomes more desirable than conglomerates under these circumstances.

Finally, after theoretically assessing the pros and cons of two different industry structure, it seems to be valuable to empirically validate our conclusions. One possibility is to do case studies, focusing on the relative advantages of different institutional arrangements, as seen in this paper.

APPENDIX A

PROOF OF PROPOSITIONS 1 TO 3

Proposition 1

Let see first the last statement. Since the government's payoffs are inversely related to the monopoly owner's payoffs, then the government optimally chooses the menu of contracts and z to drive the monopoly owner to her reservation utility, $U = 0$.

Replacing the individual rationality constraint (IR) of the monopoly owner into the government's objective function, we obtain the government's problem in period 3, which matches the planner's problem:

$$\underset{\{x_m, x_f\}}{Max}\left\{v(x_m + x_f) - k(\theta)\cdot\left[\varphi(x_m) + x_f\right] - C(x_m,\theta) - c\cdot x_f - e\right\}$$

By the assumptions on functions $v(x_m + x_f)$, $C(x_m,\theta)$, and $\varphi(x_m)$, for all (x_m, x_f), the Hessian of this problem is negative definite, for each $\theta \in \{\underline{\theta},\overline{\theta}\}$. Thus, FOC's are necessary and sufficient for a maximum. They are:

$$v_{x_m}\left(x_m^*(\theta) + x_f^*(\theta)\right) = k(\theta)\cdot\varphi'\left(x_m^*(\theta)\right) + C'\left(x_m^*(\theta),\theta\right)$$

$$v_{x_f}\left(x_m^*(\theta) + x_f^*(\theta)\right) = k(\theta) + c$$

Since $v_{x_m}(\cdot) = v_{x_f}(\cdot)$ are the inverse demand function of $x, P(\cdot)$, equations (1) and (2) are established. By the Implicit Function Theorem, there exists a unique $\begin{pmatrix} x_m^*(\theta) \\ x_f^*(\theta)\end{pmatrix}$, for each $\theta \in \{\underline{\theta},\overline{\theta}\}$.

The first best access price, $a^*(\theta)$, for each $\theta \in \{\underline{\theta},\overline{\theta}\}$, is determined by (2) and market clearing condition in the downstream market. Hence,

$$a^*(\theta) = k(\theta)$$

which is the same as (3).

Finally, let see what happens with the first best cost-reducing activities, e*. The true parameter θ is unknown at the moment of undertaken cost reducing activities (period 1). Hence, in the full contracting case the planner's problem in period 0 is:

$$\underset{e}{Max}\left\{q(e)\cdot W^{*}(\underline{\theta})+\left[1-q(e)\right]\cdot W^{*}(\overline{\theta})-e\right\}$$

FOC:

$$q_e(e^{*})\cdot\left[W^{*}(\underline{\theta})-W^{*}(\overline{\theta})\right]=1$$

Single crossing property and assumptions on $v(x_m+x_f)$, $C(x_m,\theta)$ and $\varphi(x_m,\theta)$, for all x_m, ensure a positive square bracket. Moreover, SOC's are $q_{ee}(e^*)\cdot\left[W^*(\underline{\theta})-W^*(\overline{\theta})\right]<0$ by strict concavity on $q(e)$, for all e 0. Therefore, (4) is established. This completes the proof ■

Proposition 2

Two facts. The individual rationality constraints of the inefficient type, $IR(\overline{\theta})$, and the incentive compatibility constraint of the efficient type, $IC(\underline{\theta})$, bind. Then,

$$\overline{U}=-z+\overline{T}-k(\overline{\theta})\cdot\left[\varphi(x_m(\overline{\theta},\hat{e}))+x_f(\overline{\theta},\hat{e})\right]-C(x_m(\overline{\theta},\hat{e}),\overline{\theta})-\hat{e}=0$$

and

$$\underline{U}=-z+\underline{T}-k(\underline{\theta})\cdot\left[\varphi(x_m(\underline{\theta},\hat{e}))+x_f(\underline{\theta},\hat{e})\right]-C(x_m(\underline{\theta},\hat{e}),\underline{\theta})-\hat{e}$$

$$=-z+\overline{T}-k(\underline{\theta})\cdot\left[\varphi(x_m(\overline{\theta},\hat{e}))+x_f(\overline{\theta},\hat{e})\right]-C(x_m(\overline{\theta},\hat{e}),\underline{\theta})-\hat{e}$$

Adding and substracting $k(\overline{\theta})\cdot\left[\varphi(x_m(\overline{\theta},\hat{e}))+x_f(\overline{\theta},\hat{e})\right]+C(x_m(\overline{\theta},\hat{e}),\overline{\theta})$, and using $\overline{U}=0$

$$\underline{U}=R^U(\hat{e})+R^D(\hat{e})$$

Therefore, (7) is established.

By the assumptions on $v(x_m+x_f)$, $C(x_m,\theta)$, $\varphi(x_m)$, and $q(e)$, for all (x_m, x_f, e), the government's problem in period 3 is strictly concave. The solution is interior $-\left(x_j^{lib}(\underline{\theta}),x_j^{lib}(\overline{\theta})\right)>>0$, for $j=\{m,f\}$– then FOC's are sufficient for a maximum (let us omit $\hat{e}$ as argument of these solutions because there exists only one $\hat{e}$ in equilibrium, as proved in the next proposition).

When the monopoly is efficient, FOC's are:

$$v_{x_j}\left(x_m^{lib}(\underline{\theta})+x_f^{lib}(\underline{\theta})\right)=k(\underline{\theta})\cdot\left[\zeta\cdot\varphi'\left(x_m^{lib}(\underline{\theta})\right)+(1-\zeta)\right]$$

$$+\zeta\cdot C'\left(x_m^{lib}(\underline{\theta}),\underline{\theta}\right)+(1-\zeta)\cdot c$$

where $\zeta=\begin{cases}1 \text{ if } j=m\\ 0 \text{ if } j=f\end{cases}$

Therefore, the efficient firm produces the first best levels, $x_j^{lib}(\theta)=x_j^*(\theta)$, for j = {m, f}, as required in (8).

FOC's in the inefficient type case are:

$$v_{x_m}\left(x_m(\overline{\theta})+x_f(\overline{\theta})\right)=k(\overline{\theta})\cdot\varphi'\left(x_m^{lib}(\overline{\theta})\right)+C'\left(x_m^{lib}(\overline{\theta}),\overline{\theta}\right)+\frac{\hat{q}}{1-\hat{q}}\cdot\left[R_{x_m}^D(\hat{e})+R_{x_m}^U(\hat{e})\right]$$

$$v_{x_f}\left(x_m(\overline{\theta})+x_f(\overline{\theta})\right)=k(\overline{\theta})+c+\frac{\hat{q}}{1-\hat{q}}\cdot\left[R_{x_f}^U(\hat{e})\right]$$

where all $R_{x_j}^i(\hat{e})\equiv\frac{\partial R^i(\hat{e})}{\partial x_j}$, for i = {U, D} and j = {m, f}, are strictly positive by single crossing property and monotonicity assumptions on $C(x_m, \theta)$ and $\varphi(x_m, \theta)$, for all x_m, except $R_{x_f}^D(\hat{e})$ = 0.

By the Implicit Function Theorem, there exists a unique pair $\left(x_m^{lib}(\overline{\theta}),x_f^{lib}(\overline{\theta})\right)$ solving FOC's for the inefficient type firm. Finally, assumptions on $v(x_m + x_f)$, $C(x_m, \theta)$ and $\varphi(x_m, \theta)$, for all x_m, guaranteed $\begin{pmatrix}x_m^{lib}(\overline{\theta})\\ x_f^{lib}(\overline{\theta})\end{pmatrix}<\begin{pmatrix}x_m^*(\overline{\theta})\\ x_f^*(\overline{\theta})\end{pmatrix}$. This completes the proof ■

Proposition 3

The monopoly owner's problem when undertaken investments is:

$$\underset{e}{Max}\left\{EU(e)=q(e)\cdot\left[R^U(\hat{e})+R^D(\hat{e})\right]+\left[1-q(e)\right]\cdot 0-e\right\}$$

Since $\left[R^U(\hat{e})+R^D(\hat{e})\right]$ > 0 and $q(e)$ is strictly concave, for all e 0, FOC is sufficient for a maximum[21].

FOC:

$$q_e(e)\cdot\left[R^U(\hat{e})+R^D(\hat{e})\right]=1$$

Let show that 0 < e^{lib} $(\hat{e})$ < e^*. Let us use the second best production levels, $x_j^{lib}(\underline{\theta})$ and $x_j^{lib}(\overline{\theta})$, for j = {m, f}. By definition,

$$\left[R^U(\hat{e})+R^D(\hat{e})\right]=\left[k(\overline{\theta})-k(\underline{\theta})\right]\cdot\left[\varphi\left(x_m^{lib}(\overline{\theta})\right)+x_f^{lib}(\overline{\theta})\right]$$

$$+C\left(x_m^{lib}(\overline{\theta}),\overline{\theta}\right)-C\left(x_m^{lib}(\overline{\theta}),\underline{\theta}\right)$$

by single crossing property:

$$\leq \left[k(\bar{\theta}) - k(\underline{\theta})\right] \cdot \left[\varphi\left(x_m^*(\bar{\theta})\right) + x_f^*(\bar{\theta})\right]$$

$$+C\left(x_m^*(\bar{\theta}), \bar{\theta}\right) - C\left(x_m^*(\bar{\theta}), \underline{\theta}\right)$$

adding and substracting $v\left(x_m^*(\bar{\theta}) + x_f^*(\bar{\theta})\right) + c \cdot x_m^*(\bar{\theta})$, it becomes:

$$= \left[v\left(x_m^*(\bar{\theta}) + x_f^*(\bar{\theta})\right) - k(\underline{\theta}) \cdot \left[\varphi\left(x_m^*(\bar{\theta})\right) + x_f^*(\bar{\theta})\right]\right.$$

$$\left. -C\left(x_m^*(\bar{\theta}), \underline{\theta}\right) - c \cdot x_m^*(\bar{\theta})\right]$$

$$-\left[v\left(x_m^*(\bar{\theta}) + x_f^*(\bar{\theta})\right) - k(\bar{\theta}) \cdot \left[\varphi\left(x_m^*(\bar{\theta})\right) + x_f^*(\bar{\theta})\right]\right.$$

$$\left. -C\left(x_m^*(\bar{\theta}), \bar{\theta}\right) - c \cdot x_m^*(\bar{\theta})\right]$$

by government's revealed preferences:

$$< \left[v\left(x_m^*(\underline{\theta}) + x_f^*(\underline{\theta})\right) - k(\underline{\theta}) \cdot \left[\varphi\left(x_m^*(\underline{\theta})\right) + x_f^*(\underline{\theta})\right]\right.$$

$$\left. -C\left(x_m^*(\underline{\theta}), \underline{\theta}\right) - c \cdot x_m^*(\underline{\theta})\right]$$

$$-\left[v\left(x_m^*(\bar{\theta}) + x_f^*(\bar{\theta})\right) - k(\bar{\theta}) \cdot \left[\varphi\left(x_m^*(\bar{\theta})\right) + x_f^*(\bar{\theta})\right]\right.$$

$$\left. -C\left(x_m^*(\bar{\theta}), \bar{\theta}\right) - c \cdot x_m^*(\bar{\theta})\right]$$

$$= W\left[W^*(\underline{\theta}) - W^*(\bar{\theta})\right]$$

This inequality, (4) and (10) yield:

$$q_e\left(e^{lib}(\hat{e})\right) > q_e(e^*)$$

then, by strict concavity on q

$$e^{lib}(\hat{e}) < e^*$$

On the other hand, since $\left[R^U(\hat{e})+R^D(\hat{e})\right] > 0$, then by (10) $q_e\left(e^{lib}(\hat{e})\right) > 0$. Thus, by monotonicity on q, $e^{lib}(\hat{e}) > 0$.

Finally, the uniqueness of the equilibrium is showed using the Implicit Function Theorem on (10).

$$\frac{\partial\left[q_e(e)\cdot\left[R^U(\hat{e})+R^D(\hat{e})\right]\right]}{\partial\hat{e}}=0$$

equivalently,

$$q_{ee}\left(e^{lib}(\hat{e})\right)\cdot\left[R^U(\hat{e})+R^D(\hat{e})\right]\cdot\frac{\partial\left(e^{lib}(\hat{e})\right)}{\partial\hat{e}}+q_e\left(e^{lib}(\hat{e})\right)\cdot\left[R_{\hat{e}}^U(\hat{e})+R_{\hat{e}}^D(\hat{e})\right]=0$$

hence,

$$\frac{\partial\left(e^{lib}(\hat{e})\right)}{\partial\hat{e}}=-\frac{q_e\left(e^{lib}(\hat{e})\right)\cdot\left[R_{\hat{e}}^U(\hat{e})+R_{\hat{e}}^D(\hat{e})\right]}{q_{ee}\left(e^{lib}(\hat{e})\right)\cdot\left[R^U(\hat{e})+R^D(\hat{e})\right]}$$

$$< 0$$

by strict concavity on q and negativity on $\left[R_{\hat{e}}^U(\hat{e})+R_{\hat{e}}^D(\hat{e})\right]$.

We also know that $e^{lib}(0)$ 0 by definition of efforts, $e^{lib}(e^*) < e^*$, and by the Implicit Function Theorem $e^{lib}(\hat{e})$ is decreasing and continuous. Then, the Mean Value Theorem tells us that there exists a unique fixed point $\hat{e}$ satisfying $e^{lib}(\hat{e}) = \hat{e}$. This completes the proof. ■

APPENDIX B

RESULTS OF SIMULATIONS

TABLE B.1

	First Best Allocations			
	Liberalization		Vertical Separation	
	$\underline{\theta}$	$\bar{\theta}$	$\underline{\theta}$	$\bar{\theta}$
x_m	13.75	6.25	–	–
x_f	35.15	42.50	48.90	48.75
W	1203.17	1192.19	1195.61	1188.28
e	0.0734		0.0016	
$q(e)$	60.75%		60.02%	
V	1198.78		1192.68	

	Privatization			
	Liberalization		Vertical Separation	
	$\underline{\theta}$	$\bar{\theta}$	$\underline{\theta}$	$\bar{\theta}$
x_m	13.75	5.80	–	–
x_f	35.15	42.73	48.90	48.52
Rent	8.43		7.28	
W	1203.17	1192.14	1195.71	1188.26
e	0.0064		0.0015	
$q(e)$	60.08%		60.02%	
V	1198.76		1192.57	

TABLE B.2

	First Best Allocations			
	Liberalization		Vertical Separation	
	$\underline{\theta}$	$\bar{\theta}$	$\underline{\theta}$	$\bar{\theta}$
x_m	13.75	3.75	–	–
x_f	185.15	194.75	198.90	198.50
W	19788.17	19703.94	19780.61	19701.13
e	3.35		2.28	
$q(e)$	4.57%		3.27%	
V	19704.43		19701.44	

	Privatization			
	Liberalization		Vertical Separation	
	$\underline{\theta}$	$\bar{\theta}$	$\underline{\theta}$	$\bar{\theta}$
x_m	13.75	3.74	–	–
x_f	185.15	191.75	198.90	48.52
Rent	78.93		78.79	
W	19788.17	19699.39	19780.61	1188.26
e	2.42		2.27	
$q(e)$	3.43%		3.24%	
V	19700.02		19700.33	

TABLE B.3

$\bar{\theta}\,/_{\underline{\theta}=0.1}$	$V^{pic} - V^{sep}$
0.20	1.12
0.25	0.53
0.30	0.15
0.35	– 0.11
0.40	– 0.28
0.45	– 0.33
0.50	– 0.31
0.55	– 0.18
0.60	0.01
0.65	0.20

Notes

1 In Saavedra (1999) I analyze the same efficiency implications for six alternative institutional structures. Aside from including the economic rationale for vertical separation offered here, in that paper I demonstrate i) that ownership matters, ii) a rationale for the privatization of a legal monopoly even in potentially competitive markets, and iii) a rationale for creating mixed economies in competitive markets dominated by state-owned monopolies.

2 See Proposition 1 in Shapiro and Willig (1990) or Bös (1994) for a formal proof of this Theorem. Using the same idea, I prove in this article (see Lemma 1) that liberalization Pareto dominates the vertical integration alternative.

3 There are several microfoundations to incomplete contracting. Some explanations suitable to the model presented in this paper may be found in Spier (1992), Anderlini and Felli (1994), Bernheim and Whinston (1998), Hart (1999), and Segal (1999). The unforseen contingencies assumption is just an abstraction of other more microfoundated incompleteness.

4 Laffont (1994a) stresses the relationship between incentives and privatization in developing countries. Bhaskar (1993) and Bitran and Saavedra (1993) present an extended discussion in this regard using, respectively, the Indian and the Chilean experience. Basañes, Saavedra, and Soto (1999) provide a number of specific cases on post-contractual conflicts arising in the newly privatized electric sector in Chile.

5 Regarding the British experience in privatizing utilities and problems associated with natural monopolies operating in competitive activities, see Vickers and Yarrow (1988), Armstrong, Cowan and Vickers (1994), Helm and Jenkinson (1998), and Newbery (2000).

6 It is important to mention that we are using the common network assumption (both upstream and downstream technologies have the same adverse selection parameter). Despite being a strong assumption, it is absolutely necessary to apply optimal mechanism design in this paper, as noted by Laffont and Tirole (1993) chapter 5. Otherwise, under network expansion (different adverse selection parameters), the regulator has fewer instruments than unknowns to elicit truth telling.

7 Since θ is a discrete variable, derivative symbols represent partial derivatives with respect to the other argument of the function.

8 This assumption is without further loss of generality. For our purpose, it is enough to assume that the fringe and the monopoly have different technologies when producing the downstream good.

9 My model is closer to Baron and Myerson's (1982) than Laffont and Tirole's (1986-1993, Chapter 1), in the sense that costs are not observed by the principal. Good surveys on optimal mechanism design applied to regulation of natural monopolies may be found in Caillaud, Guesnerie, Rey, and Tirole (1988) and Laffont (1994b).

10 Roughly speaking, the government does not directly regulate the competitive market. It regulates production in the monopolistic upstream market and may regulate the access price charged by the monopoly to the fringe. Since the fringe is a residual supplier of x and I follow the convention that the government collects monopoly revenue $(P(\cdot)x_m + ax_f)$, the solution to the planner's problem is equivalent to that resulting from a decentralized decision problem with firms choosing x_m and x_f for each θ (see Laffont and Tirole, 1993, Chapter 5).

11 This formula corresponds to Baumol (1983) and Willig (1979)'s result Efficient Component-Pricing Rule. ECPR becomes much more complicated when allowing for imperfect substitutes, variable coefficient technology, and bypass possibilities in the downstream market, as noted by Armstrong, Doyle, and Vickers (1996), Laffont and Tirole (1993), chapters 5 and 6, and Laffont and Tirole (1994). A complete survey of this topic, applied to the telecommunication industry, can be found in Armstrong (2001).

12 Discriminatory practices using the access price are ruled out in the model, which seems to run contrary to actual practice. This may result from two explanations, which are not mutually exclusive. Common network assumptions may be unrealistic, with network expansion better suited to analyze the access price problem. Secondly, the model does not fully capture the fact that contract enforceability in developing countries may be so poor that, even with a common network, the dominant firm may discriminate and prey on the market. The latter is the "I.O. approach" mentioned in the introduction of this paper.

[13] Notice that this vertical structure is a constrained case of the one in section IV. Accordingly, proofs are in general omitted.

[14] (**) means that this benchmark is different to that of section 3.1.

[15] That is because $\left[B'(\hat{e})\right] = \left[k(\bar{\theta}) - k(\underline{\theta})\right] = \left[R^U_{x_f}(\hat{e})\right]$ and $q(e^{sep}) < q(e^{lib})$, which comes from the fact that $\left[B'(\hat{e})\right] < \left[R^U(\hat{e}) + R^D(\hat{e})\right]$ induces $e^{sep} < e^{lib}$.

[16] Notice that the more similar the fringe and the monopoly's technologies are, the closer $W^{**}(\theta)$ to $W^{*}(\theta)$. That is, ex-ante allocative inefficiency of vertical integration tends to disappear. In such a case, it is more likely that $V^{**}(\theta) > V^{*}(\theta)$, for each $\theta \in \left\{\underline{\theta}, \bar{\theta}\right\}$. In section V, I present an example illustrating this result.

[17] By "radical parameterization" I mean that the case for vertical separation requires working with a rather unlikely calibration for the industry. Most randomly chosen parameters show that a liberalized industry performs better than a vertically separated industry.

[18] Details about first-best and second-best allocation outcomes using this parameterization are in Table B.2, Appendix B. Table B.3 contains the outcome of simulations required to construct Figure 3.

[19] There are a number of other interesting issues pertinent to developing countries, such as corruption, regulatory capture, political instability, and credibility problems. I prefer to exclude these from my analysis in order to focus on the welfare consequences of informational, contracting and enforceability problems.

[20] See further details in Saavedra (2001), where the implications of these problems in the Chile's electric sector are documented. See Saavedra and Soto (2000) for a more institutional assessment of the same issue.

[21] Notice that we are taking derivatives with respect to the level of efforts e and not with respect to beliefs, $\hat{e}$.

References

ANDERLINI, L. and L. FELLI (1994). "Incomplete Written Contracts: Underscribable States of Nature". *Quarterly Journal of Economics* 109, pp. 1085-1124.

ARMSTRONG, M. (2001). "The Theory of Access Pricing and Interconnection". In M. Cave, S. Majumdar, and I. Vogelsang eds. *Handbook of Telecommunications Economics*, North-Holland (forthcoming).

ARMSTRONG, M., S. COWAN, and J. VICKERS (1994). *The Regulatory Reform: Economic Analysis and British Experience*. MIT Press.

ARMSTRONG, M., C. DOYLE, and J. VICKERS (1996). "The Access Pricing Problem: A Synthesis". *Journal of Industrial Economics* 44, pp. 131-150.

BARON, D., and R. MYERSON (1982). "Regulating a Monopoly with Unknown Costs". *Econometrica* 50, pp. 911-930.

BASAÑES, F., E. SAAVEDRA and R. SOTO (1999). "Post-Contractual Renegotiations and Disputes in Chile". Working Paper IFM-116, *Inter-American Development Bank.*

BAUMOL, W. (1983). "Some Subtle Issues in Railroad Transportation". *Journal of Transport Economics* 10, pp. 341-355.

BERNHEIM, B.D. and M. WHINSTON (1998). "Incomplete Contracts and Strategic Ambiguity". *American Economic Review* 88, pp. 902-932.

BHASKAR, V. (1993). "Privatization in Developing Countries: Theoretical Issues and the Experience of Bangladesh". *UNCTAD Review*, 4.

BITRAN, E. and E. SAAVEDRA (1993). "Algunas Reflexiones en Torno al Rol Regulador y Empresarial del Estado". In: O. Muñoz (ed.), *Después de las Privatizaciones: Hacia un Estado Regulador*. CIEPLAN.

BÖS, D. (1994). *Privatization: A Theoretical Treatment*. Oxford University Press.

CAILLAUD, B., R. GUESNERIE, P. REY and J. TIROLE (1988). "Government Intervention in Production and Incentives Theory: A Review of Recent Contributions". *RAND Journal od Economics* 19, pp. 1-27.

DIAZ, C. A. and R. SOTO (2000). "Open-Access Issues in the Chilean Telecommunications and Electricity Sectors". *Working Paper I-121*, ILADES-Georgetown University, Universidad Alberto Hurtado.

GALAL, A., L. JONES, P. TANDON and I. VOGELSANG (1994). *Welfare Consequences of Selling Public Enterprises: An Empirical Analysis*. Oxford University Press.

GALETOVIC, A. (2000). "Integración Vertical en el Sector Eléctrico: Una Guía para el Usuario". *Mimeo*, Universidad de Chile.

GROSSMANN, S. and O. HART (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration". *Journal of Political Economy* 94, pp. 691-719.

HART, O. (1999). "Foundations of Incomplete Contracts". *Review of Economic Studies*, 66 (1), pp. 115-138.

HELMS, D. and T. JENKINSON (1998). *Competition in Regulated Industries*. Cambridge University Press.

HOLMSTRÖM, B. and P. MILGROM (1991). "Multi-Task Principal Agent Problems: Incentive Contracts, Asset Ownership and Job Design". *Journal of Law, Economics, and Organization 7*, Special Issue, pp. 24-52.

JOSKOW, P. (1985). "Vertical Integration and Long-Term Contracts: The Cased of Coal-Burning Electric Utilities". *Journal of Law, Economics and Organization* 1, pp. 33-80.

LAFFONT, J.J. (1994a). "Regulation, Privatization, and Incentives in Developing Countries". *Mimeo*, IDEI and GREMAQ.

LAFFONT, J.J. (1994b). "The New Economics of Regulation: Ten Years After". *Econometrica* 62, pp. 507-537.

LAFFONT, J.J. (1995). "Privatization and Incentives". *Revista Española de Economía*, Monográfico: "Regulación".

LAFFONT, J.J. and J. TIROLE (1986). "Using Cost Observation to Regulate Firms". *Journal of Political Economy* 94, pp. 614-641.

LAFFONT, J.J. and J. TIROLE (1991). "Privatization and Incentives". *Journal of Law, Economics and Organization 7*, Special Issue, pp. 84-105.

LAFFONT, J.J. and J. TIROLE (1993). *A Theory of Incentives in Procurement and Regulation*. MIT Press.

LAFFONT, J.J. and J. TIROLE (1994). "Access Pricing and Competition". *European Economic Review* 38, pp. 1673-1710.

LEVY, B. and P. SPILLER (1996). *Regulation, Institutions and Commitment*. Cambridge University Press.

NEWBERY, D. (1997). "Privatisation and Liberalisation of Network Utilities". *European Economic Review* 41, pp. 357-383.

NEWBERY, D. (2000). *Privatization, Restructuring, and Regulation of Network Utilities*. Cambridge University Press.

PERRY, M. (1989). "Vertical Integration: Determinants and Effects". In: R. Schmalensee and R. Willig (eds.), *Handbook of Industrial Organization*, North-Holland.

SAAVEDRA, E. (1999). "Alternative Institutional Arrangements in Network Utilities: A Complete Contracting Approach". *Working Paper I-117*, ILADES-Georgetown University, Universidad Alberto Hurtado.

SAAVEDRA, E. (2001). "Opportunistic Behavior and Legal Disputes in the Chilean Electricity Sector". *Working Paper I-130*, ILADES-Georgetown University, Universidad Alberto Hurtado.

SAAVEDRA, E. and R. SOTO (2000). "Reformas Económicas e Institucionales del Estado en América Latina". *Working Paper I-128*, ILADES-Georgetown University, Universidad Alberto Hurtado.

SAPPINGTON, D. and J. STIGLITZ (1987). "Privatization, Information and Incentives". *Journal of Policy Analysis and Management* 6, pp. 567-582.

SCHMIDT, K. (1990). "The Costs and Benefits of Privatization". *Discussion Paper A-287*, Bonn University.

SCHMIDT, K. (1996). "Incomplete Contract and Privatization". *European Economic Review* 40, pp. 569-579.

SEGAL, I. (1999). "Complexity and Renegotiation: A Foundation for Incomplete Contracts". *Review of Economic Studies*, 66 (1), pp. 57-82.

SHAPIRO, C. and R. WILLIG (1990). "Economic Rationales for the Scope of Privatization". In: E.N. Suleiman and J. Waterbury (eds.), *The Political Economy of Public Sector Reform and Privatization*. Westview Press.

SPENGLER, J. (1950). "Vertical Integration and Antitrust Policy", *Journal of Political Economy* 53, pp. 347-352.

SPIER, K. (1992). "Incomplete Contracts and Signalling". *RAND Journal of Economics* 23, pp. 432-443.

TIROLE, J. (1988). *Industrial Organization*. MIT Press.

VICKERS, J. (1995). "Competition and Regulation in Vertically Related Markets". *Review of Economic Studies* 62, pp. 1-17.

VICKERS, J. and G. YARROW (1988). *Privatization: An Economic Analysis*. MIT Press.

WILLIAMSON, O. (1985). *The Economic Institutions of Capitalism.* New York: Free Press.

WILLIG, R. (1979). "The Theory of Network Access Pricing". In: H. M. Trebing (ed.), *Issues in Public Utility Regulation*. Michigan State University Public Utilities Papers.