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John Richard Morris

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by

John Richard Morris

Federal Trade Commission

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1. Introduction

Regulators often confront the question of whether they should allow a regulated firm to vertically integrate. For instance, Arkla, Inc's acquisition of Entex, Inc. was reviewed by the Texas Railroad Commission, the Louisiana Public Service Commission, the Mississippi Public Service Commission, and the Federal Trade Commission. The relevant policy concerns are whether the downstream price will rise from the vertical integration and what, if any, additional constraints must be placed on the integrated firms to prevent a potential price increase. The extant literature does not have much to offer the regulators in the analysis. The transactions cost literature [Coase (1937); Williamson (1971); Arrow (1975); Klein, Crawford, and Alchian (1978); Joskow (1985)] provides motives for vertical integration, but is silent on vertical integration's effects on the downstream price of a regulated firm.[1] Other work [Westfield (1981); Vernon and Graham (1971)] deal with an upstream monopolist vertically integrating downstream into a competitive industry. But a regulator usually faces the opposite problem: a downstream (regulated) monopolist vertically integrates upstream into a competitive industry. Analyses of upstream integration [Scherer (1980), pp. 306-12] almost exclusively assume market power at the upstream level. Perry (1978) does examine the case of a monopsonist integrating upstream, but he does not explore the behavior of regulated firms.

Dayan's analysis of vertical integration does examine upstream vertical integration by a regulated firm [Dayan (1973)]. In Dayan's

[1] Joskow uses regulated firms for his empirical examination of the transactions costs framework, but he does not examine downstream market power problems in his analysis.

analysis, a regulated firm subject to a rate of return constraint on its capital base integrates into the production of capital. His analysis demonstrates that such integration can eliminate the overuse of capital first explored by Averch and Johnson (1961). His analysis also shows that regulation can be made ineffective by upstream integration unless the regulator extends the rate of return regulation upstream.

This paper provides an alternative analysis of the effects of upstream vertical integration by a regulated firm. The analysis considers integration into the production of an intermediate input whose costs are automatically transferred to the downstream customers. Instead of focusing attention on the rate of return regulatory constraint, the approach utilizes the implied price constraint that most regulated firms face. The approach also assumes that capital at the downstream level is fixed; therefore, it abstracts from Averch-Johnson effects. Finally, the analysis assumes no market power by the sellers of the input. The analysis, however, does allow for the regulated firm to have monopsony power in the purchase of the input.[2]

The analysis presented below has relevance for any regulated firm that purchases an input whose costs are directly passed through to end users. Within the United States natural gas and electric utilities are often subject to such regulation. For example, interstate natural gas pipelines generally file semi-annual Purchase Gas Adjustments (PGAs) with the Federal Energy Regulatory Commission to account for changes in

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[2] For example, independent producers of natural gas in a field may have no market power, but the pipelines purchasing gas in the field may exert monopsony power.

their costs of natural gas purchases. An electric utility may have a "fuel adjustment charge" to account for changes in the cost of fuel used to produce electricity. Expenditures in the United States on natural gas and electricity totaled more than $236 billion in 1985. Thus, even small regulatory imperfections caused by vertical integration leading to higher prices would lead to substantial consumer losses. The theoretical insights of this paper outline what constraints are necessary to ensure that vertical integration by integrated firms does not result in higher downstream prices.

The remainder of the paper is organized as follows. Section 2 contains an analysis of the base case: the profit-maximizing solution for a vertically integrated firm that is not regulated. Section 3 provides a discussion of the price constraint that regulated firms often face. The profit-maximizing solution to the integrated firm's input decision is then calculated. The analysis indicates that, absent additional constraints, vertical integration effectively "deregulates" the firm. The analysis also suggests which additional constraints are necessary to make regulation effective. Given errors in regulation, however, a firm can vertically integrate, increase profits, and increase the downstream price. Section 4 lists and discusses the comparative statics of the various models. The comparative statics can assist in determining the binding constraints on the regulated firm which, in turn, can be used to predict the effects of vertical integration. Section 5 closes with a summary and conclusions.

2. The unregulated firm

Table 1 summarizes the notation and assumptions used throughout the analysis. The analysis concerns a firm purchasing an input (x) and transforming it by the technology described in f(x). The firm then sells the finished good at price P. The total revenue of the firm is represented by R. The firm can either purchase x from nonaffiliated suppliers at a price equal to or greater than $w(x_n)$ or can produce x at cost $c(x_a)$. The "a" subscripts stand for values associated with affiliated transactions and the "n" subscripts indicate values associated with nonaffiliated transactions. The parameters in the analysis are represented by the Greek characters ϵ, β, γ, σ, α, and δ. The parameter ϵ is a demand shifter, β shifts the supply of nonaffiliated production, and γ shifts the costs of affiliated production. The remaining parameters are relevant for regulated firms and are introduced in section 3.

Table 1

Notation

Variable	Description
x_a	Quantity of input purchased from affiliated suppliers
x_n	Quantity of input purchased from nonaffiliated suppliers
x	Total input used; $x = x_a+x_n$
f	Downstream output; $f=f(x)$; $f' > 0$; $f'' \leq 0$
P	Downstream price: $P=P(f(x);\epsilon)$; $\partial P/\partial f < 0$; $\partial P/\partial \epsilon > 0$
R	Total revenue from downstream sales; $R=R(x;\epsilon)=P(f(x);\epsilon)\cdot f(x)$; $\partial R/\partial \epsilon > 0$; $\partial^2 R/\partial x \partial \epsilon > 0$.
w_a	Transfer price of input x.
w	Market price of input x_n; $w = w(x_n;\beta)$; $\partial w/\partial x_n \geq 0$; $\partial w^2/\partial x_n^2 \geq 0$; $\partial w/\partial \beta > 0$; $\partial((\partial w/\partial x_n)\cdot x_n+w(x_n))/\partial \beta > 0$
w_n	Price vertically integrated firms pays for x_n; $w_n \geq w(x_n)$
c	Cost of input x supplied by affiliated suppliers; $c = c(x_a;\gamma)$; $\partial c/\partial x_a > 0$; $\partial^2 c/\partial x_a^2>0$; $\partial c/\partial \gamma>0$; $\partial^2 c/\partial x_a \partial \gamma>o$
π	Firm profits
ϵ	Downstream demand shifter
γ	Parameter shifting cost of x_a
β	Supply shifter for x_n
σ	Parameter reflecting regulation allowed price-variable cost margin
δ	Parameter reflecting error in measuring w_a
α	Technology parameter; $\alpha \approx 1/f'(x)$

The profits of the firm are equal to the revenue of the firm less then costs associated with affiliated and nonaffiliated transactions. In terms of the notation:

$$(1) \qquad \pi = R(x) - c(x_a) - w(x_n)\cdot x_n$$

The firm chooses the level of affiliated production (x_a) and the level of nonaffiliated purchases (x_n) to maximize its profits. Assuming an interior solution ($x_a>0$, $x_n>0$), the first order conditions to the maximization problem are:

(2a) $$\frac{\partial \pi}{\partial x_a} = \frac{\partial R}{\partial x} - \frac{\partial c}{\partial x_a} = 0$$

(2b) $$\frac{\partial \pi}{\partial x_n} = \frac{\partial R}{\partial x} - w(x_n) - \frac{\partial w}{\partial x_n} \cdot x_n = 0$$

Rearranging the first order conditions gives:

(3) $$\frac{\partial c}{\partial x_a} = w(x_n) + \frac{\partial w}{\partial x_n} \cdot x_n$$

Thus, from equation (3), the integrated firm produces additional quantities of x_a up to the quantity where its marginal cost of producing x_a equals the marginal cost of producing alternative supplies (w) plus any additional payments to alternative suppliers of x that results from driving the price of x_n up. First consider when the firm is a price taker with respect to x_n ($\partial w/\partial x_n=0$). In this case the firm produces an efficient level of x because it produces up to the point where its marginal cost equals the marginal cost of alternative suppliers. Now consider when the firm buys x in a market with monopsonistic characteristics ($\partial w/\partial x_n>0$). In this case the firm produces at a level where its marginal costs are greater than alternative suppliers because the integrated firm equates marginal product costs with the price of nonaffiliated supplies plus the increase in purchase costs given an increase in purchases from nonaffiliated producers. Therefore, the allocation of production between the affiliated production and nonaffiliated production is inefficient.

Although vertical integration results in production that does not minimize production costs, vertical integration can result in an increase in output and total surplus.[3] To see this, suppose that the level of affiliated production is temporarily fixed at x_a for some time.[4] The firm would then select the level of nonaffiliated purchases to maximize profits. The first order condition for the modified maximization problem is given in equation (2b). For each level of x_a, equation (2b) implicitly defines a level of x_n. It is, therefore, meaningful to determine how x_n changes as x_a changes. The relationship is:

$$(4)\qquad \frac{\partial x_n}{\partial x_a} = \frac{-\dfrac{\partial^2 R}{\partial x^2}}{\dfrac{\partial^2 R}{\partial x^2} - 2\cdot\dfrac{\partial w}{\partial x_n} - \dfrac{\partial^2 w}{\partial x_n^2}\cdot x}$$

The denominator of equation (4) is negative by the sufficient second order conditions of profit maximization. When the firm is not a monopsonist[5] ($\partial w/\partial x_n=0$), equation (4) collapses to $\partial x_n/\partial x_a = -1$ indicating that the firm cuts back on nonaffiliated purchases as fast as it increases affiliated purchases. However, when the firm is a

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[3] "Total surplus" is equal to the firm's profits, plus consumer surplus, plus rents earned by inframarginal producers of x_n in the relevant input market.

[4] Alternatively, suppose the firm is considering the purchase of an asset that would lower its costs of affiliated production (decrease γ). With the purchase, the firm would then increase its affiliated purchases.

[5] The term "monopsonist" in the paper means a firm whose average cost of purchasing x_n increases with additional purchases (i.e., $\partial w/\partial x_n>0$). The term does not necessarily mean that the firm is the only purchaser of x_n.

monopsonist ($\partial w/\partial x_n > 0$), $\partial x_n/\partial x_a > -1$ indicating that the firm reduces nonaffiliated by less than one unit as it increases affiliated purchases by one unit. Thus, the total amount of x used would increase. Because the total amount of x_a used increases and the cost of x is below the marginal revenue product (equations (2a) and (2b)), vertical integration necessarily leads to an increase in total surplus when the firm is a monopsonist. Given equation (4) and the assumption that the (inverse) demand curve slopes downward, the following proposition results.

Proposition 1: For the unregulated firm, vertical integration results in no change in downstream price if the downstream monopolist is not also a monopsonist and results in a lower downstream price if the downstream monopolist is also a monopsonist.

The analysis thus far gives only two potential motives for vertical integration. First, if the downstream monopolist is also a monopsonist, vertical integration can result in an increase in total surplus [Perry (1978)]. Because the firm collects a share of the increased surplus in higher profits, the firm has an incentive to vertically integrate. The only other motive for vertical integration is that the downstream monopolist has a comparative advantage in the production of x that is not capitalized within the firm's entry into production of x.[6] The comparative advantage would result in an economic rent to the firm as well as a resource savings to society. Therefore, whether the downstream monopolist is also a monopsonist or not, vertical integration by unregulated firms leads to increases in

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[6] See, for example, Arrow (1975).

economic welfare. Furthermore, vertical integration leads to no loss in consumer welfare.[7]

3. Price regulation and vertical integration

Government constraints (except, perhaps, taxation) are generally ignored in analyses of firm behavior. With Averch and Johnson (1961) economists began to more rigorously consider the many other constraints that government often places on businesses. One such constraint is a pricing constraint. Public utilities often are severely restricted in their ability to set prices. With the increase in variance of energy prices since the late 1960s, many public utilities now face per unit price constraints that can be divided into two parts. The first part reflects some input cost (usually a fuel cost) and changes in the input cost are automatically passed through to consumers.[8] The second part allows for a margin between price and the average cost associated with the adjustable input cost. The margin goes toward the other variable cost of the firm and, perhaps, an amount to help cover the fixed costs of the firm.[9]

In terms of the notation of Table 1, the price constraint can be represented by:

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[7] Using a different analysis of upstream vertical integration, Perry (1978) made the same conclusion.

[8] Price adjustments may be as often as every billing cycle (monthly) or as long as one year.

[9] The margin may not fully recover fixed costs of the firm because the regulator may choose to have a share of costs recovered in lump-sum connect fees.

(5) $P(f(x)) \leq \sigma + \alpha \cdot w(x_n)$

where σ represents the margin that the regulator allows the firm to collect in the per unit price and α is a constant technical coefficient approximately equal to $1/f'(x)$.[10] The parameter α represents the amount of input x needed to produce one unit of output f(x). Therefore, the intuitive meaning of relation (5) is that price must be equal to or less than the cost of input x to supply one unit of the output plus a margin allowed by the regulator.

Relation (5) would apply to a regulated firm that is not vertically integrated. The constraint for the vertically integrated firm is somewhat more complicated. Assume that the "price" used to determine the cost of input x is the weighted average price of affiliated and nonaffiliated purchases.[11] Then relation (5) can be rewritten as

(6) $P(f(x)) \leq \sigma + \alpha \cdot \dfrac{w_a x_a + w(x_n) \cdot x_n}{x_a + x_n}$

where w_a represents the transfer price from the upstream affiliate to the downstream regulated firm. In searching for a profit maximizing

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[10] If f(x) exhibits constant returns to scale, then $x = 1/f'(x)$. However, if f(x) exhibits either increasing or decreasing returns to scale, then $\alpha = 1/f'(x^o)$ evaluated at some representative input level x^o. This is essentially the constraint that the Federal Energy Regulatory Commission places on the commodity charge of interstate natural gas pipelines for system sales of gas. Other regulators often places similar constraints on regulated firms.

[11] Utilities often purchase supplies from more than one source. The weighted average of the input costs are generally used as the cost of the input.

solution, the vertically integrated regulated firm has a new variable that it can adjust: the transfer price of affiliated purchases.

Therefore, the vertically integrated regulated firm selects its purchases from affiliated supplies, its purchases from nonaffiliated suppliers, and its transfer price to maximize equation (1) subject to the constraint given in (6). The Lagrangian for this constrained maximization problem is:

$$L = R(X) - c(x_a) - w(x_n)\cdot x_n + \lambda\cdot[\sigma + \alpha\cdot(w_a x_a + w(x_n)x_n)/(x_a+x_n) - P(f(x))] \tag{7}$$

Necessary conditions for profit maximization are:

$$\frac{\partial L}{\partial x_a} = \frac{\partial R}{\partial x} - \frac{\partial c}{\partial x_a} + \lambda\cdot\alpha\cdot\frac{[w_a\cdot(x_a+x_n) - w_a\cdot x_a - w(x_n)\cdot x_n]}{(x_a+x_n)^2} - \lambda\cdot\alpha\cdot\frac{\partial P}{\partial f}\cdot f' = 0 \tag{8a}$$

$$\frac{\partial L}{\partial x_n} = \frac{\partial R}{\partial x} - w(x_n) - \frac{\partial w}{\partial x_n}\cdot x_n + \lambda\cdot\alpha\cdot\frac{[-w_a x_a + w(x_n)\cdot(x_a+x_n) + \frac{\partial w}{\partial x_n}\cdot x_n\cdot(x_a+x_n) - w(x_n)\cdot x_n]}{(x_a+x_n)^2} - \lambda\cdot\alpha\cdot\frac{\partial P}{\partial f}\cdot f' = 0 \tag{8b}$$

(8c) $$\frac{\partial L}{\partial w_a} = \lambda \cdot \alpha \cdot \frac{x_a}{x_a + x_n} = 0$$

(8d) $$\lambda \cdot \frac{\partial L}{\partial \lambda} = \lambda \cdot [\sigma + \alpha(w_a x_a + w_n(x_n) \cdot x_n)/(x_a + x_n) - P(f(x))] = 0$$

These necessary conditions directly imply:

Proposition 2: The vertically integrated regulated firm without a constraint on its transfer pricing (or a joint profit constraint) behaves as an unregulated firm.

The logic of the proposition is straight forward. Equation (8c) implies that as long as the firm purchases supplies from its affiliates, λ equals 0. Equation (8d) then implies that the price constraint is not binding. Further, with $\lambda=0$ equations (8a) and (8b) collapse to equations (2a) and (2b). Therefore, the firm makes the same input purchase decisions as if it was not regulated.[12] The intuition of the proposition is also straight forward. If the regulators do not control the transfer price, the regulated firm could purchase just one unit of the input from an affiliated supplier and price the unit at a level so that the downstream price (via the price constraint) is set at the unregulated level given input costs. The monopoly profits would be captured in the price of the affiliated purchases. Given that the vertically integrated firm wishes to maximize profits and can set any downstream price by adjusting the affiliated transfer price, it will seek to minimize its cost of

[12] This result is similar to Dayan's considering the firm's long-run decision on the acquisition of capital.

acquiring the input. It minimizes costs by purchasing affiliated and nonaffiliated supplies just if it was not regulated.

To maintain its ability to regulate the downstream price,[13] the regulatory body must restrict the price of affiliated purchases. In a world with no information costs, the regulators could set the transfer price at the price paid for nonaffiliated transactions. Regulators, however, in practice, will have some error in measuring prices and in enforcement. Therefore, the affiliated transfer price constraint will, in effect, constrain the transfer price to be equal or less than the price of nonaffiliated purchases plus some error, δ. The constraint can be represented as

$$(9) \qquad w_a \leq w_n + \delta$$

where w_n is the price of nonaffiliated purchases. The constraint (9), however, gives the integrated firm yet another avenue to evade the price constraint. The integrated regulated firm may artificially inflate w_n to avoid detection of its artificially inflated affiliated purchase prices. Therefore, the analysis of the integrated regulated firm will now also consider the firm choosing w_n to maximize profits. Whether the firm wishes to raise w_n above the market price $w(x_n)$ or lower w_n below the market price is a priori unknown. The price offered to nonaffiliated producers must be at least the market price for the quantity purchased. To account for this a market constraint must also be considered

[13] And hence the rate of return on capital.

(10) $\quad w_n \geq w(x_n)$

The vertically integrated firm under effective regulation would, then, desire to maximize (1) by choosing x_a, x_n, w_a, and w_n subject to the constraints (6), (9), and (10). The Lagrangian for the maximization problems is:

(11)
$$L = R(x) - c(x_a) - w(x_n) \cdot x_n$$
$$+ \lambda \cdot [\sigma + \alpha \cdot (w_a x_a + w_n x_n)/(x_a + x_n) - P(f(x))]$$
$$+ \mu \cdot [w_n + \delta - w_a]$$
$$+ \eta \cdot [w_n - w(x_n)]$$

The necessary conditions of profit maximization are:

(12a)
$$\frac{\partial L}{\partial x_a} = \frac{\partial R}{\partial x} - \frac{\partial c}{\partial x_a}$$
$$+ \lambda \cdot \left[\alpha \cdot \frac{(w_a \cdot (x_a + x_n) - w_a x_a - w_n x_n)}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f' \right] = 0$$

(12b)
$$\frac{\partial L}{\partial x_n} = \frac{\partial R}{\partial x} - w_n$$
$$+ \lambda \cdot \left[\alpha \cdot \frac{(w_a x_a + w_n \cdot (x_a + x_n) - w_n x_n)}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f' \right] - \eta \cdot \frac{\partial w}{\partial x_n} = 0$$

(12c)
$$\frac{\partial L}{\partial w_a} = \lambda \cdot \alpha \cdot \frac{x_a}{(x_a + x_n)} - \mu = 0$$

(12d) $$\frac{\partial L}{\partial w_n} = -x_n + \lambda \cdot \alpha \cdot \frac{x_n}{(x_a + x_n)} + \mu + \eta = 0$$

(12e) $$\lambda \cdot \frac{\partial L}{\partial \lambda} = \lambda \cdot [\sigma + \alpha \cdot (w_a x_a + w_n x_n)/(x_a + x_n) - P(f(x))] = 0$$

(12f) $$\mu \cdot \frac{\partial L}{\partial \mu} = \mu \cdot [w_n + \delta - w_a] = 0$$

(12g) $$\eta \cdot \frac{\partial L}{\partial \eta} = \eta \cdot [w_n - w(x_n)] = 0$$

There are three constraints in the analysis, each of which may or may not be binding. Thus, it would appear that there are eight different solutions to consider. Examination of the necessary conditions for maximization, however, reveals that there are only three situations to consider--one of which has already been discussed. This focusing begins with

> Proposition 3: For the integrated firm under regulation with control of transfer prices, the transfer price constraint is binding if and only if the downstream price constraint is binding.

The proposition is a direct result of equation (12c). The constraints are binding if their respective Lagrange multipliers are not zero. As long as firm purchases from affiliated suppliers ($x_a>0$), λ and μ have the same sign. When one constraint is not binding, then (12c) also implies that the other is also not binding. In this situation, equation (12d) then implies that the market constraint is binding ($\eta=x_n>0$) and equations (12a) and (12b) collapse to equations (2a) and (2b); therefore, the firm behaves as if it was not regulated. Or, Proposition 4: For the integrated firm under regulation with control of transfer prices; if the regulatory constraints are not binding then the market constraint is binding. Further, now the firm behaves as if it was not regulated.

The intuition behind Propositions 3 and 4 is fairly straightforward. Proposition 4 states that if the firm is not constrained by regulation, the firm behaves as any other vertically integrated firm with market power. As any price searcher it seeks to minimize its costs; therefore, the market price constraint on input costs must be binding (the firm desires lower costs). The intuition in the forward direction of Proposition 3 is also straightforward. If the transfer price constraint is binding, the firm desires to raise the price on affiliated purchases which would also raise the downstream price. Thus, the downstream price must be below the desired unconstrained price, implying that the downstream price constraint is binding. Similarly, if the downstream price constraint is binding, the firm desires to increase the downstream price. If the transfer price constraint were not binding, the firm could simply raise the transfer price which would also raise the downstream price. Therefore, if the downstream price constraint is binding, the transfer price constraint is also binding.

Propositions 3 and 4 reduce the eight possible solutions to three possible solutions. Proposition 3 states that both regulatory constraints are, or are not, binding at the same time. It reduces the possible solutions from eight to four. Proposition 4 eliminates the possibility that all three constraints are simultaneously not binding; therefore, only three possible solutions remain. Moreover, Proposition

4 states that one of the solutions--when the regulatory constraints are not binding--is simply the unregulated solution discussed in Section 2. Therefore, only two solutions remain to be discussed: first, the case when regulation and the market constraints are binding; and second, the case when regulation is binding and the firm pays above market prices for nonaffiliated supplies.

First consider the case when all the constraints are binding. From equations (12c) and (12d), $\eta = x_n - \lambda \cdot \alpha$. The level of nonaffiliated purchases (x_n) represents the loss from an increase in the nonaffiliated prices. The term $\lambda \cdot \alpha$ represents the increase in revenue from an increase in nonaffiliated price. When the market constraint is binding the loss from raising the nonaffiliated price (w_n) is greater than the gain in revenue; therefore η is positive ($\eta > 0$). However, nothing in the structure of the analysis restricts η to be positive. If η is negative, its interpretation, of course, would be different. The correct interpretation would be that the regulators perfectly restrain the firm from purchasing nonaffiliated supplies at above market prices. Hence, the analysis of this case would apply to a firm constrained by regulation to pay the market price for nonaffiliated supplies as well as to a firm constrained by the market to pay the market price for nonaffiliated gas.

In this situation the Lagrangian (11) can be simplified because the affiliated pricing constraint and the market constraint are binding. Substituting $w(x_n)$ for w_n and $w(x_n)+\alpha$ for w_a in the downstream price constraint (8) gives:

$$(13) \quad P(f(x)) = \sigma + \alpha \cdot w(x_n) + \alpha \cdot \delta \cdot \frac{x_a}{x_a + x_n}$$

The integrated regulated firm chooses x_a and x_n to maximize profits (1) subject to the downstream price constraint (13). The Lagrangian for the constrained maximization problems is:

$$(14) \quad L = R(x) - c(x_a) - w(x_n) \cdot x_n + \lambda \cdot [\sigma + \alpha \cdot w(x_n) + \alpha \cdot \delta \cdot (x_a + x_n) - P(f(x))]$$

The necessary conditions for maximization are:

$$(15a) \quad \frac{\partial L}{\partial x_a} = \frac{\partial R}{\partial x} - \frac{\partial c}{\partial x_a} + \lambda \cdot \left[\alpha \cdot \delta \cdot \frac{x_a}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f' \right] = 0$$

$$(15b) \quad \frac{\partial L}{\partial x_n} = \frac{\partial R}{\partial x} - w(x_n) - \frac{\partial w}{\partial x_n} \cdot x_n + \lambda \cdot \left[\alpha \cdot \frac{\partial w}{\partial x_n} - \alpha \cdot \delta \cdot \frac{x_a}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f' \right] = 0$$

$$(15c) \quad \lambda \cdot \frac{\partial L}{\partial \lambda} = \lambda \cdot [\sigma + \alpha \cdot w(x_n) + \alpha \cdot \delta \cdot \frac{x_a}{(x_a + x_n)} - P(f(x))] = 0$$

Equations (15a) and (15b) can be rearranged to give:

$$(16) \quad \frac{\partial c}{\partial x_a} = w(x_n) + \frac{\partial w}{\partial x_n} \cdot x_n + \lambda \cdot \frac{\alpha \delta}{(x_a + x_n)}$$

Comparing equations (3) and (16) reveals that the integrated regulated firm has a greater incentive to purchase supplies from affiliated suppliers than does the unregulated firm. The last term on the right hand side of (16) represents the increase in revenues from purchasing an additional unit of affiliated supplies. As long as regulation imperfectly monitors affiliated transactions ($\delta>0$), revenues increase as affiliated purchases increase. The gain in revenues represents an additional return to affiliated purchases. As a result, affiliated purchases would increase, ceteris paribus.

To examine how changes in vertical integration affect the downstream price, first suppose that the amount of affiliated purchases is temporarily fixed. The firm would then select the amount of nonaffiliated purchases (x_n) to maximize profits. The downstream price constraint, however, would effectively determine the level of x_n purchased. Given an amount of affiliated purchases, the firm then has no choice of nonaffiliated purchases. The downstream price constraint implicitly defines the level of nonaffiliated purchases as a function of affiliated purchases. It is therefore meaningful to determine from the constraint how x_n changes with respect to x_a. The relation is:

$$(17) \qquad \frac{\partial x_n}{\partial x_a} = \frac{-\left[\alpha\cdot\delta\cdot\dfrac{x_n}{(x_a+x_n)^2} - \dfrac{\partial P}{\partial f}\cdot f'\right]}{\alpha\cdot\dfrac{\partial w}{\partial x_n} - \alpha\cdot\delta\cdot\dfrac{x_a}{(x_a+x_n)^2} - \dfrac{\partial P}{\partial f}\cdot f'}$$

The numerator is clearly negative and the denominator is positive by the first order conditions;[14] therefore, the expression is negative.

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[14] See equation (15b).

This is consistent with the structure of the production function in which affiliated and nonaffiliated supplies are perfect substitutes. Now suppose that the firm is not a monopsonist. Then (17) clearly indicates that $\partial x_n/\partial x_a < -1$; a unit increase in affiliated purchases leads to more than a unit decline in the purchase of nonaffiliated supplies. In terms of the downstream price,

Proposition 5: For the integrated regulated firm with all constraints binding, if the firm is not a monopsonist then the downstream price will increase with increases in vertical integration as measured by increases in affiliated purchases.

In fact, the firm not being a monopsonist is a sufficient condition for Proposition 5, not a necessary one. Manipulation of the derivative in (17) reveals that $\partial x_n/\partial x_a<-1$ as long as $\delta/(x_a+x_n)>\partial w/\partial x_n$. The intuition behind the relationship is simple. The term $\delta/(x_a+x_n)$ approximates the increase in price given a unit increase in affiliated purchases. The term $\partial w/\partial x_n$ approximates the decrease in price given a unit decline in nonaffiliated purchase (because the market input price declined in response to decreased purchases). As long as $\delta/(x_a+x_n)>\partial w/\partial x_n$, the downstream price will rise with an increase in affiliated purchases. For a unit increase in affiliated purchases, total purchases must decline; therefore, nonaffiliated purchases must decline by more than one unit.

Now consider the case when the regulatory constraints are binding, but the input market constraint is not binding. That is, the situation when the firm is constrained by regulation yet manages to raise the downstream price (and total profits) by paying above market prices for nonaffiliated supplies.

In this case the firm would select x_a, x_n, and w_n to maximize profits given by

(18) $$\pi = R(x) - c(x_a) - w_n \cdot x_n$$

subject to the downstream price constraint:

(19) $$P(f(x)) = \sigma + \alpha \cdot w_n + \alpha \cdot \delta \cdot \frac{x_a}{x_a + x_n}$$

The Lagrangian for the constrained maximization profits is:

(20) $$L = R(x) - c(x_a) - w_n \cdot x_n + \lambda \cdot \left[\sigma + \alpha \cdot w + \alpha \cdot \delta \cdot \frac{x_a}{x_a + x_n} - P(f(x))\right]$$

The necessary conditions for profit maximization are:

(21a) $$\frac{\partial L}{\partial x_a} = \frac{\partial R}{\partial x} - \frac{\partial c}{\partial x_a} + \lambda \cdot \left[\alpha \cdot \delta \cdot \frac{x_a}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f'\right] = 0$$

(21b) $$\frac{\partial L}{\partial x_n} = \frac{\partial R}{\partial x} - w_n + \lambda \cdot \left[- \alpha \cdot \delta \cdot \frac{x_a}{(x_a + x_n)^2} - \frac{\partial P}{\partial f} \cdot f'\right] = 0$$

(21c) $$\frac{\partial L}{\partial w_n} = - x_n + \lambda \cdot \alpha = 0$$

(21d) $$\frac{\partial L}{\partial \lambda} = \sigma + \alpha \cdot w_n + \alpha \cdot \delta \cdot \frac{x_a}{x_a + x_n} - P(f(x)) = 0$$

As before, the first two conditions can be rearranged to give the relationship between affiliated and nonaffiliated purchases.

$$(22) \qquad \frac{\partial c}{\partial x_a} = w_n + \lambda \cdot \frac{\alpha \cdot \delta}{(x_a + x_n)}$$

The regulated integrated firm still produces the input at a level where its marginal costs are greater than other firms' opportunity costs because $w_n > w(x_n)$. Moreover, lack of perfect regulation ($\delta > 0$) accentuates the incentive. The firm may, however, purchase less affiliated supplies and more nonaffiliated than if it was not regulated. The ratio of affiliated purchases to nonaffiliated purchases in the unregulated case and this case depends on the magnitudes of $w(x_n)$, $(\partial w/\partial x_n) \cdot x_n$, w_n, and $\lambda \cdot x \cdot \delta/(x_a + x_n)$. In general, the difference in the purchasing ratios is not known.

To determine how the level of nonaffiliated purchases changes with respect to changes in the level of affiliated purchases, assume that the level of affiliated purchases is temporarily fixed. Then solve the price constraint (19) for w_n and substitute it into the profit function (18). The first order condition for profit maximization implicitly defines the level of nonaffiliated purchases x_n as a function of the level of affiliated purchases. The change in nonaffiliated purchases given an increase in affiliated purchases is

$$(23) \qquad \frac{\partial x_n}{\partial x_a} = \frac{-\dfrac{\partial^2 \pi}{\partial x_n \partial x_a}}{\dfrac{\partial^2 \pi}{\partial x_n^2}}$$

$$= -1 + \frac{\left[-\dfrac{\partial P}{\partial f} \cdot f' - \dfrac{2 \cdot \delta \cdot x_a}{(x_a + x_n)} \right]}{\left[\psi - \dfrac{2 \cdot \delta \cdot x_a^2}{(x_a + x_n)^2} \right]}$$

where

$$\psi = \frac{\partial^2 P}{\partial f^2} \cdot f' \cdot f' \cdot (f - x_n) + \frac{\partial P}{\partial f} \cdot f'' \cdot (f - x_n) + 2 \cdot \frac{\partial P}{\partial f} \cdot (f' - 1)$$
$$+ P(f(x)) \cdot f''$$

The denominator of the second term in the right hand side of equation (23) is negative by the second order condition for an interior solution. Therefore, affiliated production more than displaces production as long as the denominator is positive. That is, as long as:

$$(24) \qquad -2 \cdot \delta \cdot \frac{x_a}{(x_a + x_n)^2} > \frac{\partial P}{\partial f} \cdot f'$$

The inequality in relation (24) is clearly satisfied when the regulator constrains the affiliated and nonaffiliated prices to be the same (δ=0) and when the firm is not currently integrated (x_a=0) because the right hand side of (24) is negative. In these situations an increase in the level of affiliated purchase leads to a net reduction in input purchases ($\partial x_n/\partial x_a<-1$), which causes the downstream price to rise. Or, in other words:

Proposition 6: For the integrated regulated firm unconstrained by the market price of nonaffiliated purchase, if i) regulation constrains the transfer price to equal the price for nonaffiliated purchases, or ii) the firm was not previously integrated, then additional affiliated purchases will raise the downstream price.

A short example illustrates some of the features of the potential solutions in this case. Let output equal the amount of input, f(x) = x. Further, let the transfer price equal the nonaffiliated price (δ=0), and let the level of affiliated purchases be temporarily fixed. The first order condition for profit maximization would be:

$$(25) \qquad \frac{\partial \pi}{\partial x_n} = \sigma + x_a \cdot \frac{\partial P}{\partial x} = 0$$

That is, the firm would desire to select output so that the slope of the (inverse) demand curve is equal to $-\sigma/x_a$. A unique interior solution exists only if the demand curve is concave to the origin. But now suppose that the demand curve is linear. If $x_a<-\sigma/(\partial P/\partial x)$, the firm would want to increase output as much as possible by purchasing nonaffiliated supplies. The purchases of nonaffiliated supplies would continue until the market constraint on the nonaffiliated purchase price was binding. If $x_a>-\sigma/(\partial P/\partial x)$, the firm would desire to not purchase nonaffiliated supplies (except perhaps enough to justify its inflated transfer price). If the level of affiliated purchases was also less than the level that a monopolist would choose to purchase, the downstream price would be above the monopoly level. In this situation increase affiliated purchases would lower the downstream price. Of course it may be hard to argue that vertical integration has increased as the firm was fully integrated.

The example also highlights the need for regulators to monitor the price of nonaffiliated purchases relative to the price of comparable affiliated transactions. Without such monitoring it is possible that at least for some period of time the downstream price under regulation may be <u>above</u> the monopoly price.

4. Comparative statistics

The analysis presented in Sections 2 and 3 outlines the determinants of whether upstream vertical integration leads to lower or higher downstream prices. The most important determining factors are whether the firm has monopsony power and whether the firm is constrained by regulation. Determining the firm's operating environment -- constrained by regulation or not, monopsonist or not-- may not be a trivial task. For example, a firm subject to price regulation may price at the same level as if it were not regulated. Why else would firms ask for rate decreases?

One method of determining the firm's operating environment is to infer the environment from the firm's past behavior. Table 2 presents the comparative statistics results for the various models discussed in Sections 2 and 3. If the firm is not vertically integrated prior to the integration under review, then examining the comparative statistics will not be fruitful. As Table 2 indicates, in its selection of its inputs the firm reacts to demand and supply changes similarly whether it is regulated or not. On the other hand, if the firm were vertically integrated, one may be able to infer a regulatory regime. For instance, suppose a statistically significant negative relationship is found between a variable that increases demand and a variable that measures the level of nonaffiliated purchases. One could then infer that downstream the firm is constrained by regulation and not the market. Further, if increases in the allowed margin between the input cost and the downstream price also lead to decreases in nonaffiliated purchases, one could infer that the input market constraint is also binding. In such a case, there is a significant likelihood that vertical integration would lead to an increase in the downstream price.

Table 2

Comparative Statistics

Model	Variable	Parameters					
		ϵ	β	γ	σ	α	δ
Unregulated firm							
Nonintegrated	x_n	+	-				
Integrated ($w(x_n)=w$)	x_a	0	+	-			
	x_n	+	-	+			
Integrated (monopsonist)	x_a	+	?	-			
	x_n	+	-	?			
Regulated firm							
Nonintegrated	x_n	+	-		-	-	
Integrated ($w_n=w(x_n)$)	x_a	?	?	-	?	?	?
	x_n	?	?	+	?	?	?
Integrated ($w_n>w(x_n)$)	x_a	?	0	-	-	?	?
	x_n	?	0	?	+	?	?

This method has two limitations for evaluating whether a particular vertical acquisition will lead to an increase in the downstream price. First, reliable information (particularly on an individual firm) to estimate the comparative statistics may not be available. The analysis indicates that variables measuring changes in demand, nonaffiliated supply costs, affiliated supply costs, allowed margin, production technology and error in measuring the affiliated transfer price would have to be accounted for. Then the variables must have enough systematic variance to obtain statistically significant estimates of the parameters. If the available data are not of sufficient quality to produce reliable results, the method will not be useful. Second, even if reliable estimates of the comparative statistics are available, they may not determine which model is appropriate to analyze the acquisition. For example, suppose estimates consistent with those predicted for an unregulated firm that was not a monopsonist were obtained. These estimates are also consistent with a regulated firm. Therefore, additional information would still have to be used.

The first order conditions provide some indication of where additional information comes from. Consider equation (15a) which states that the marginal revenue product of affiliated purchases is equal to the marginal costs plus an amount reflection the regulatory constraint. From studies of market demand elasticity (of which there are many for regulated industries), estimates of the marginal revenue product may be derived. From documents, estimates of marginal cost may be discovered. These numbers can then be used to help decide whether regulation is binding or not. If marginal revenue product is substantially less than marginal cost of affiliated purchases, then there is strong evidence that regulation is binding.

Of course, other evidence is also relevant. The price differences between affiliated and nonaffiliated production (δ) is important to the analysis. The ability of the regulator to control the transfer price should be considered as should the ability of the regulator to control the nonaffiliated price. In summary, the more information a regulator has on a particular vertical integration proposal, the more refined the analysis can be, and the more accurate will be the prediction on the effects in the downstream market.

5. Summary and Conclusions

This paper presents a short-run partial equilibrium analysis of the downstream price effects of a monopolist vertically integrating upstream into a competitive industry. The analysis is short-run in the sense that capital at the downstream level of production is assumed fixed. The analysis indicates that if the firm is not regulated, integration will not lead to a downstream price increase. If the firm, however, is regulated, vertical integration may lead to an increase in the downstream price. Under the price constraint considered, if 1) affiliated transactions are imperfectly monitored, 2) the firm is not a monopsonist, and 3) the firm does not inflate the price of nonaffiliated purchase, a price increase from vertical integration is ensured. Even when the affiliated transfer price equals the price of nonaffiliated purchases, the downstream price would increase in cases where the firm still has the incentive and ability to inflate the price of nonaffiliated transactions.

The analysis implicitly gives three motives for the vertical integration. Unregulated and regulated firms alike may find it desirable to vertically integrate if they are monopsonists or if they have a comparative advantage at the upstream level of production. Vertical integration for such motives is desirable in the sense that it increases total available surplus. Regulated firms, however, also have regulatory evasion as a motive for vertical integration. The only way to ensure that vertical integration by regulated firms does not lead to an increase in the downstream price is to limit the transfer price and the price of nonaffiliated supplies. In situations where regulators have neither adequate authority nor sufficient information to control input prices, vertical integration can lead to downstream price increases--even to levels above the monopoly price.

References

Arrow, Kenneth J. "Vertical Integration and Communication." Bell Journal of Economics and Management Science 6 (Spring 1975): 173-83.

Averch, Harvey, and Leland L. Johnson, "Behavior of the Firm Under Regulatory Constraint." American Economic Review 52 (December 1961): 1052-69.

Coase, Ronald H. "The Nature of the Firm." Economica 4 (1937): 386-405.

Dayan, David. Vertical Integration and Monopoly Regulation. Ph.D. Dissertation, Princeton University. Ann Arbor, Michigan: University Microfilms, 1973.

Joskow, Paul L. "Vertical Integration and Long-term Contracts: The Case of Coal-burning Electric Generating Plants." Journal of Law, Economics, and Organization 1(1) (Fall 1985): 33-80.

Klein, Benjamin, Robert G. Crawford, and Armen A. Alchian. "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process." Journal of Law and Economics 21 (1978): 297-326

Perry, Martin K. "Vertical Integration: The Monopsony Case." American Economic Review 68 (September 1978): 561-70.

Scherer, Frederick M. Industrial Market Structure and Economic Performance. 2nd. ed. Boston: Houghton Mifflin Company, 1980.

Vernon, John M., and Daniel A. Graham. "Profitability of Monopolization by Vertical Integration." Journal of Political Economy 82 (July/August 1974): 924-5.

Westfield, Fred M. "Vertical Integration: Does Product Price Rise or Fall?" American Economic Review 71 (June 1981): 334-346.

Williamson, Oliver E. "The Vertical Integration of Production: Market Failure Considerations." American Economic Review 61 (May 1971): 112-27.