KILLING THE GOOSE THAT LAID THE GOLDEN EGG: A COMMENT ON AND EXTENSION OF "THE INCENTIVE FOR NON-PRICE DISCRIMINATION BY AN INPUT MONOPOLIST*"

David M. Mandy**

Department of Economics
University of Missouri
118 Professional Building
Columbia, MO 65211 USA
Voice 573-882-1763; Fax 573-882-2697
e-mail mandy@econ.missouri.edu

May, 1999

Keywords: Monopoly; Discrimination; Vertical integration

JEL Classifications: L1; D4

Economides (1998) studies an upstream monopoly supplier of a necessary input to a downstream Cournot oligopoly. The upstream monopolist participates in the downstream market through a fully vertically integrated subsidiary, so the upstream monopolist and its subsidiary make a joint maximization decision. This vertically integrated firm also has the ability to "sabotage" the rivals of its downstream subsidiary by raising their marginal cost, presumably through discriminatory provision of the necessary input, and this sabotage is costless for the vertically integrated firm. A central concern of the paper is the degree to which the integrated firm will optimally choose to engage in sabotage. In the context of linear downstream demand and costless sabotage, Economides (p. 281) states:

"**Proposition 3.** *Even if the monopolist's subsidiary has a cost advantage or disadvantage compared to its rivals, the monopolist still has an incentive to increase the costs of rivals to its downstream subsidiary until they are driven out of business.*"

*Nicholas Economides, "The Incentive for Non-Price Discrimination by an Input Monopolist," *International Journal of Industrial Organization* **16** (1998), 271-284.

**I am grateful to Dennis Weisman for pointing out this problem, for helpful comments, and for the 24-carat waterfowl characterization; and to David Sappington for reading and commenting upon an earlier draft. As always, any remaining errors are mine alone.

This statement is an important observation that has empirical support in the contemporary U.S. telecommunications industry within the context of Economides' model. More generally, however, additional considerations may arise.

In particular, we show that it is optimal for the input monopolist to completely refrain from sabotage when 1) double marginalization is not too severe; 2) the monopolist's subsidiary has a "large enough" cost disadvantage compared to its rivals; and 3) the input price exceeds marginal cost. Hence the sabotage issue must be resolved empirically by taking account of the number of downstream oligopolists, comparing their costs, and examining the upstream profit margin. Within the context of Economides' model, we find that data for the U.S. telecommunications industry strongly support the conclusion that Bell Operating Companies (BOCs) currently have incentives to discriminate against their long-distance rivals. The robustness of this conclusion across industries with a similar vertical structure, such as the software examples cited by Economides, and across models that capture more of the salient characteristics of the sabotage decision, such as the expected cost of sabotage, remains an unanswered question.[1]

The intuition is straightforward. The vertically integrated firm makes profit from both selling its input to downstream rivals and the activities of its downstream subsidiary (assuming price exceeds marginal cost upstream). Sabotage is an increase in marginal cost to the downstream rivals, which causes them to decrease output in the Cournot equilibrium and therefore purchase fewer inputs, while the output of the downstream subsidiary increases. As in any stable Cournot equilibrium, the cost increase causes aggregate output to decrease and price to increase. Thus, for the vertically integrated firm, sabotage results in less profit from input sales but more profit from the downstream subsidiary. Ultimately, even the profits on input sales are derived from the downstream market, so the best possible outcome for the vertically integrated firm is to earn the full downstream monopoly profit of the least-cost downstream firm. When the input monopolist's downstream subsidiary has no cost disadvantage, the net effect of sabotage is a gain for the vertically integrated firm because shutting down rivals allows the vertically integrated firm to sell the monopoly output of the least-cost downstream firm (itself), whence the integrated firm garners the maximum possible profit.

[1] Sabotage has costs with at least some positive probability in most settings. For example, Section 271(d)(6) of the Telecommunications Act of 1996 empowers the FCC to issue orders, penalites, and ultimately to "suspend or revoke" the interLATA authority of a BOC if the agency determines that the BOC has ceased to meet the conditions for interLATA approval. More broadly, both regulation and antitrust enforcement create expected costs of sabotage.

However, when the input monopolist's subsidiary has a cost disadvantage, its rivals are able to generate more profit downstream than its subsidiary. The input monopolist cannot capture all of this profit because the downstream Cournot oligopoly restricts output in order to push price above the sum of the input price and other marginal costs (double marginalization). Although the extent of double marginalization approaches zero as the number of Cournot competitors increases, the input monopolist still may not be able to capture the maximal downstream profit because the input price may be set too low (the input price is exogenous in this model). However, if the relatively efficient downstream rivals generate enough extra profit, and the upstream monopolist captures enough of this profit through its input sales, then the integrated firm is better off reducing its own downstream output (perhaps to the point of shutdown) rather than favoring its own subsidiary through sabotage.

1. The Theoretically Optimal Sabotage Choice

To see this formally we use Economides' linear demand model and assume for simplicity that fixed costs are zero.[2] The downstream subsidiary of the upstream monopolist is labeled firm 1, and downstream demand is $p = a - bQ$. The sum of Economides' equations (27) and (28) gives equilibrium profit for the vertically integrated firm, $\Pi_1^*(r)$, as a function of the degree of sabotage r. Economides' equation (30) provides the derivative of this function:

$$\frac{\partial \Pi_1^*}{\partial r} = \frac{2(n-1)}{b(n+1)^2}[(a-c-s) - 2(w-c) + r(n-1) - nx], \tag{1}$$

where:

- $n - 1$ is the number of downstream rivals.
- c is the upstream monopolist's marginal cost of producing the necessary input.
- x is the extra marginal cost for firm 1 in producing the downstream product (i.e., the degree of inefficiency in downstream production for the input monopolist's subsidiary).
- s is the downstream rivals' marginal cost, net of the price charged by the upstream monopolist for the necessary input (so firm 1's marginal cost is $s + x$, net of the price charged by the upstream monopolist for the necessary input).

[2]Since the number of firms is fixed in Economides' model (there is no entry), sunk costs have no effect on the analysis. See the paragraphs at the end of this section for the changes brought about by positive fixed (non-sunk) costs.

- w is the input price.
- for brevity, we henceforth denote the upstream margin by $m \equiv w - c$ and also let $\theta \equiv a - c - s$.

Equation (1) is derived under the assumption that all firms participate in the downstream market. Since fixed costs are zero, Economides' equation (31) provides the participation constraint for the downstream rivals:

$$\theta - 2m - 2r + x > 0, \tag{2}$$

which must hold for r small in order for the problem to have any content. Moreover, in any interesting case the firms must be profitable when they are identical and there is no sabotage. Accordingly, we assume henceforth that (2) holds when $x = r = 0$. Substituting (1) above into Economides' equation (23) expresses the downstream participation constraint for firm 1 as

$$q_1^*(r) = \frac{n+1}{2(n-1)} \frac{\partial \Pi_1^*}{\partial r} + \frac{m}{b} > 0. \tag{3}$$

If (2) holds but (3) is violated, then integrated profit is just upstream profit $\Pi_1^{U*}(r)$, similar to Economides' equation (27), but this expression must be re-derived to account for $q_1^*(r) = 0$. The symmetric Cournot equilibrium quantities in this case are

$$q_i^* = \frac{a - (w + s + r)}{nb} \quad i = 2, \ldots, n$$

and so upstream profit is

$$\Pi_1^{U*}(r) = \frac{m(n-1)[a - (w + s + r)]}{nb}. \tag{4}$$

This has a derivative of

$$\frac{\partial \Pi_1^{U*}}{\partial r} = -\frac{m(n-1)}{b(n+1)}, \tag{5}$$

which is negative whenever the upstream profit margin is positive. This simply says that the vertically integrated firm cannot benefit from decreased input sales when it is not participating in the downstream market and its upstream margin is positive. We assume henceforth that $m > 0$.[3]

[3]If the input price is regulated so that it equals upstream marginal cost, then the vertically integrated firm clearly cannot earn any profit from input sales no matter how many units it sells to more efficient downstream rivals. In this case the foreclosure level of sabotage is optimal. Paradoxically, allowing the input price to rise toward the monopoly level is beneficial, in the sense that it reduces the incentive to engage in sabotage.

Economides notes (p. 280) that Π_1^* is strictly convex in r (when demand is linear). From (3), convexity implies $q_1^*(r)$ is increasing in r (this is also immediate from Economides' equation (23)). Thus, if (3) holds at $r = 0$ then (1) is the correct expression for the profit derivative for all r up to the shutdown level for the rivals. Assume for the moment that (3) holds at $r = 0$. Then by strict convexity, the optimal choice of r is either the $r = 0$ corner or the corner at which the rivals exit the market. Also by strict convexity, if (1) is nonnegative at $r = 0$ it is positive for all $r > 0$, in which case the vertically integrated firm benefits from increasing r above 0 and continuing to increase r up to $r^* = (\theta - 2m + x)/2$ (from (2)), at which point the rivals exit the market. From (2) evaluated at $r = 0$, it is clear that (1) is nonnegative at $r = 0$ when $(n + 1)x$ is small. In this case, the conclusion of Economides' Proposition 3 holds. However, (1) can be negative at $r = 0$ if the number of rivals $n - 1$ and the vertically integrated firm's inefficiency parameter x are large enough. So for $(n + 1)x$ large, we must check whether $\Pi_1^*(r)$ reaches a minimum as a function of r, and whether as r increases further it then recovers to $\Pi_1^*(0)$ at some level of r below the level that drives the rivals out of the market. If so, then the conclusion of Economides' Proposition 3 still holds. If not, then the vertically integrated firm's profit as a function of r is everywhere below $\Pi_1^*(0)$, *in which case the optimal choice for the vertically integrated firm is $r = 0$ (i.e., no sabotage).*

It is straightforward from Economides' equations (27) and (28) to set $\Pi_1^*(r) = \Pi_1^*(0)$ and solve for r. The critical value at which $\Pi_1^*(r)$ recovers to $\Pi_1^*(0)$ is

$$\bar{r} = -2(\theta - 2m - nx)/(n - 1).$$

Hence, if $\bar{r} \leq r^*$ then the conclusion of Economides' Proposition 3 holds, while if $\bar{r} > r^*$ then optimal sabotage is zero (maintaining the assumption that (3) holds at $r = 0$). The condition $\bar{r} > r^*$ reduces to

$$x > \frac{n+3}{3n+1}(\theta - 2m). \tag{6}$$

From (2) evaluated at $x = r = 0$, the right side is positive. Nonetheless, it is clear that the inequality will hold when x and n are large.

This situation is illustrated in Figure 1, in which the vertical axis is $n = 2$ since there must be at least one rival. By manipulating (3) we can express the $q_1^*(0) = 0$ locus as

$$x = \frac{\theta + (n-1)m}{n}. \tag{7}$$

This equation is plotted along with the $\bar{r} = r^*$ locus (6). The shaded area shows the combinations of downstream rivalry and downstream inefficiency of the input monopolist's subsidiary that result in sabotage. Here, the sabotage is complete and forecloses the rivals. In the unshaded area, the input monopolist chooses zero sabotage. Note that the degree of inefficiency must be at least $(\theta - 2m)/3$ to avoid sabotage.

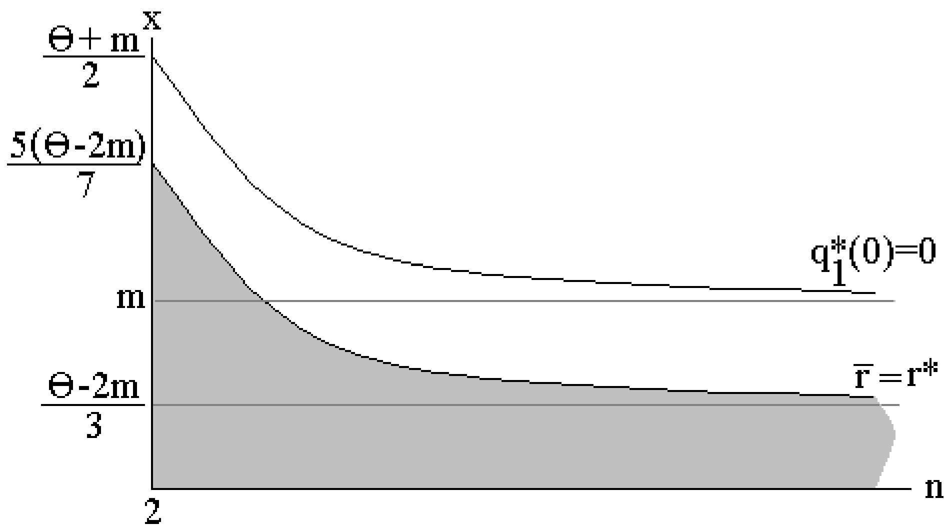

FIGURE 1: SABOTAGE AREA WHEN $q_1^*(0) > 0$

We have assumed that (3) holds for $r = 0$ at all (n, x) combinations satisfying $\bar{r} = r^*$, but this need not be true. When (3) fails at $r = 0$ then (5) is the correct expression for the derivative of the integrated firm's profit at small values of r. In this case the vertically integrated firm loses profit from its initial units of sabotage, and can only hope to recover that lost profit if r is increased enough to make (3) hold. Then, for larger r, (1) is the correct expression and so optimal sabotage is once again a corner, determined by whether $\Pi_1^*(r)$ recovers to $\Pi_1^{U*}(0)$ at some level of r below r^*. Let $\hat{r}$ denote the critical value of r at which $\Pi_1^*(r)$ equals $\Pi_1^{U*}(0)$. It is straightforward but tedious to show that $\hat{r}$ is defined by

$$n[bq_1^*(\hat{r})]^2 \equiv m(n-1)[bq_1^*(\hat{r}) + \hat{r}].$$

Substituting $r^* = \hat{r}$ and solving this quadratic for x yields the $\hat{r} = r^*$ locus:

$$x = \theta - 2\sqrt{\frac{m(n-1)(\theta - m)}{n}}. \tag{8}$$

Figure 2 illustrates (7) and (8) for the case in which (3) fails at $r = 0$ for all (n, x) combinations satisfying $\hat{r} = r^*$. Once again, the shaded area shows the combinations of downstream rivalry and downstream inefficiency of the input monopolists's subsidiary that lead to the foreclosure choice of sabotage. In the unshaded area sabotage is zero, which requires that inefficiency be at least $\theta - 2\sqrt{m(\theta - m)}$.

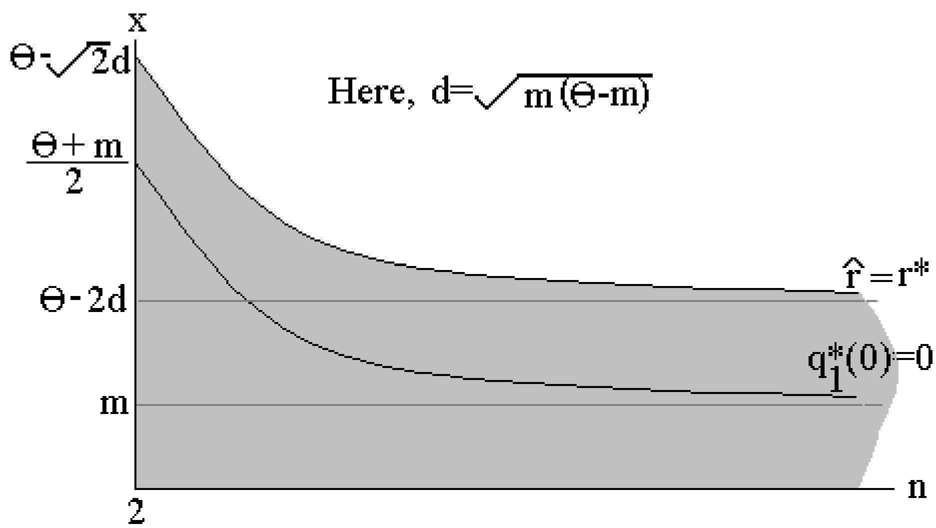

FIGURE 2: SABOTAGE AREA WHEN $q_1^*(0) = 0$

There is an intermediate case, in which (3) fails at $r = 0$, at the (n, x) combinations for which n is large along the $\hat{r} = r^*$ locus, while (3) holds at $r = 0$ at the (n, x) combinations for which n is small along the $\bar{r} = r^*$ locus. By studying the derivatives of (6), (7), and (8) it can be shown that the $\bar{r} = r^*$ and $\hat{r} = r^*$ loci cross the $q_1^*(0) = 0$ locus at most once, at the same point, with $\bar{r} = r^*$ below the $q_1^*(0) = 0$ locus left of the crossing and $\hat{r} = r^*$ above the $q_1^*(0) = 0$ locus right of the crossing. This case is illustrated in Figure 3, with the foreclosure sabotage area again shaded. As in Figure 2, inefficiency must be at least $\theta - 2\sqrt{m(\theta - m)}$ to avoid sabotage.

One way to interpret Figures 1-3 is to recall that if the vertical structure were unregulated bilateral monopoly then the upstream monopolist would set its margin at $m = \theta/2$. No upstream monopolist would ever charge more than this unless it were attempting to effect a price squeeze, and from (6) we see that the incentive to sabotage completely disappears at this very high markup no matter how small the downstream subsidiary's inefficiency or the level of downstream rivalry. If the upstream margin is held below this level, perhaps by regulation, then (6) shows that the level of inefficiency needed to avoid sabotage is directly proportional to the extent that the upstream margin is suboptimal from an upstream bilateral monopolist's

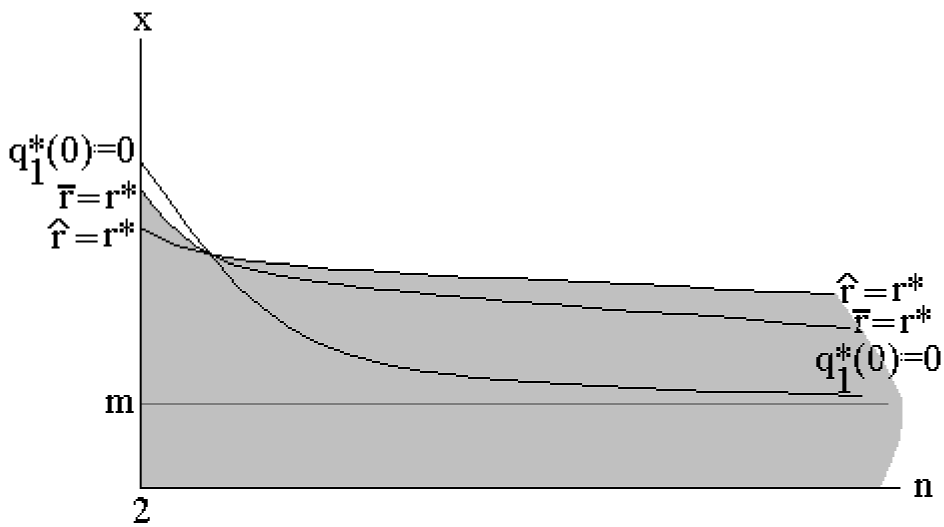

FIGURE 3: SABOTAGE AREA IN THE MIXED CASE

perspective.

Very little of this analysis changes qualitatively if we allow for positive fixed (non-sunk) costs. If firm 1 has avoidable fixed costs then the $q_1^*(0) = 0$ locus shifts downward, making the Figure 1 scenario relatively less likely. Within that scenario, the choice for the integrated firm is between two points on the $\Pi_1^*(r)$ function, both of which are reduced by the amount of the fixed costs, so the decision criterion is unchanged. The shape of $\Pi_1^*(r)$ *is* affected by avoidable fixed costs of the downstream rivals, but not in a way that changes the decision-relevant corner values. When rivals' fixed costs are positive the level of sabotage required to produce foreclosure is lower because the rivals' optimal quantity jumps discontinuously from some positive level to zero when shutdown occurs. But this merely creates a discontinuity in $\Pi_1^*(r)$ at which it jumps up to the $\Pi_1^*(r^*)$ level that occurs when rivals' fixed costs are zero, albeit at a lower level of r than the zero-fixed-cost value r^*. Since the relevant corner values of $\Pi_1^*(r)$ are unaffected by rivals' fixed costs, the binary zero/full sabotage decision is unaffected by such costs. Note, however, that this conclusion is heavily dependent on the assumption that sabotage is a costless activity. Otherwise, the integrated firm cares about *how much* sabotage is required to produce foreclosure, in which case positive rivals' fixed costs make sabotage more likely because less of it is needed to implement foreclosure.

In the relatively more likely Figure 2 scenario when firm 1 has avoidable fixed costs, the choice for the integrated firm is between an unchanged $\Pi_1^{U*}(0)$ and a lower $\Pi_1^*(r)$ function, making sabotage less likely (the upstream firm is in business in both cases, so its fixed costs are irrelevant for the choice of sabotage). As in the Figure 1 scenario, $\Pi_1^*(r)$ has a discontinuity at the foreclosure value of r when rivals have avoidable fixed costs, but the relevant corner *value* of $\Pi_1^*(r)$ is unchanged, so the (costless) sabotage decision is unaffected by such fixed costs. Thus, overall, the presence of fixed costs for firm 1 makes sabotage less likely by making the Figure 2 scenario more likely and making sabotage less likely within that scenario, while the presence of fixed costs for the rivals does not affect the sabotage decision as long as sabotage is costless.

2. The Empirically Optimal Sabotage Choice in Telecommunications

MacAvoy, Weisman, and Williams (1999) study the welfare effects of entry by a BOC into its in-region interLATA market, as authorized subject to stipulations by the Telecommunications Act of 1996. In this setting the BOC is likely to be a near-monopoly supplier of the input "exchange access" while simultaneously competing with AT&T, Sprint, MCI, and others for the downstream "long distance" product. Economides (1998, p. 272) mentions the allegations that such a BOC will use various tactics to discriminate against its long-distance rivals in the provision of exchange access. As shown above, whether these allegations are consistent with the BOC's incentives cannot be determined by relying on Economides' Proposition 3. Rather, this must be tested by studying the cost and demand parameters to determine the industry's position in the (n, x) space. MacAvoy, Weisman, and Williams (pp. 4-5) cite relevant literature to parameterize three plausible linear demands for the long distance market. They also report (p. 6) a regulated input price of $w = 3.82$ cents per minute and a downstream marginal cost of approximately $s = 1$ cent per minute. Kahn and Tardiff (1998, pp. 13-14) report upstream marginal cost of about $c = 1$ cent per minute (both this cost and the reported w include origination and termination, so the analysis here is for calls that are both originated and terminated by the same BOC). Hence, we have three industry estimates of θ and also an estimate of $m = w - c = 2.82$ cents per minute.

Using these parameters, Table 1 reports the x-values of the $\bar{r} = r^*$, $q_1^*(0) = 0$, and $\hat{r} = r^*$ loci (equations (6), (7), and (8), respectively) for each of the three θ estimates. In the first panel the $\hat{r} = r^*$ locus lies everywhere above the $q_1^*(0) = 0$ locus, so the situation is as depicted in Figure 2. The $\hat{r} = r^*$ column gives the level of inefficiency required of the BOC long distance subsidiary in order to avoid sabotage. In the second and third panels, the $\hat{r} = r^*$ and $\bar{r} = r^*$ loci cross the $q_1^*(0) = 0$ locus between $n = 2$ and $n = 3$, so the situation is as depicted in Figure 3. When $n = 2$ the $\bar{r} = r^*$ column gives the level of inefficiency required of the BOC long distance subsidiary in order to avoid sabotage, while the $\hat{r} = r^*$ column gives this estimate for $n > 2$. In all cases we see that the levels of inefficiency that would produce zero sabotage appear implausibly high, requiring downstream BOC inefficiency at least 6.5 times the rivals' cost of $s = 1$.

TABLE 1: INEFFICIENCY LOCI FOR TELECOMMUNICATIONS

MARGIN $m = 2.82$

Demand Intercept: $a = 31.09 \Rightarrow \theta = 29.09$

n	$\bar{r} = r^*$	$q_1^*(0) = 0$	$\hat{r} = r^*$
2 (intercept)	16.75	15.96	16.92
3	14.07	11.58	15.03
4	12.63	9.39	14.18
10	9.83	5.45	12.76
∞ (asymptote)	7.82	2.82	11.88

Demand Intercept: $a = 27.18 \Rightarrow \theta = 25.18$

n	$\bar{r} = r^*$	$q_1^*(0) = 0$	$\hat{r} = r^*$
2 (intercept)	13.96	14.00	13.95
3	11.72	10.27	12.21
4	10.52	8.41	11.43
10	8.19	5.06	10.11
∞ (asymptote)	6.51	2.82	9.30

Demand Intercept: $a = 22.80 \Rightarrow \theta = 20.80$

n	$\bar{r} = r^*$	$q_1^*(0) = 0$	$\hat{r} = r^*$
2 (intercept)	10.83	11.81	10.73
3	9.10	8.81	9.17
4	8.16	7.32	8.47
10	6.36	4.62	7.29
∞ (asymptote)	5.05	2.82	6.56

It is straightforward to verify that the $\bar{r} = r^*$ and $\hat{r} = r^*$ loci both shift down with increases in the upstream margin m (stemming from increases in the input price w, holding upstream cost c constant). Hence an increase in the upstream margin makes sabotage less likely, but how strong is this effect? In Table 2 we see that the upstream margin would have to be very high indeed, involving more than a 1,000% markup, before the inefficiency levels that produce zero sabotage drop below 10% of rivals' cost. This high upstream margin is very near the margin $m = \theta/2 = 10.4$ that the upstream firm in an unregulated bilateral monopoly would charge an efficient downstream firm. Essentially, to avoid sabotage inefficiency must be very large in this market because the regulated upstream margin is far below the upstream bilateral monopolist's optimum.

TABLE 2: INEFFICIENCY LOCI FOR TELECOMMUNICATIONS

HYPOTHETICAL MARGIN $m = 10.3$

Demand Intercept: $a = 22.80 \Rightarrow \theta = 20.80$

n	$\bar{r} = r^*$	$q_1^*(0) = 0$	$\hat{r} = r^*$
2 (intercept)	0.14	15.55	6.09
3	0.12	13.80	3.82
4	0.11	12.93	2.79
10	0.08	11.35	1.07
∞ (asymptote)	0.07	10.30	0.00

3. Conclusion

There are many aspects of the sabotage decision not captured by the model studied here. Market characteristics that may ameliorate the incentive to sabotage include downstream product differentiation (as in Beard, Kaserman, and Mayo (1997)), downstream increasing returns (as with Sibley and Weisman's (1998) capacity constraints), and the degree of autonomy granted to the downstream subsidiary (motivated, perhaps, by the type of structural separations and safeguards required by Section 272 of the Telecommunications Act of 1996). A very important characteristic of the model here is that sabotage is costless to the input monopolist. Regulation and antitrust enforcement both create expected costs from sabotage, so no conclusion regarding the incentive to sabotage can be regarded as definitive until these costs are incorporated into the model.

Within the context of Economides' model, telecommunications industry data predict that BOCs have incentives to engage in the foreclosure level of sabotage. This prediction does not derive from theoretical considerations, but rather from industry parameters. In an industry that has an upstream margin much closer to the bilateral monopolist's optimum; due to more elastic demand, higher costs, or simply a high margin; the level of inefficiency needed to avoid sabotage would be correspondingly lower. Indeed, according to the model, intense downstream competition (n large), a large cost disadvantage for the upstream monopolist's downstream subsidiary (x large), and a large upstream margin ($m \approx \theta/2$) are jointly sufficient for there to be no sabotage. These conditions are sensible. They simply say that the vertically integrated firm is better off capturing a share of the profit from other downstream suppliers if the double marginalization problem is not too large, if the downstream rivals have a large enough efficiency advantage, and if the upstream margin enables this capture. To do otherwise would be "killing the goose that laid the golden egg."

References

Beard, T. R., D. L. Kaserman, and J. W. Mayo, *Regulation, Vertical Integration, and Sabotage (manuscript)* (November, 1997).

Economides, N., *The Incentive for Non-Price Discrimination by an Input Monopolist*, International Journal of Industrial Organization **16** (1998), 271-284.

Kahn, A. E. and T. J. Tardiff, *Affidavit before the Public Service Commission of Missouri in the Matter of the Application of Southwestern Bell Long Distance for Provision of In-Region, InterLATA Services in Missouri* (November, 1998).

MacAvoy, P. W., D. L. Weisman, and M. A. Williams, *Should Local Telephone Companies be Allowed to Enter the Long-Distance Market? A Regulatory Conundrum*, Manuscript (February, 1999).

Sibley, D. S. and D. L. Weisman, *Raising Rivals' Costs: The Entry of an Upstream Monopolist into Downstream Markets*, Information Economics and Policy **10** (1998), 451-470.