Vertical Foreclosure versus Downstream Competition with Capital Precommitment*

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Final Version, July 2003

Abstract

The recent literature on vertical foreclosure suggests that vertical integration can have the anticompetitive effect of enabling an upstream firm to commit to restricting output to downstream firms at the monopoly level. We allow the upstream firm to make an ex ante capital precommitment. We show that, if integration is outlawed, the upstream firm will distort capital downward as an alternative device to restrict output. We show that this alternative may be socially less efficient than vertical integration.

JEL Classification Numbers: C72, C73, D82, L10.

Keywords: Foreclosure, commitment, vertical restraints.

*We are grateful to two anonymous referees, the editor in charge of the paper, Simon Anderson, and Brian Wallace for very useful comments. Conference and seminar participants at DIW Berlin, Freie Universität Berlin, Universität Frankfurt, George-Washington University, Universität Köln, Universität Magdeburg, University of Nottingham, Verein für Socialpolitik 2001 meeting, and Warwick University helped improving the paper. A previous version of the paper was entitled "Vertical Integration with Capital Precommitment: Monopolization vs. Long-Run Inefficiency".

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1 Introduction

The recent literature on vertical foreclosure[1] challenges the Chicago School's friendly position on vertical restraints (e.g., Bork (1978)). A central argument in this literature about the anticompetitive effects of vertical integration is that a dominant upstream monopolist may want to foreclose downstream firms because the competition between these downstream firms does not allow the firm to realize the monopoly profits.

A model with a such a proposition is by Hart and Tirole (1990).[2] They analyze an industry with an upstream monopoly and multiple downstream firms. Without vertical integration, the upstream firm cannot credibly restrict output at the monopoly level. To see this, suppose that some downstream firms have accepted the monopoly output at terms of exchange that would allow the upstream firm to extract the full monopoly profit. Then the monopolist still has an incentive to sell more of the product to other downstream firms to the disadvantage of those who bought the good at monopoly conditions in the first place. Since downstream firms anticipate this kind of opportunistic behavior, the upstream firm's monopoly power is lost in equilibrium. By contrast, vertical integration helps the monopolist to overcome the commitment problem and reestablishes the monopoly solution. Downstream rivals are foreclosed and total output is reduced. Therefore, vertical integration unambiguously reduces welfare.

[1]The first contributions include Salinger (1988), Hart and Tirole (1990), and Ordover et al. (1990).

[2]We refer to Hart and Tirole's (1990) *ex post monopolization* variant. For a thorough discussion of this model, see Rey and Tirole (1997). Related papers are DeGraba and Postlewaite (1992), O'Brien and Schaffer (1992) and McAfee and Schwartz (1994). A general framework is analyzed in Segal (1999). Further, see Snyder (1995) for a survey on empirical tests of the models and Martin, Normann and Snyder (2001) for experimental evidence.

In this paper we show that this argument does not necessarily support a prohibition of vertical integration because such a prohibition will often not fully eliminate monopoly power but only one way of exploiting it. In general, a monopolist will search for alternative means to retain its market power at least to some extent. By doing so, the monopoly may generate inefficiencies and these welfare losses may be larger than those resulting from vertical integration.

To establish this argument, we introduce an ex-ante capital precommitment into the Hart and Tirole (1990) model. The capital investment determines the monopolist's short-run costs. We show that downstream competition distorts the incentives for long-run investment in capital. Underinvestment raises marginal costs which, in turn, reduces the monopolist's incentive to expand output. Thus, it serves as a profitable commitment device at the cost of a long-run inefficiency.[3]

With vertical integration, the monopolist invests efficiently but the usual monopolistic restriction of output occur. From a welfare point of view, the two industry structures are therefore characterized by different inefficiencies. Using a parametrized example, we show that the monopolistic welfare loss with vertical integration may be smaller than the loss from the inefficient capital structure with downstream competition.

[3]This argument is closely related to the problem of Coase's durable goods monopolist. Bulow (1982) shows that monopolist who is not able to commit to a price will choose an inefficiently low degree of product durability. This inefficiency partially compensates for the inability to commit.

2 The Model

There is a single upstream firm, U, and $n > 1$ downstream firms, D_i, $i = 1, ..., n$. The upstream monopolist and the downstream firms play the following game. Ex ante, U decides on a capital investment, K, which determines its marginal costs of producing the good. This capital precommitment is observed by the downstream firms. Ex post, U offers each D_i a take-it-or-leave-it contract, (x_i, T_i), where x_i denotes the quantity to be delivered and T_i is a lump-sum payment. Following Hart and Tirole (1990), we assume that contracts are offered secretly. The downstream firms decide to accept or reject the offers. Finally, downstream firms engage in Cournot competition by putting the accepted quantities on the market.

We will look for a perfect Bayesian equilibrium of this game. As there are multiple perfect Bayesian equilibria, we will use a refinement to select a unique equilibrium. We assume that downstream firm hold *passive* believes or *market-by-market* conjectures (see McAfee and Schwartz, 1994), that is, each D_i believes that the other downstream firms are offered their equilibrium contracts irrespectively of D_i's own contract.[4]

Inverse demand is $p(X) = \max\{\widetilde{p}(X), 0\}$, where $X := \sum_{i=1}^{n} x_i$ denotes aggregate output. We assume that $\widetilde{p}(X)$ is twice continuously differentiable and that $\widetilde{p}(X)$ is weakly concave.

Downstream firms have constant marginal costs of transforming the good which we normalize to zero. U produces with a quasi-concave production function, $X = F(Z, K)$, which is twice continuously differentiable. Z is the vector of all variable inputs and K denotes the ex-ante capital investment.

[4]Other beliefs yield equilibria in which the producer overcomes the commitment problem without vertical restraints (see McAfee and Schwartz (1994)).

We assume that Z and K are both necessary for production and that they have positive but decreasing marginal products:

$$F_Z|_{K=0} = 0;\ F_Z > 0 > F_{ZZ} \text{ if } K > 0 \tag{1}$$

$$F_K|_{Z=0} = 0;\ F_K > 0 > F_{KK} \text{ if } Z > 0 \tag{2}$$

(where F_Z and F_K denote the partial derivative of F with respect to the Z and K, and similarly for second order partial derivatives). Furthermore, Z and K are substitutes, i.e., $F_{ZK} > 0$ for all $Z, K > 0$. These assumptions imply that the short-run cost function $c(X, K)$ is increasing and strictly convex in X. Note that $c_{XK} < 0$. Furthermore, $c(X, K)$ has a unique minimum in K, that is, there is an efficient capital level, $K^e(X)$, such that $c_K \gtreqless 0$ if and only if $K \gtreqless K^e(X)$. Finally, we assume that the market is viable, i.e., $p(0) > \lim_{X\to 0} c(X, K^e(X))$.

3 Equilibrium With and Without Integration

Consider first the vertically integrated industry including U and all downstream firms $D_1, ..., D_n$. The integrated firm maximizes

$$\Pi^m(X, K) = p(X)X - c(X, K), \tag{3}$$

where $X := \sum_{j=1}^n x_j$. This profit function is independent of the distribution of the outputs, $x_1, ..., x_n$, so that the total supply can be sold through one or through several downstream firms.[5] The following first-order conditions determine the optimal (aggregate) quantity X^m and the optimal level of capital K^m by

$$\frac{\partial \Pi^m(X, K)}{\partial X} = p_X X + p - c_X = 0 \tag{4}$$

[5]This only results with linear downstream costs. With convex costs, nonintegrated downstream firms are delivered positive amounts of the good. See Baake, Kamecke and Normann (2002).

and by

$$\frac{\partial \Pi^m(X,K)}{\partial K} = -c_K = 0. \tag{5}$$

Hence, vertical integration gives the usual monopoly solution with an efficient level of capital, i.e. $K^m = K^e(X^m)$, and inefficiently low output X^m.

Integration between U and just one downstream firm, D_1, would not change the result. By choosing $x_1 = X^m$, $x_j = 0$ for all $j > 1$, and $K = K^m$ the integrated firm stills earns the monopoly profit. In fact, delivering a positive amount to nonintegrated downstream firms will lead to a larger output and lower profits (see Rey and Tirole, 1997). Hence, nonintegrated firms will be completely foreclosed.

We now analyze the nonintegrated monopolist dealing with $n \geq 2$ downstream firms. As first shown by Hart and Tirole (1990), the following argument determines the unique (refined) Bayesian Nash equilibrium of the game. Passive beliefs imply that U offers each D_i a contract (x_i, T_i) which satisfies $p(X_{-i} + x_i)x_i = T_i$ (where $X_{-i} := \sum_{j=1, j\neq i}^{n} x_j$) and which maximizes the surplus to be gained from this individual contract, taking all other contracts with $D_{j\neq i}$ as given. Therefore, U maximizes

$$p(x_i + X_{-i})x_i - c(x_i + X_{-i}, K) \tag{6}$$

and the corresponding first order conditions

$$p_X\, x_i + p - c_X = 0 \tag{7}$$

are necessary and sufficient to define the equilibrium level of x_i.

The n first order conditions in (7) coincide with the usual Cournot oligopoly equilibrium conditions—except that c_X is evaluated at total output. The assumptions on cost and demand give a unique symmetric solution with the quantity $x^*(K,n)$ per firm and the corresponding equilibrium transfer $T^*(K,n) = p\left(nx^*(K,n)\right) \cdot x^*(K,n)$.

To analyze the ex-ante capital precommitment, define $X^*(K,n) := nx^*(K,n)$ and let

$$\Pi^*(n,K) = p(X^*)X^* - c(X^*,K) \tag{8}$$

denote the monopolist's aggregate profit. Differentiating with respect to K yields the following first-order condition

$$\frac{\partial \Pi^*}{\partial K} = \frac{\partial X^*(K,n)}{\partial K} \left[p_X(X)X + p - c_X\right]|_{X=X^*} - c_K(X^*,K) = 0. \tag{9}$$

We denote $K^*(n)$ as the solution of (9) and obtain

Proposition 1 *Vertically nonintegrated and for all $n \geq 2$, U underinvests in capital, that is, $K^*(n) < K^e(X^*(K^*(n),n))$.*

Proof. Differentiating (7) and using symmetry reveals

$$\frac{\partial X^*(K,n)}{\partial K} = \frac{nc_{XK}}{p_X X^* - nc_{XX} + (n+1)p_X} > 0, \tag{10}$$

where the sign follows from the second order conditions for x^* and from $c_{XK} < 0$. Since $X^*(K,n) > X^m(K)$ for all $n > 1$, we have

$$\left[p_X(X)X + p - c_X\right]|_{X=X^*} < 0. \tag{11}$$

Hence, (9) implies $c_K(X^*,K) < 0$. ■

The intuition behind Proposition 1 is straightforward. Secret contracts and downstream competition force U to supply more than the monopoly quantity. With an inefficiently small level of capital, U increases his marginal costs and thus commits to supply lower quantities to the downstream firms. This partly solves the commitment problem, however, at the cost of the inefficient capital structure. Crucial for this argument is that U can precommit and that the capital level can be observed by the downstream firms. The precommitment effect arises when capital is less easily and less quickly adjusted in the short run than other factors of production, for example, labor. The capital investment will be observable if it consists, e.g., in an observable number of plants or machines, or if investment orders are public.

Before we turn to the discussion of the welfare consequences, let us mention two results on the robustness of this underinvestment effect.[6] Firstly, we show that the underinvestment result in Proposition 1 also holds for infinitely many downstream firms. Note that infinitely many downstream firms imply the first-best solution in Hart and Tirole (1990). In their model, price equals marginal cost in this case and no inefficiency can prevail. In our model, price also tends to the short run marginal cost if the number of firms becomes large, but since the first term in (9) does not converge to zero, the downward bias in capital also remains in the limit. Secondly, we show that $K^*(n) < K^m$ holds under mild regularity conditions. That is, the monopolist underinvests not only relative to the efficient capital input but also relative to the capital level chosen in the integrated monopoly solution.

4 Welfare Comparison

The main implication of Proposition 1 is that there is an efficiency loss both with and without vertical integration. There is either monopolization or a long-run cost inefficiency. Comparing the two, it turns out that neither alternative welfare dominates the other in the general model. Therefore,

[6] A file containing the proofs is available from the *IJIO* website, www.mgmt.purdue.edu/centers/ijio.

we now analyze a parametrized model. Suppose that inverse demand is $p(X) = 2 - X$ and that the cost function is $c(X, K) = (K^2 + X^2)/2K$. This cost function is implied, for example, by the Cobb-Douglas technology $X = Z^{0.5}K^{0.5}$ and both input prices equal to 0.5.

With vertical integration and given K, the monopolist's output and profit are

$$X^m(n, K) = \frac{2K}{1 + 2K}, \tag{12}$$

$$\Pi^m(n, K) = \frac{(3 - 2K)K}{2 + 4K}. \tag{13}$$

Maximizing $\Pi^m(n, K)$ with respect to capital yields $K^m = 0.5$ and, hence, $X^m = 0.5$.

For the vertically nonintegrated structure, we can use (7) to obtain

$$X(n, K) = \frac{2Kn}{n + K(1 + n)} \tag{14}$$

and

$$\Pi^*(n, K) = \frac{4nK(K + n)}{(n + K(1 + n))^2} - \frac{K(5n^2 + K(1 + n)(2n + K(1 + n))}{2(n + K(1 + n))^2}. \tag{15}$$

While (15) can be used to explicitly solve for K^*, the formula for K^* is too complex to be informative and we refrain from writing it down.

Welfare, denoted by W, is the sum of consumers surplus and producers surplus, that is,

$$W = \int_p^2 (2 - v)dv + \Pi. \tag{16}$$

We analyze the difference in welfare of the nonintegrated case and the integrated case, $\Delta W = W^* - W^m$. With the explicit solution for $K^*(n)$, we can derive the numerical solution for ΔW. The relation between ΔW and the number of downstream firms is shown in Figure 1.

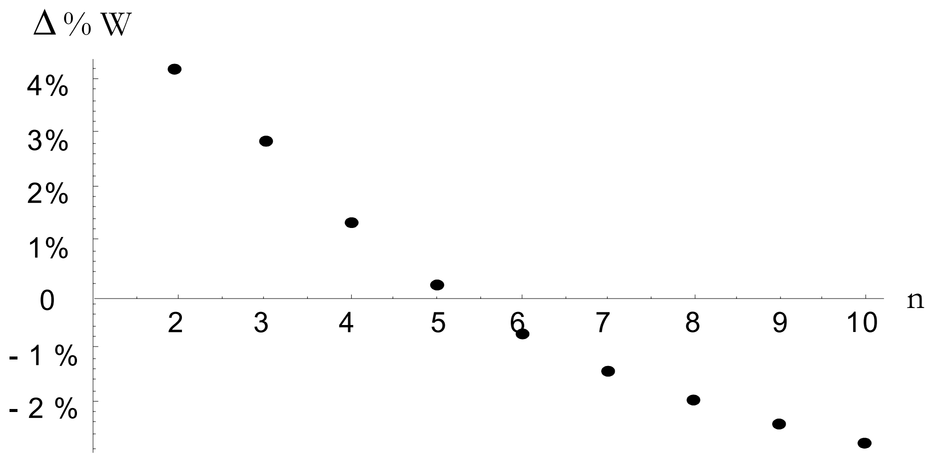

Figure 1: The impact of the number of downstream firms on the difference in welfare.

We observe that $\Delta W < 0$ when $n > 5$. That is, when there are more than five downstream firms, the efficiency loss from integration (and therefore monopolization) is smaller than the loss resulting from downward bias in capital with downstream competition. Further, we find that $\lim_{n\to\infty} K^* = 0.365$ and $\lim_{n\to\infty} X^* = 0.534$, compared to $K^m = X^m = 0.5$. With a large number of firms, the change in welfare becomes $\lim_{n\to\infty} \Delta W \approx -0.023$. Compared to $W^m = 0.375$, the reduction is 6.13%. Figure 1 also demonstrates that vertical integration becomes more beneficial with more intensive downstream competition. By contrast, in Hart and Tirole's (1990) model, vertical integration leads to higher welfare losses as the number of downstream firms increases.

5 Conclusion

In this paper, we show that vertical separation together with downstream competition leads to inefficient upstream capital investments. With vertical integration, the capital level is efficient but the usual monopolistic reduction of output occurs. Hence, from a policy perspective, the alternative is either monopolization or long-run inefficiencies and, a priori, neither of the two alternatives clearly welfare dominates the other. For a parametrized model, we show that six or more downstream firms are sufficient to make vertical integration preferable from a public perspective.

Our results are an additional line of critique on the new foreclosure theories as developed by Salinger (1988), Ordover et al. (1990) and Hart and Tirole (1990).[7] So far, it has been pointed out that vertical integration is neither necessary nor sufficient for the monopolization of the market. It is not necessary since other, arguably simpler, vertical restraints (e.g., public contracts, non-discrimination clauses) successfully help monopolizing the market (see McAfee and Schwartz, 1994, and Rey and Tirole, 1997). Integration is not always sufficient either. For example, when downstream firms have convex costs, partial integration does not yield maximum industry profits (see Baake, Kamecke, and Normann, 2002). However, these papers do not make a rigorous point against the prohibition of vertical integration because a policy against integration still does not reduce welfare. In our model, preventing integration may indeed be harmful.

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