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QUANTIFYING THE COMPETITIVE EFFECTS OF PRODUCTION JOINT VENTURES

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A joint venture among competitors to produce output alters the parents' competitive incentives. Any joint venture involves both joint financial interest and control over the production levels of the venture entity and the parent firms. The competitive incentives of the parents and rival firms depend on the exact financial interest and control arrangements made. This paper analyzes a number of alternative arrangements within the standard non-cooperative oligopoly model and devises a Modified Herfindahl–Hirshman Index (*MHHI*) to quantify their relative competitive incentives. Independent entry by a single parent and a full merger of the parents may be viewed as particular financial interest and control arrangements. The use of this methodology for policy analysis of proposed ventures is illustrated with the facts of the recent GM–Toyota joint venture.

1. Introduction

A horizontal joint venture among competitors alters competitive incentives. Following on the work of Reynolds and Snapp (1986), this note analyzes these effects and devises a Modified Herfindahl–Hirshman Index (*MHHI*) to quantify these incentives. We focus on the impact of the financial interest and management control structure of the venture. Analysis of these two avenues does not provide a complete policy analysis of the desirability of joint ventures, but does allow a quantification of the competitive incentives of alternative ownership and control structures.

By its very nature, a horizontal joint venture involves financial interest among competitors. This occurs because the profits of the joint venture are shared by the parent stockholders, which reduces the parent's private incentive to expand output and thereby lower price toward the competitive

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level. A second, related issue concerns the management control over the pricing and output decisions of the joint venture. Just as the parents' financial interest makes competition against the joint venture unprofitable, competitive moves by the joint venture against the parents are also self-destructive. In order to prevent unprofitable competition by the joint venture entity against the parent corporations, the parents have a private incentive to structure the joint venture agreement in a way that removes the discretion of the joint venture management over these competitive instruments and replaces discretion with either control by the parents or with a formula that determines prices or outputs.

Joint ventures may affect competition in other important ways not analyzed here. First, joint ventures may increase production efficiency. As with the traditional Herfindahl–Hirschman Index (*HHI*) analysis of mergers, the calculation of the Modified *HHI* (*MHHI*) for a joint venture does not attempt to construct the tradeoff between these social benefits and the harm to competition, but instead focuses on quantifying the anticompetitive effects. Then, an analyst can compare likely competitive harm against likely efficiency benefits. Second, there are a number of avenues through which a joint venture among competitors in an oligopolistic industry can facilitate tacit coordination beyond the scope of the joint venture itself [See Pitofsky (1969) and Brodley (1982).] An alternative theory of these anticompetitive effects of joint ventures could be developed following Stigler (1968), Orr and MacAvoy (1965), and Green and Porter (1984). In such a theory, the quantitative index of market power would measure the probability of successful collusion as a function of market structure. Analysis of these issues is beyond the scope of this paper. We believe that two approaches to horizontal arrangements are complementary: theories of the incentive effects of the arrangements under the assumption of continuing non-cooperative behavior complement theories of the probability of collusion.

For any joint venture, a number of financial interest and control arrangements are possible. By formalizing each of these control arrangements in the context of the standard non-cooperative oligopoly model, the *MHHI* formula can be derived. By calculating an *MHHI* for alternative financial interest and management control structures for a prospective joint venture, the likely competitive impacts of the alternatives can be better compared. For any initial (pre-joint venture) market shares, an *MHHI* gauges the relative competitive incentives of the firms in the industry arising from the alternative financial interest and control structures.

The remainder of this paper is organized as follows. Section 2 lays out assumptions and notation. In section 3, the *MHHI* is derived for several alternative joint venture arrangements. Subsection 3.5 summarizes of the results of that analysis and provides a comparison of the competitive effects of alternative financial interest and control structures. In section 4, illustrative calculations are provided based upon the facts of the GM–Toyota automobile joint venture.

2. Assumptions and notation

Consider a model of a homogeneous-product industry with n production units that are organized into firms. The production units are not necessarily symmetric. Each production unit has strictly upward sloping marginal costs. All firms behave as Cournot (quantity-taking) oligopolists. The potential joint venture involves ownership of production unit n by two parent firms identified with production units 1 and 2. Except for the possibility of a joint venture, we follow Cowling and Waterson (1976).

2.1. Notation

n = number of firms,
x_i = output of firm i ($i=1, 2, \ldots, n$),
X = total industry output ($X=\sum_{i=1}^{n} x_i$),
p = price of output,
$p(X)$ = market (inverse) demand curve,
η = demand price elasticity; $\eta = -p(X)/Xp'(X)$,
s_i = market share of firm i,
B_i = share of venture ownership held by firm i,
$C_i(x_i)$ = average (unit) costs of firm i,
π_i = profits of firm i; $\pi_i=(p-C_i(x_i))x_i$,
c_i = marginal costs of firm i,
$c_i(x_i)$ $=\partial(x_i C_i(x_i))/\partial x_i$; $\partial c_i(x_i)/\partial x_i > 0$,
PCM = industry average price/marginal cost margin: $PCM=\sum_{i=1}^{n} s_i(p-c_i)/p$,
HHI = Herfindahl–Hirshman Index: $HHI=\sum_{i=1}^{n} s_i^2$.

To keep the analysis simple, we assume that there is no efficiency gain from the formation of the joint venture. That is, the costs of production in units n, 1 and 2 will be $x_n C_n(x_n) + x_1 C_1(x_1) + x_2 C_2(x_2)$ independent of the ownership and control structure. We further assume that marginal costs are increasing in output at each of the units. These assumptions follow from our view of the nature of many production joint ventures, that they involve consolidation of ownership and decision-making, but do not involve any integration of production facilities. Instead, production continues to be managed at the plant level, so that additional production scale economies may not be achieved. Of course, if multiplant organization necessarily causes cost efficiencies as well as joint decision-making about the level of output, these cost assumptions will be inconsistent.[1]

[1]However, we do not believe that such efficiencies are a necessary feature of production joint ventures. We are unaware of any theoretical or empirical evidence suggesting this.

In the base case of n independent entities, Cowling and Waterson (1976) derive the relationship between the price–cost margin[2] and the HHI,

$$PCM = \sum_{i=1}^{n} s_i(p-c_i)\Big/p = \frac{1}{\eta}\sum_{i=1}^{n} s_i^2 = \frac{1}{\eta}HHI. \tag{1}$$

The assumption of Cournot behavior is inessential to the analysis, as long as all firms have the same conjectures. [See Ordover et al. (1981).] The assumption of strictly upward-sloping marginal cost is crucial, however. With identical constant marginal costs, mergers for market power can be privately unprofitable. [See Stigler (1950) and Salant et al. (1983).] Much the same will be true of joint ventures. But the finding that socially undesirable mergers (or joint ventures) are also privately unprofitable depends on the assumption of identical and constant marginal cost. [See Perry and Porter (1985).] Second, many of the results proved below require an interior solution to the first-order conditions for all production units. Such a solution will typically not exist for firms 1, 2, and n if all three have constant marginal costs.

3. Derivation of the modified *HHI* for joint ventures

In this section, we modify the standard analysis to account for the various financial interest and control mechanisms that might govern joint venture agreements. This analysis draws on and extends the work of Reynolds and Snapp (1986). As in the case of merger analysis using the HHI, this analysis determines the effect of the control arrangements on competitive incentives as a function of industry structure. We do not calculate which of these alternative financial interest and control structures would lead to the largest profits for the parents.

3.1. Silent financial interest

The simplest arrangement to analyze is the case of a pure equity interest, where the parents maintain no control over the pricing or output decisions of the joint venture (*jv*). We refer to this case as a silent financial interest.

Suppose two industry rivals, firm 1 and firm 2, own profit shares B_1 and B_2 in the jv, firm n. Even though n is owned by 1 and 2, an independent management of firm n retains full control over its own output decisions. By this we mean that it does not take its parents' interests into account in making its decisions. Formally, firm n maximizes its profit π_n, or

$$\max_{x_n} \pi_n = (p - C_n(x_n))x_n. \tag{2}$$

[2]For a general analysis of economic welfare measurement using PCM and various concentration indices, see Dansby and Willig (1979) and Encaoua and Jacquemin (1980).

However, the managements of firm 1 and firm 2 each recognize their respective financial interests in firm n. Each parent will take into account its share B_i of firm n's profits in making its own output choice. Formally, for each parent firm, we have

$$\max_{x_i} \pi_i + B_i \pi_n, \qquad i=1,2. \tag{3}$$

Substituting for π_i and π_n, we have

$$\max_{x_i} (p - C_i(x_i))x_i + B_i(p - C_n(x_n))x_n. \tag{4}$$

The first-order conditions can be written as follows:

$$p - c_i = -p'(X)(x_i + B_i x_n), \qquad i=1, 2. \tag{5}$$

The first-order conditions for the remaining firms ($i=3,4,\ldots,n$) are unchanged. Transforming the equations and summing, we have

$$PCM = \frac{1}{\eta} \sum_{i=1}^{n} (s_i^2 + B_i s_i s_n). \tag{6}$$

The extra $B_i s_i s_n$ terms represent the effect on the PCM of the profit-sharing provisions, relative to the case of firm n being a stand-alone competitor, fully independent of its rivals. Defining the $MHHI$ in the form $MHHI = PCM^*\eta$, we have

$$MHHI = \sum_{i=1}^{n} s_i^2 + B_1 s_1 s_n + B_2 s_2 s_n. \tag{7}$$

3.2. Control by one parent

3.2.1. Control by one parent with silent financial interest

If only one parent (say firm 1) were to control a venture in which firm 1 and firm 2 have shares B_1 and B_2, eq. (7) would be altered accordingly. In this case, both x_n and x_1 will be chosen to maximize firm 1's total profits, $\pi_1 + B_1 \pi_n$. The first-order condition for x_n is

$$B_1(p - c_n) = -p'(X)(x_1 + B_1 x_n),$$

while the condition for x_1 is given by (5). Dividing by B_1 in the x_n-equation, we have

$$MHHI=\sum_{i=1}^{n} s_i^2+\left(\frac{1}{B_1}+B_1\right)s_1s_n+B_2s_2s_n. \tag{8}$$

We refer to this case as 'control by one parent'.

3.2.2. Full ownership by one parent

If firm 1 owned 100% of firm n and maintained full control over firm n, then $B_1=1$ and $B_2=0$. Eq. (8) becomes

$$MHHI=\sum_{i=1}^{n} s_i^2+2s_1s_n. \tag{9}$$

We call this case 'full ownership by one parent'. That (9) is equivalent to the standard formula for the post-merger HHI is no surprise. Such an arrangement is conceptually equivalent to the merger.

3.3. Financial interest plus joint control

3.3.1. Limited joint control

The parents of the joint venture may jointly control the output decisions of the joint venture firm. In that case the joint venture management would not only be concerned with the profits of firm n, but also with the interdependent profits of firm 1 and firm 2. The joint venture would choose its output x_n to maximize the profits of itself and its parents, which we denote by π_J, where $\pi_J=\pi_1+\pi_2+\pi_n$. If the parents do not act cooperatively, each parent would continue to maximize $\pi_i+B_i\pi_n$. We refer to this case as 'limited joint control'.

Using the definition of π_i, the jv acts to maximize π_J, or

$$\max_{x_n}(p-C_1(x_1))x_1+(p-C_2(x_2))x_2+(p-C_n(x_n))x_n. \tag{10}$$

Firm n's first-order condition is given by

$$p-c_n=-p'(X)(x_1+x_2+x_n). \tag{11}$$

The parents' first-order conditions remain as given by (5). Substituting eq. (11) for the earlier first-order condition of firm n and recalculating the $MHHI$ formula, we have

$$MHHI=\sum_{i=1}^{n} s_i^2+(1+B_1)s_1s_n+(1+B_2)s_2s_n. \tag{12}$$

3.3.2. Partial merger

The parents may be able to do better than limited joint control. They may be able to use the jv to effect a cooperative partial merger as follows. If the joint venture agreement is sufficiently complex, it may allow for substantial profit redistribution among the parents even within the apparent constraint of a profit split according to the shares B_1 and B_2. For example, if it is desired to distribute a disproportionate return to one parent, that parent can achieve a higher return on investment by making a smaller capital contribution to the venture. Or the transfer prices of materials sold to the joint venture by either parent, or output sold by the venture to one of the parents, could be inflated or deflated. A joint venture might also allow profit redistribution through additional royalty payments, or management fees.

If sufficient freedom to redistribute profits is available, higher joint profits can be earned. It would be in both parents' interest for each parent (as well as the venture) to maximize joint profits and then to redistribute the profits among the parents. If this policy were followed successfully, the outcome would be equivalent, of course, to a merger among the two parents and the venture in the lines of business in which the venture operates For this case of 'partial merger', we have

$$MHHI=\sum_{i=3}^{n-1} s_i^2+(s_1+s_2+s_n)^2=\sum_{i=1}^{n} s_i^2+2(s_1s_2+s_1s_n+s_2s_n). \tag{13}$$

3.4. Financial interest plus competitor-based escalator clauses

The joint venture agreement may determine the level of jv production by a formula that depends on the prices or output levels chosen by other firms in the market. If the joint venture sells in the same market as the parents, a *competitor-based output formula* sets the output of the venture according to output decisions of the competitors in the industry. In this case, control over the jv's production level is effectively assigned to all of the firms in the industry according to the formula. Alternatively, the venture may sell its output to one of the parent firms for distribution, with the transfer price determined by a formula. Although the transfer price is set by the formula, the level of production of the venture could be controlled by the distributing parent, by the other parent, or by the parents jointly, or the transfer pricing formula could be part of a partial merger control arrangement. The incentive effects of a *competitor-based transfer pricing formula* will depend on which of these control arrangements is adopted.

3.4.1. Competitor-based output formula

Suppose a contractual formula determines x_n as a function of the outputs of other firms in the market, including possibly the parents. For example, the formula might be designed to keep the jv's market share constant. This alternative control structure would eliminate direct control over the jv output by the parents, but would change the incentives of all of the firms whose outputs are given weight in the formula. Now they can anticipate exactly how the joint venture will respond to their competitive moves.

Formally, consider the following formula in which firm n's output is determined by the outputs of its rivals as follows:

$$x_n = \underline{x}_n + \sum_{i=1}^{n-1} a_i(x_i - \underline{x}_i), \tag{14}$$

where $\underline{x}_i$ denotes a baseline level of x_i. The weights a_i might depend on initial market-shares or some other factors. Under this output-setting formula, if firm i contracts output, it will expect industry output to contract by the amount of its contraction times the factor $(1+a_i)$. The first-order conditions are

$$p - c_i = -p'(X)(1+a_i)x_i \quad \text{for} \quad i = 1, 2, \tag{15}$$

$$p - c_i = -p'(X)(1+a_i)(x_i + B_i x_n) - B_i(p - c_n)a_i \quad \text{for} \quad i = 3, 4, \dots, n-1. \tag{16}$$

Firm n has no first-order condition. Instead, in order to calculate PCM, by adding the tautology $p - c_n = p - c_n$ and multiplying each equation by the appropriate x_i, summing and dividing by $p(X)$, we have[3]

$$PCM = \frac{1}{\eta} \sum_{i=1}^{n-1} (1+a_i)(s_i^2 + B_i s_i s_n) + z, \tag{17}$$

where the term z is given by

$$z = (s_n - B_1 a_1 s_1 - B_2 a_2 s_2)(p - c_n)/p. \tag{18}$$

Under the further assumption that the price–cost margin of firm n equals the average of the PCM's for the other firms in the industry, the PCM given by eq. (17) can be easily adjusted.[4] Substituting PCM for $(p-c_n)/p$ in (18)

[3]Note that the first term is now summed only over the range $i=1$ to $n-1$. This adjustment is due to the fact that firm n does not select its output.

[4]If the assumption of identical price–cost margins does not hold, a further small adjustment can be made. In particular, if $PCM = w(p-c_n)/p$, where w is the proportional difference in price–cost margins, and if eq. (18) is rewritten in the form $z = k(p-c_n)/p$, then the multiplicative adjustment term to PCM would become $a = (1-k)/(1-wk)$. The adjustment is typically small. For example, if $k=0.05$ and $w=1.2$, then $a = 0.95/0.94 = 1.011$. If $k = -0.05$ and $w = 1.2$, then $a = 1.05/1.06 = 0.991$. Thus, even for an $MHHI$ of 2,000, an adjustment of only 20 points (plus or minus) is needed.

and replacing z in (17) with its definition (18), we have

$$MHHI=\sum_{i=1}^{n-1} A(1+a_i)(s_i^2+B_i s_i s_n), \tag{19}$$

where the adjustment term A is given by

$$A=\frac{1}{1-s_n+\sum_{i=1}^{n-1} a_i B_i s_i}. \tag{20}$$

Comparing (19) with the *MHHI* formula for control by one parent, given by (8) or with the formula for limited joint control, given by (12) it follows that the impact of removing control from one or both parent firms to a competitor-based output formula can either increase or decrease the competitiveness of the arrangement. The intuition of this can be seen by examining the implicit objectives of the competitor-based output formula. In the case of control by a single parent, the joint venture maximized the sum of jv plus that single parent's profits. Under limited joint control, the jv maximizes $\pi_n+\pi_1+\pi_2$. What does the competitor-based output formula cause the joint venture to (implicitly) maximize?

Suppose that the output formula works to keep the jv's market share constant. Then the other firms' decisions do not just determine their own quantities; they also collectively determine industry output. As a result, a constant market-share rule is the same policy that would be adopted by a perfectly policed cartel if all firms had had the same costs.[5]

Thus the intuitive difference between parental control and a competitor-based formula is this: parental control involved the joint venture maximizing the profits of a subset of the industry, while a competitor-based output formula involves the joint venture (implicitly) maximizing the profits of the entire industry. Which of these is less competitive depends upon whether it is the parents or the other firms in the industry which would gain more from membership in a partial cartel.

3.4.2. Transfer-price formula with control by distributing parent

The joint venture might sell its product to one of the parents for distribution, with the transfer price based upon the prices of competing products. As in the previous case, the joint venture has no independent pricing power. However, in this case the distributing parent might control

[5]If firms have different costs, a joint profit-maximizing cartel would assign output rules slightly different from constant market shares [Osborne (1976) and Orr and MacAvoy (1965)]. Note that this means that the qualification we mentioned earlier, that a_i needs to be greater than r_{in}, is unimportant if $a_i=s_i$. It will only be true that $a_i<r_{in}$ if the industry is already producing less output than would a perfectly-policed cartel.

the output of the joint venture. In this case, the 'silent' (non-distributing) parent has no control, so that its incentives are determined solely by its financial interest in the joint venture.

Formally, assume that firm 1 is the distributing parent, and that the transfer price formula at which it buys the good from the joint venture is given by $w(p)$, $w'>0$. A formula that does not depend on competitors' prices (e.g., fixed price contract) would have $w'=0$ while a full pass-through contract would have $w'=1$.[6] Now the profit of the joint venture is given by

$$\pi_n=(w(p)-C_n(x_n))x_n, \tag{21}$$

where the revenue of the joint venture depends not on the final price p but on the transfer price $w(p)$. The profit of the silent parent is given by

$$\pi_2=(p(X)-C_2(x_2))x_2+B_2(w(p)-C_n(x_n))x_n. \tag{22}$$

The first-order condition is given by

$$p-c_2=-p'(x_2+B_2x_nw'(p)). \tag{23}$$

The distributing partner's maximization problem is given by

$$\max_{x_1,\, x_n}(p-C_1(x_1))x_1+B_1(w(p)-C_n(x_n))x_n+(p-w(p))x_n, \tag{24}$$

where the second term is its share of jv profits and the third term represents its profits from distributing the jv product. The distributing parent's share in the joint venture leads it to face an effective cost less than the full transfer price w. If it purchases an extra unit, its distribution wing must pay w for it, but it receives back B_1w as a result of its share of the joint venture revenue. The first-order conditions are given by

$$x_1\colon\ p-c_1=-p'(x_1+(1-(1-B_1)w')x_n) \tag{25}$$

and

$$x_n\colon\ p-c_n=-p'(x_1+(1-(1-B_1)w')x_n)+(1-B_1)(w-c_n). \tag{26}$$

From (23), (25) and (26) we have

$$\sum_{i=1}^{n-1}s_1(p-c_i)/p+s_n(p-B_1c_n-(1-B_1)w)/p$$
$$=\frac{1}{\eta}\left(\sum_{i=1}^{n-1}s_i^2+B_2w's_2s_n+(1-B_2w')s_n^2+(2-B_2w')s_ns_1\right). \tag{27}$$

[6] We assume that the function is set so as to ensure that $w(p)>c_n$ for all p, i.e., the transfer price never falls below the jv's marginal cost.

To derive an *underestimate* of the industry average PCM, we assume $w=c_n$. Then,

$$MHHI=\sum_{i=1}^{n} s_i^2+2s_1s_n+B_2w'(s_2s_n-s_n^2-s_1s_n)<\eta PCM. \tag{28}$$

The intuition of this control arrangement can be seen by comparing it with the special case of a fixed-price supply contract, where $w'=0$. Then firm 1 acts as if it is facing a 'blended' marginal cost given by $B_1c_n-(1-B_1)w$. However, this cost would not equal the marginal cost of the jv production. Instead, we would have

$$\sum_{i=1}^{n-1} s_1(p-c_i)/p+s_n(p-B_1c_n-(1-B_1)w)/p=\frac{1}{\eta}\left(\sum_{i=1}^{n} s_i^2+2s_1s_n\right). \tag{29}$$

This is identical to (9), full ownership by firm 1, except that firm-1 buys the joint-venture product at the blended marginal cost. If the transfer price were a constant, the financial interest of firm 2 in the jv would not affect its output incentives, since changes in x_2 would have no impact on the price received by the jv. If firm 1 reduced x_1, however, it would receive the full benefit of the price increase in terms of its distribution profit for x_n. Thus if firm 1 owns a half interest in the joint venture, it can buy the jv units both at half-price and at half-cost; firm 1 behaves as if it had marginal cost $(w+c_n)/2$ for the jv output.

When $w'>0$, the transfer price is not a constant and financial interests come into play. From the last term in (27) we can identify two effects. First, firm 2's incentives are changed by its financial interest in the jv. The only difference from the earlier analysis is that the $B_2s_2s_n$ is multiplied by w'; firm 2's incentives are changed by its effect on the transfer price, not the final sales price. Second, compared to the case of full ownership by firm 1, firm 1's incentives change. [This results from the $B_2w'(-s_n^2-s_1s_n)$ term.] This reflects the fact that, when the transfer price is not a constant, firm 1 does not own the entire profit of the joint venture at the margin, but has transferred some of that profit to firm 2. This increases firm 1's incentive to expand output.

3.4.3. Transfer-price formula with limited joint control

The fact that firm 1 distributes the joint venture output does not necessarily mean that firm 1 has control over the jv production. An alternative control arrangement would have the jv control its own output. If the jv management acts in the interest of both parents jointly: we denote this case as 'transfer-price formula with limited joint control'.

In this case, x_1 and x_2 continue to be set as they were in the last section by eqs. (23) and (25). But now the jv output is set so as to maximize the sum of profits π_I *from* x_1, x_2 and x_n, as in the case of 'limited joint control' without a transfer pricing formula. Thus the first-order condition for firm n continues to be given by (10).

$$MHHI = \sum_{i=1}^{n} s_i^2 + (2-(1-B_1)w')s_1 s_2 + (1+B_2 w')s_2 s_n. \tag{30}$$

Comparing (30) to the *MHHI* for 'limited joint control' without the competitor-based transfer price formula, given by (12), shows that if $w'=1$, the two control schemes are identical.[7]

3.4.4. Transfer-price formula and partial merger

The use of the transfer-pricing scheme, together with other available instruments, may be sufficient to effect collusive side-payments and thereby to enforce a partial merger. In this case, x_1, x_2 and x_n are each set to maximize joint profits. Thus, the analysis and conclusion are identical to the case of a 'partial merger' without a 'transfer pricing formula'.

3.5. Comparing alternative control structures

The *MHHI* formulae for alternative financial interest and control structures are summarized in table 1. As can be seen from inspection of table 1, the competitive effects of any particular ownership and control structure depend on industry structure. There are, however, some relationships among the different structures which can be determined in general.

The first line shows the ordinary *HHI*, as if the jv production unit entered as an independent firm. This industry structure is more competitive than any of the others, because the jv exerts a full, independent competitive force on the industry. Within the class of control structures that do not utilize a competitor-based formula, we can establish the following results in general:

(1) 'independent entry' is more competitive than *any* of 'silent financial interest', 'limited joint control', 'partial merger', 'full ownership by one parent', and 'control by one parent',
(2) 'silent financial interest' is more competitive than *any* of 'limited joint control', 'partial merger', 'full ownership by one parent', and 'control by one parent',

[7]Intuitively, $w'=1$ means that firm 1 cannot affect the margin it receives for distributing the jv output, $p-w$. Thus the fact that firm 1 distributes the jv output has no impact on its incentives in this case. In the other polar case $w'=0$, (30) implies the same *MHHI* as 'limited joint control' without the competitor-based transfer-price formula, given by (12), but with complete ownership by firm 1, $B_1=1$. In this case, neither parent can affect the jv's profit margin, since w is a constant. But firm 1 receives the full benefit of price increases on the jv output through its distribution profit. Thus the incentives in this case are as if firm 1 owned all of the jv.

Table 1

Summary of modified *HHI* formulae.

Control structure	*MHHI* formula
0. Independent entity	$\sum_{i=1}^{n} s_i^2$
1. Silent financial interest	$\sum_{i=1}^{n} s_i^2 + B_1 s_1 s_n + B_2 s_2 s_n$
2. Control by one parent	$\sum_{i=1}^{n} s_i^2 + \left(\frac{1}{B_1} + B_1\right) s_1 s_n + B_2 s_2 s_n$
3. Full ownership by one parent	$\sum_{i=1}^{n} s_i^2 + 2 s_1 s_n$
4. Limited joint control	$\sum_{i=1}^{n} s_i^2 + (1+B_1) s_1 s_n + (1+B_2) s_2 s_n$
5. Partial merger	$\sum_{i=3}^{n-1} s_i^2 + (s_1 + s_2 + s_n)^2$
6. Competitor-based output formula[a]	$\sum_{i=1}^{n-1} A(1+a_i)(s_i^2 + B_i s_i s_n)$
7. Transfer-price formula with control by distributing parent[b]	$\sum_{i=1}^{n} s_i^2 + 2 s_1 s_n + B_2 w'(s_2 s_n - s_n^2 - s_1 s_n) + \varepsilon$
8. Transfer-price formula with limited joint control	$\sum_{i=1}^{n} s_i^2 + 2 s_1 s_n + s_2 s_n + B_2 w'(s_2 s_n - s_1 s_n)$

[a] $A = 1/(1 - s_n + \sum_{i=1}^{n-1} a_i B_i s_i)$.
[b] Lower bound underestimate.

(3) 'limited joint control' is more competitive than 'partial merger',
(4) 'control by one parent' is more competitive than 'partial merger',
(5) 'full ownership by one parent' is more competitive than 'control by that parent' with a 'silent financial interest' by the other parent. This follows because $B + 1/B > 2$ for $B < 1$.

More results can be determined as a function of the market shares of the parents and their equity shares in the venture. We have:

(6) 'control by one parent' (firm 1) is more competitive than 'limited joint control' if and only if $s_1/s_2 < B_1/B_2$, that is, if and only if firm 1's share in the joint venture is larger than its share of total firm 1 plus firm 2 output.[8]
(7) 'control by firm 1' is more competitive than 'control by firm 2' if and only if $s_1/s_2 < B_1/B_2$.

[8] To see this, subtract the *MHHI* formulae for the two cases (table 1), to get $(1/B_1 + B_1) s_1 s_n + B_2 s_2 s_n < (1 + B_1) s_1 s_n + (1 + B_2) s_2 s_n$.

(8) 'full ownership by firm 1' is more competitive than 'full ownership by firm 2' if and only if $s_1 < s_2$.

These results completely order the anticompetitive effects of control schemes without competitor-based formulae. Comparing schemes with competitor-based escalator clauses depends on the precise details of the escalators. We therefore defer such comparison to the following section which discusses the specifics of the GM–Toyota automobile joint venture.

4. Application to the GM–Toyota joint venture

In this section, we use the *MHHI* to prospectively analyze a joint venture.[9] We consider a variety of governance structures to evaluate the potential competitive effects of alternatives and to establish benchmarks by which the structure adopted by the parents can be evaluated. Specifically, we analyze alternative ways in which the GM–Toyota joint venture might be organized, including the possibility that the venture might be wholly owned and operated by only one of the parties.

The *MHHI* can be a useful tool for evaluating the likely competitive effects of proposed joint ventures in the same way that the *HHI* is useful for evaluating proposed horizontal mergers. By comparing the *MHHI* for alternative financial interest and control structures, the *relative* competitive incentives of the alternatives can be gauged. Given a set of common market shares, if one structure leads to a higher *MHHI* than another, then it is likely that the post-jv *PCM* will be higher for the first structure.

Calculation of the *MHHI* necessarily requires the assignment of baseline market-shares to the joint venture entity and to the parent firms. This market-share assignment should have an objective basis rather than reflecting the analyst's subjective estimate of post-jv market-shares. Objectivity in the choice of the market-shares and consistency with the approach taken by the Justice Department in using the *HHI* to evaluate prospective mergers can be maintained by calculating shares on the basis of pre-jv shares or capacity levels for established firms and planned sales for the jv entity.[10] There are two methods by which we determine the market shares used in our analysis.

As a general matter, a joint venture represents the combining or merging of a fraction of the production capacity of the parents, while a merger involves the combination of 100% of the parents' capacity. Thus, a joint

[9]Although the GM–Toyota jv is now in operation, we use only pre-jv information in our analysis.

[10]It would not be logically inconsistent for an analyst to base *MHHI* calculations on an *objectively* derived set of post-jv equilibrium outputs, as long as the same set of market shares was used in all calculations. Then comparisons of different *MHHI* figures would gauge the relative incentive effects of the different possible control structures. However, such predictions are fraught with difficulty in avoiding circular reasoning.

venture is analogous to a partial merger. This view of joint ventures can be quantified for *MHHI* analysis by assuming that the jv entity (firm *n*) is constituted from the *existing* pre-jv production capacity of the parents in proportion to their ownership shares in the venture. In calculating the *MHHI*, the parents' pre-jv outputs are reduced accordingly and rivals' outputs are held at pre-jv levels. We denote this procedure as Method A.

Method A can be used to compare the relative competitive incentives of alternative governance structures for the jv. However, it is also useful for gauging the aggregate effect on incentives arising from the venture, relative to the pre-jv ownership and control structure. This latter comparison is made by comparing the post-jv *MHHI* for a selected governance structure to the pre-jv *HHI* for the industry. In this way, the effect of the joint ownership and control over a share of the parents' outputs can be measured. For example, it is sometimes claimed that a jv that represents a small fraction of the parent's total capacity can have no significant competitive effects because the parents remain independent competitors over the remaining capacity. Method A offers quantitative evidence on this issue.

Under Method B, we assume that the jv entity is constituted from *new* capacity. Parents' and rivals' outputs are held at pre-jv levels, while jv output is estimated by jv capacity. Because industry output differs from the pre-jv level, it is not proper to compare the *MHHI* levels calculated under Method B to either the pre-jv *HHI* or to the *MHHI* calculated under Method A. Instead, Method B is useful for gauging the competitive effects of *alternative* ways of organizing the ownership and control of the new capacity.

As a mechanical matter, these methods involve calculations on the basis of working assumptions about industry output. However, these working assumptions are not intended to represent an analytic presumption that industry output will necessarily remain the same (or rise) after the jv or that the jv entity will operate at the same scale regardless of the structure of the venture. Instead, this assignment is designed to provide reasonable baseline levels, common to all calculations.[11] In the GM–Toyota calculations below, the choice of baseline makes little difference to the results. Another way to see this point is as follows. If a jv would increase production efficiency, we would expect two different effects: lower costs would tend to reduce output, and altered competitive incentives would tend to decrease output. Like the *HHI* analysis of a merger, the *MHHI* analysis only quantifies the second of these two effects.

We now apply this methodology to the GM–Toyota joint venture. Under the consent decree concluded with the Federal Trade Commission, GM and

[11] For small jv's, the relationship among the *MHHI*'s for alternative structures will not be particularly sensitive to these assumptions. For example, in our calculations the assumption that industry output rises by the amount of the jv output or the assumption that each individual firm's output falls by 5% as a result of the jv changes the *MHHI* by about 1%.

Toyota each own 50% shares in a new firm, NUMMI (New United Motor Manufacturing, Inc.), which manufactures a subcompact auto with a design similar to the Toyota Corolla, at GM's plant in Fremont, California. Each parent appoints half the directors to the new firm, but Toyota appoints the president and has operational responsibility. GM distributes the output of the jv through its network of Chevrolet dealers. Formally, the jv sells the cars to GM, which in turn resells them to Chevrolet dealers. The transfer price paid by GM for the vehicles is determined by a formula based on competitors' prices. The Memorandum of Understanding (MOU) between GM and Toyota does not specify how the level of jv production is to be determined. The FTC consent decree limits jv output for distribution to GM to 250,000 units.

The transfer-pricing formula set out in the MOU might imply that any of the competitor-based formula models derived in section 2 apply to the jv. Although the formula does fix the price at which the jv car is transferred to GM, it is not clear from the MOU whether the jv output is controlled by GM, Toyota, or jointly by both parents. Because GM sets the wholesale price to Chevrolet dealers, it would be reasonable to assume that GM effectively controls the quantity of jv cars that can be sold, and thus the quantity produced by the jv. In this case, we use the formula $w(p)=0.9p$ to approximate the transfer price provisions of the MOU. Alternatively, any of the other control arrangements with a competitor-based transfer pricing formula also might apply. Still another possibility is that the jv chooses the price or quantity of the jv car to maintain a constant market share. In this case, the appropriate model would be the competitor-based output formula, with the weights derived from the MOU.

We do not attempt to define the relevant market but use the market definition and data adopted by the FTC Bureau of Competition: new cars sold in North America, in the size classes subcompact, compact and intermediate. 1982 unit sales by firm are reported in table 2, as are market shares under both Method A and Method B.

4.1. MHHI calculations

We calculate the effect of alternative financial interest and management control arrangements in a number of cases relevant to the GM–Toyota joint venture. The *MHHI* statistics for these cases are set out in table 3 for the two methods. Method A leads to *MHHI* figures below Method B, but no rankings of alternative structures are changed by the choice of method.

The first issue we address is the effect on incentives of the venture, relative to pre-jv incentives. GM's and Toyota's capacity contributions of 125,000 units each represent 4.4% and 22.0% of their respective pre-jv output levels. Comparing the pre-jv *HHI* of 2,099 to the various *MHHI*'s calculated under

Table 2

Output and market share data.[a]

Firm	Pre-jv Quantity[b]	Method A Quantity	Method A Share	Method B Quantity	Method B Share
GM	2,816	2,691	38.0	2,816	38.4
Toyota	568	443	6.3	568	7.7
Ford	1,113	1,113	15.7	1,113	15.2
Chrysler	845	845	11.9	845	11.5
AMC/Renault	165	165	2.3	165	2.2
Datsun	486	486	6.9	486	6.6
Honda	408	408	5.8	408	5.6
VW	177	177	2.5	177	2.4
Mazda	174	174	2.5	174	2.4
Subaru	146	146	2.1	146	2.0
Isuzu	15	15	0.2	15	0.2
Fiat	15	15	0.2	15	0.2
Other[c]	159	159	0	159	0
jv	—	250	3.5	250	3.4
Total	7,087	7,087	100.0	7,337	100.0

[a]Except for the Fremont plant, production data are for subcompacts, compacts and midsized cars as of 1982. [See Johnson (1983, p. 1007).] Fremont production of 250,000 units is the rated capacity of the plant.

[b]In thousands of units.

[c]'Other' firms are assumed to contribute 0 to all *MHHI* calculations. As a result, the *MHHI* calculations are all understated by a small, constant amount. This assumption does not affect the comparison between any two *MHHI* figures, as they are understated by the same amount.

Table 3

MHHI calculations for alternative ownership and control structures.

Financial and control structure	Method A	Method B
0. Pre-joint venture	2,099	n.a.
1. Silent financial interest	2,062	2,081
2.1. Toyota control	2,106	2,134
2.2. GM control	2,330	2,343
3.1. Toyota full ownership	2,028	2,055
3.2. GM full ownership	2,252	2,264
4. Limited joint control	2,218	2,238
5. Partial merger	2,771	2,911
6. Competitor-based output formula[a]	2,339	2,358
7. Transfer-pricing formula with GM control[b]	2,196	2,212
8. Transfer-pricing formula with limited joint control	2,224	2,244
9. Formula average[c]	2,253	2,271

[a]Calculated using the illustrative weights in the GM–Toyota MOU as follows: GM, 0.156 (two models in formula); Toyota, 0.3 (by special provision); Ford, 0.156; Datsun, 0.078 (one model in formula); Honda, 0.156; VW, 0.078; Subaru, 0.078.

[b]Underestimate.

[c]Average of lines 6, 7, and 8.

Method A, we see that some structures lead to an increase in competitive incentives for the industry, while others reduce competitive incentives in aggregate. For example, while 'silent financial interest' reduces the *MHHI* by 37 points, GM control adds 231 points and the average of the pricing formulae raises it by 154 points. While none of these figures approaches the 639 point increase that would arise from a full merger of the parents, the larger ones imply a substantial change in competitive incentives compared to the pre-jv situation.

Using either Method A or Method B, it is clear that control by the larger parent, GM, has a significant adverse effect on incentives. While Toyota control raises the *MHHI* only about 50 points above 'silent financial interest' under either method, the impact of GM control is much larger. about 260 points. Similarly, GM ownership implies much less competitive incentives than does Toyota ownership. A second clear implication of the table is that the competitor-based formulas leave substantial anticompetitive incentives in the industry, relative to some other potential governance structures. The transfer pricing formulae raise the *MHHI* above the baseline levels about as much as does GM control. These figures, based on the relatively small GM–Toyota joint venture, refute the presumption that a small jv has little impact on competitive incentives.

Assuming that the actual GM–Toyota governance structure is best captured by the average of the transfer pricing formulae, the overall conclusion about the competitive incentive effects of the jv does not depend crucially on the choice of baseline. If one believes that Toyota entry would have been likely, the jv increases the *MHHI* significantly relative to the benchmark of independent entry (i.e., 'Toyota full ownership'). On the other hand, if Toyota entry were considered unlikely, then the pre-jv *HHI* (of Method A) is the appropriate benchmark. Method A shows significant increases due to the jv. While the competitive incentive effects of a jv are not the only aspects relevant for policy purposes,[12] it is interesting that their approximate size is robust to alternative treatments of the capacity-expanding effects of the joint venture and to choice of benchmark.

Of course, assuming that the joint venture will go ahead still leaves the second policy issue of the choice of governance structure. 'Silent financial interest' and 'Toyota control' lead to superior competitive incentives than the transfer pricing formulae. Under Method B, for example, the average transfer pricing *MHHI* is 137 points above 'Toyota control' and 190 points above 'silent financial interest', a significant difference. However, regardless of one's conclusion, it is clear that use of the *MHHI* concept is superior to ad hoc theorizing.

[12]Of course, as discussed in the Introduction, a policy analysis of any jv must also take into account entry barriers, potential efficiency benefits, and other competitive factors.

4.2. Potential problems

Several potential criticisms of the application of the *MHHI* analysis to the GM–Toyota jv should be addressed.

Does the existence of the import quota on Japanese automobiles (VRA) limit the usefulness of the analysis? If the VRA were a rigid quota, Japanese outputs and price–cost margins would be determined by government action, not profit incentives. We find this criticism unconvincing. First, Japanese importers are not in fact so rigidly bound by the VRA. By altering the size and quality mix of automobiles exported, the Japanese firms can continue to compete by increasing the quantity of 'standardized' units exported. That is, an increase in quality is like an increase in quantity at the same prices.[13] Second, some of the Japanese producers can control their U.S. sales levels with their U.S. production.[14] Thus some or all of these firms are not rigidly constrained by the VRA. Finally, the quotas were substantially weakened in Spring, 1985.

The FTC staff[15] criticized Method A because it sets industry output at pre-jv levels. Although Method B satisfies this criticism, we believe that this criticism misconstrues both the jv and the *MHHI* analysis more generally.

First, the fact that the jv will utilize a plant that is currently mothballed does not by itself imply that total industry output will rise as a result of the jv. The plant might have been reopened by GM if there were no jv or additional vehicles might have been produced elsewhere by GM or a competitor.[16] Similarly, production of jv vehicles might lead GM or Toyota to reduce their production elsewhere or to delay the introduction of new models. For example, GM may phase out the Chevette more rapidly, rather than increase total subcompact production. Second, this criticism misunderstands the proper application of the *MHHI* analysis. The function of the *MHHI* analysis is to gauge the *incentives* of firms to expand or contract output as a result of alternative ways of structuring a jv. It does this by comparing *MHHI* levels for alternative financial interest and control structures, given a set of baseline levels for market shares. Under these circumstances, a higher *MHHI* for one structure implies reduced incentives

[13]See Feenstra (1984) for an empirical analysis of this effect. Feenstra reports that more than half of the increase in the price of Japanese automobiles resulting from the VRA has been offset by increases in quality. Thus there has been a large increase of standard quality imports under the VRA.

[14]For example, Honda produces passenger cars at its U.S. plant. Nissan might be able to produce passenger cars at its plant, and Toyota could produce in the U.S. if it opened up an assembly plant at Fremont or elsewhere.

[15]See especially Johnson (1983, pp. 1358, 1377).

[16]In fact, Fremont was closed during the longest post-war recession faced by the auto industry. The demand curve for automobiles has shifted out substantially since the time the plant was closed, and demand is forecast to remain high for the next several years. Thus there would have been some expansion of industry output, at the Fremont plant or elsewhere, even if there were no GM–Toyota jv.

to compete, and thus, a likelihood of lower industry output and higher prices resulting from that structure. Finally, as illustrated by table 3, use of Method B instead of Method A does not change the rankings of different governance structures.

Thus there are two separate issues involved in a jv that uses new capacity. First, what do the ownership and control features of the jv imply about competitive incentives? The *MHHI* answers this question. Second, would that capacity, or other capacity, have been brought on line absent the joint venture? An argument that industry capacity would be less absent the jv will turn out, in many cases, to be a disguised efficiency defense of the joint venture. For example, the argument that the jv parents bring unique capabilities to the operation of the jv is an argument for scale economies in management. Such an argument, if true, could show that the efficiency gains to a jv outweigh the change in competitive incentives, exactly as the managerial efficiency gains to a merger might outweigh its adverse competitive impact.

5. Conclusion

In the case of a merger, *HHI* analysis is used to gauge the extent to which the competitive incentives of the merged firm will be different from those of the two merging firms. The *HHI* quantifies the effect of the combination of the interests of the two firms. When firms partially combine their resources in a joint venture, some but not all of the firms' interests are also combined. Thus one would expect the change in competitive incentives to be less than the change resulting from a merger of the two firms. This paper has provided a Modified *HHI* for production joint ventures involving control of a single production entity by otherwise independent parents. Under these assumptions, the *MHHI* formulae derived here are conceptually similar to the *HHI* formula for a merger. The important difference is that a joint venture can have a great many different control arrangements, each combining the interests of the parent firms in a different way.

Our analysis of the GM–Toyota automobile production joint venture shows the applicability of this method to the prospective analysis of a joint venture. There are substantial differences in competitive incentives resulting from the different ownership and control structures, although none of them changes competitive incentives as much as a merger.

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