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ABSTRACT

Coexistence of Strategic Vertical Separation and Integration

by Jos Jansen*

This paper gives conditions under which vertical separation is chosen by some upstream firms, while vertical integration is chosen by others in the equilibrium of a symmetric model. A vertically separating firm trades off fixed contracting costs against the strategic benefit of writing a (two-part tariff, exclusive dealership) contract with its retailer. Equilibrium coexistence emerges when observable and non-renegotiable contracts are offered to downstream Cournot oligopolists that supply close substitutes. The scope for equilibrium coexistence diminishes when assumptions on contract observability and commitment are relaxed.

JEL Codes. L22, L42
Keywords: vertical oligopoly, contract costs, strategic substitutes

ZUSAMMENFASSUNG

Koexistenz von strategischer vertikaler Trennung und Integration

In der Arbeit werden die Bedingungen identifiziert, unter denen im Gleichgewicht eines symmetrischen Modells einige, in der Produktionskette vorgelagerte Firmen vertikale Trennung wählen, während andere sich für vertikale Integration entscheiden. Ein vertikal getrenntes Unternehmen wägt die fixen Vertragskosten gegen den strategischen Vorteil eines Vertrages (mit gespaltenem Tarif und exklusiven Vertriebsrechten) mit dem nachgelagerten Einzelhändler ab. Die Koexistenz der beiden Organisationsformen im Gleichgewicht entsteht, wenn den nachgelagerten Cournot-Oligopolisten, die fast perfekte Substitute produzieren, beobachtbare und nicht nachverhandelbare Verträge angeboten werden. Die Koexistenz der Organisationsformen im Gleichgewicht tritt weniger häufig auf, wenn die Annahmen bezüglich der Beobachtbarkeit der Verträge und der Möglichkeit sich zu binden, gelockert werden.

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1 Introduction

The strategic advantages of delegation are well-known. Examples of strategic delegation can be found in papers on delegation within the firm (e.g. see Fershtman, 1985, Sklivas, 1987, and Vickers, 1985), vertical structure of distribution channels (e.g. see Bonanno and Vickers, 1988, Coughlan and Wernerfelt, 1989, and Gal-Or, 1990), and bargaining (e.g. see Jones, 1989).[1] Delegation does not only offer strategic advantages, it comes at a cost. The existence of information asymmetries, transaction costs, and opportunism between principal and agent makes delegation costly, as Williamson (1975) observes. A delegation decision therefore trades off the strategic advantages of delegation against its costs.

Most literature on strategic contracts within distribution channels focuses on vertical duopolies, and on symmetric vertical market structures resulting from symmetric models. In the real world, however, we often see the coexistence of vertically integrated and separated distribution channels. In this paper we give conditions under which asymmetric equilibrium market structures result from a symmetric model. In other words, we answer the following question: *Under what conditions do strategic vertical integration and separation coexist in equilibrium?* In particular, these conditions are on the nature of downstream market competition, and the observability of retailing contracts.

Gal-Or (1990) analyzes this problem with final good Bertrand competition. To countervail the strategic advantage of vertical separation, Gal-Or introduces a fixed cost for a vertically separating upstream firm of writing a contract. Despite the cost of vertical separation, the analysis of Gal-Or does not result in coexistence of vertical separation and integration in equilibrium. The aim of this paper is to show that in a symmetric model with final good Cournot competition strategic vertical separation and integration can coexist in equilibrium.

We focus attention on strategic incentives to vertically separate or integrate. To obtain a clear trade-off of strategic incentives and contract costs,

[1] For recent surveys on the literature of strategic delegation, see e.g. Caillaud and Rey (1994), or Gal-Or (1997).

we abstract completely from vertical externalities among vertically separated firms. If vertical externalities were present, then the incentive to internalize them would bias the results towards vertical integration. In general vertical integration internalizes at least two vertical externalities among firms. First, there is the well-known vertical externality of double-marginalization with linear pricing contracts between upstream and downstream firms. Second, the vertical externality of foreclosure is due to intra-brand competition among two retailers that supply a final good from the same upstream firm. We eliminate these vertical externalities by imposing three vertical restraints on the relationship between upstream and downstream firms. First, we allow for non-linear pricing between upstream and downstream firms. A two-part tariff contract, consisting of a per-unit wholesale price and fixed franchise fee, internalizes the double-marginalization externality among vertically separated firms. Second, we assume that firms write exclusive dealing contracts to eliminate the foreclosure externality. Under exclusive dealership contracts assign one unique downstream supplier to each upstream firm. The third vertical restraint is a royalty scheme, which makes contractual payments in a distribution channel a function of the quantities of final goods that retailers supply to consumers. A royalty scheme makes the implementation of two-part tariff and exclusive dealership contracts possible. With a royalty scheme contracts with wholesale prices below marginal costs can be profitably set, while exclusive dealership can be enforced.

Although these vertical restraints are exogenous to our model, the literature suggests that such restraints are chosen in equilibrium. For example, Gal-Or (1991) shows that if final goods are sufficiently differentiated, firms prefer two-part tariffs over linear prices and resale price maintenance in equilibrium. Salinger (1988) shows that, with final good Cournot competition, a vertically integrated firm prefers not to supply to an second downstream firm. Furthermore, Lin (1990) shows that, in the absence of intra-brand competition, exclusive dealing is chosen by firms in equilibrium for both linear and two-part tariff pricing contracts.

The paper is organized as follows. In section 2 we describe the model. Section 3 analyzes the equilibrium vertical structures with observable strate-

gic contracts between upstream and downstream firms. The assumptions concerning observability of contracts are discussed in section 4 of this paper. Section 5 concludes the paper. The proofs of propositions are relegated to the Appendix.

2 The Model

Our model is identical to that in Gal-Or (1990), except for the assumption that retailers set quantities in the final good market. We consider an industry with N (where $N \geq 2$) upstream firms, $U_1, .., U_N$, and many potential downstream firms with reservation payoff 0. Because there are many potential downstream firms, the upstream firms have all bargaining power, and make take-it-or-leave-it offers to downstream firms. That is, we focus attention on forward vertical integration. We assume that the industry is organized as N independent distribution channels. The downstream firms transform one unit of the upstream firm's intermediate good into one unit of final good at zero cost.

The game has three stages. In the first stage of the game upstream firms simultaneously choose whether to vertically integrate or separate. We make the following assumptions on vertical integration. One upstream firm can be vertically integrated with one downstream firm only. An integrated firm neither offers nor accepts contracts from other channels. Vertical integration resolves all conflicts of interest within the distribution channel.

Without loss of generality we assume that only the first m upstream firms chose to separate vertically, i.e. firms $U_1, .., U_m$ separate while firms $U_{m+1}, .., U_N$ integrate vertically, with $m \in \{0, .., N\}$. In stage 2 of the game each vertically separating upstream firm U_i offers an exclusive dealership contract to downstream firm D_i, with $i = 1, .., m$. The upstream firm bears a fixed cost $F > 0$ for offering the contract to the downstream firm.[2] Firm U_i's contract specifies a per-unit wholesale price, w_i, and fixed franchise fee, f_i, for $i = 1, .., m$. Denote $(w^m, f^m) = ((w_1, f_1), .., (w_m, f_m))$. We assume that all contracts are observable, and not secretly renegotiable. The intermediate

[2]This revenue loss could be due to e.g. inefficient bargaining or information asymmetries.

goods are supplied by all firms to the downstream firms at no cost at the end of stage 2.

In the third stage of the game downstream firms simultaneously choose the quantities of the final good they supply to consumers. We assume that final goods are symmetrically differentiated, where consumers' inverse demand is linear in quantities. Final product i's demand is as follows:

$$P_i(q) = \alpha - q_i - \delta Q_{-i},$$

with $\alpha > 0$, $\delta \in [0,1]$, and $Q_{-i} = \sum_{j \neq i} q_j$. We interpret parameter δ as the degree of product differentiation between final products. For $\delta = 1$ downstream firms supply homogeneous goods, while for $\delta = 0$ downstream firms supply to independent markets.

Finally payoffs are realized. Given contract (w_i, f_i), vertically separated upstream and downstream firms receive the following profits, respectively:

$$\begin{aligned} \pi_{U_i}(q) &= w_i q_i + f_i - F, \text{ and} \\ \pi_{D_i}(q) &= (P_i(q) - w_i)\, q_i - f_i, \text{ for } i = 1, .., m. \end{aligned}$$

A vertically integrated firm receives the following profits:

$$\pi_i(q) = P_i(q) q_i, \text{ for } i = m+1, .., N.$$

We solve the game for pure-strategy subgame perfect equilibria (SPEs).

3 Basic Results

In this section we give conditions under which our symmetric model results in coexistence of strategic vertical separation and integration in SPE. The first subsection describes the SPEs of the final two stages of the game, by deriving equilibrium final good quantities and contracts. The second subsection describes the SPE in the first stage, and gives conditions for coexistence of vertical integration and separation in SPE.

3.1 Equilibrium in Retailing and Contracting

In stage 3 of the game firms set final good quantities. Suppose that m distribution channels are vertically separated with contracts (w^m, f^m), while

$N - m$ channels are vertically integrated, with $m = 0, 1, .., N$. Define the function $v(w^m, m)$ as follows:

$$v(w^m, m) = \frac{(2-\delta)\alpha + \delta \sum_{k=1}^{m} w_k}{(2-\delta)[2 + (N-1)\delta]}.$$

The equilibrium final good quantities, prices and profits are summarized in the following lemma.

Lemma 1 *Given $m = 0, 1, .., N$ and contracts (w^m, f^m), the final good market equilibrium is as follows.*
(VS) For $i = 1, .., m$:

$$\begin{aligned} q_i^*(w^m, m) &= P_i^*(w^m, m) - w_i = v(w^m, m) - \frac{w_i}{2-\delta}, \\ \pi_{U_i}^*(.) &= w_i q_i^*(.) + f_i - F, \text{ and } \pi_{D_i}^*(.) = (P_i^*(.) - w_i)\, q_i^*(.) - f_i. \end{aligned}$$

(VI) For $i = m + 1, .., N$:

$$q_i^*(w^m, m) = P_i^*(w^m, m) = v(w^m, m), \text{ and } \pi_i^*(w^m, m) = v(w^m, m)^2.$$

Downstream firms' reaction functions are downward sloping in the total quantity of the firm's competitors. An increase in a distribution channel's wholesale price is similar to an increase of its downstream firm's marginal cost. Therefore the vertically separated downstream firm's reaction function shifts inward, which makes it a less aggressive Cournot competitor. Therefore each firm's equilibrium final good quantity is increasing in its competitors' wholesale prices. Each vertically separated firm's equilibrium final good quantity is decreasing in its own wholesale price. Equilibrium final good prices are increasing in wholesale prices. Hence each distribution channel's equilibrium profit is increasing in a competitor channel's wholesale price, while it is decreasing in its own wholesale price.

In stage 2 of the game each vertically separated upstream firm U_i chooses its contract (w_i, f_i), with $i = 1, .., m$. It is immediate that the franchise fee is set such that it fully extracts the distribution channel's anticipated equilibrium profits. Since each distribution channel's equilibrium profit is decreasing in the channel's wholesale price, the upstream firms decrease their wholesale prices below marginal cost (i.e. below zero). The equilibrium

wholesale price trades off the marginal benefit of the final good price increase against the marginal cost due to the decrease of equilibrium final good quantities. The equilibrium marginal wholesale price is as stated in the following lemma.

Lemma 2 *Given $m = 0, 1, .., N$, and $i = 1, .., m$, firm U_i's SPE contract (w_i^*, f_i^*) is such that: $f_i^*(m) = (P_i^*(w^*, m) - w_i^*)\, q_i^*(w^*, m)$, and*

$$w_i^*(m) = \frac{-\delta^2(2-\delta)(N-1)\alpha}{2[2+(N-2)\delta][2-\delta+(N-1)\delta(1-\delta)]+\delta^3(N-1)(m-1)} \leq 0.$$

Note that the equilibrium wholesale price is indeed non-positive, and symmetric due to the symmetry of our model. This is commonly observed in the literature on strategic delegation with strategic substitutes. Furthermore, the wholesale price increases in the number of vertically separated firms m, for $\delta > 0$.

3.2 Equilibrium Coexistence

In stage 1 of the game upstream firms choose whether to vertically integrate or separate. In other words, the SPE m is determined. When we substitute the SPE contract in the upstream firms' revenue functions we obtain the following revenues of vertical integration and separation, respectively:

$$\begin{aligned} \pi^{VI}(m) &= v(w^*, m)^2, \text{ and} \\ \pi^{VS}(m) &= \left(v(w^*, m) + \frac{1-\delta}{2-\delta}w^*\right)\left(v(w^*, m) - \frac{1}{2-\delta}w^*\right). \end{aligned}$$

Define the following function:

$$H(m) \equiv \pi^{VS}(m+1) - \pi^{VI}(m).$$

For simplicity we introduce the tie-breaking rule that makes a firm choose for vertical integration whenever it is indifferent between vertical integration and separation. Equilibrium conditions for symmetric vertical structures with all firms vertically integrated or separated are, respectively:

$$\begin{aligned} \pi^{VS}(1) - \pi^{VI}(0) &\leq F, \text{ or } H(0) \leq F \text{ for } m^* = 0, \text{ and} \\ \pi^{VS}(N) - \pi^{VI}(N-1) &> F, \text{ or } H(N-1) > F \text{ for } m^* = N. \end{aligned}$$

It is straightforward that we can always obtain a symmetric vertical industry structure in SPE. Since $H(0)$ is finite, we can always find a contract cost F that exceeds it. Such a high contract cost prevents firms from writing contracts, and consequently all firms vertically integrate in SPE. If contracts are costless, i.e. $F = 0$, each firms will vertically separate in SPE, since this gives firms a strategic advantage at zero cost. The condition for obtaining an asymmetric vertical structure in SPE, with m^* vertically separating firms ($m^* = 1, .., N-1$) is: $H(m^*) \leq F < H(m^* - 1)$. Note that this condition can only be met if $H(m)$ is decreasing in m. This is stated in the following proposition.

Proposition 1 *There is always a contract cost such that a symmetric vertical oligopoly in SPE exists. In particular, if $H(.)$ increases monotonically in m, then two symmetric SPEs exist for intermediate contract costs: full vertical integration ($m^* = 0$) and full vertical separation ($m^* = N$). If $H(.)$ decreases monotonically in m, then the SPE m is unique, and neither full vertical integration ($m^* = 0$) nor full vertical separation ($m^* = N$) is chosen in SPE for intermediate contract costs.*

Most literature focuses on strategic delegation effects in a duopolistic setting. The following proposition confirms that the literature's focus on symmetric vertical structures is consistent with our results.

Proposition 2 (Duopoly) *For a duopolistic industry, $N = 2$, there is no contracting cost such that vertical separation and integration coexist in SPE.*

When we combine propositions 1 and 2, we obtain the following for vertical duopolies. If contracting costs are low, i.e. $F < H(0)$, all firms separate vertically in a unique SPE, i.e. $m^* = N$, since the precommitment effect dominates the cost of writing a contract. For high contracting cost, i.e. $F \geq H(1)$, both upstream firms choose to integrate vertically in a unique SPE, i.e. $m^* = 0$, since the contracting costs outweigh the precommitment benefits. Intermediate contracting costs, $H(0) \leq F < H(1)$, result in a duplicity of SPEs, with full vertical integration in one, and full vertical separation in the other equilibrium. This result confirms that the main focus

of the literature, on vertical duopolies with symmetric equilibrium market structures, is consistent with our results. However, in the remainder of this section we show that this consistency breaks down when there are more than two distribution channels in the industry.

In an oligopoly with more than two firms symmetric vertical structures need no longer be the only equilibrium outcomes, as we show in the following proposition.

Proposition 3 (Oligopoly) *For an oligopolistic industry, with* $N \geq 3$*, there are degrees of product differentiation* $\underline{\delta}(N)$ *and* $\overline{\delta}(N)$*, with* $0 < \underline{\delta}(N) \leq \overline{\delta}(N) < 1$*, such that:*
(i) for all $\delta \geq \overline{\delta}(N)$ *and any* $m^* \in \{1, .., N-1\}$ *there is a contracting cost such that* m^* *firms separate while* $N - m^*$ *firms integrate vertically in SPE,*
(ii) for all $\delta \leq \underline{\delta}(N)$ *there is no contracting cost such that vertical separation and integration coexist in SPE. In particular, all firms remain vertically integrated in SPE.*

Part (i) of the proposition results from the fact that for sufficiently substitutable final goods the marginal benefit of vertical separation is decreasing in the number of vertically separating firms. Therefore the SPE number of vertically separating firms is *unique*, as follows from proposition 1, and supports coexistence for intermediate contracting costs, i.e. $H(N-1) \leq F < H(0)$. In particular for $H(m^*) \leq F < H(m^*-1)$ the unique SPE number of vertically separating firms is m^*, for all $m^* \in \{1, .., N-1\}$. In part (ii) of the proposition the retailers supply to approximately independent markets. In that case vertical separation loses its strategic impact on competing distribution channels. The fixed cost F of writing such a nonstrategic contract discourages upstream firms from separating vertically. Therefore all firms remain vertically integrated in SPE.

The proposition shows that the negative result of Gal-Or (1990) for strategic complements does not carry over to a model with strategic substitutes. In a vertical oligopoly where retailers supply close substitutes equilibrium coexistence of vertical separation and integration is possible. This result implies that the main conclusions in the strategic delegation literature on symmetric vertical duopolies need not carry over to vertical oligopolies.

4 Discussion

Recently the importance of contract observability and secret contract renegotiation on the precomitment effect of delegation received considerable attention in the literature. In this section we discuss the effects of relaxing our assumptions on the observability and renegotiability of firms' contracts.

An influential paper on the precommitment effects of unobservable contracts is Katz (1991). The paper shows that the strategic effect of vertical separation vanishes in the "rational-agent equilibrium" of our delegation game when contracts are unobservable. Recently Fershtman and Kalai (1997) show that this negative conclusion need not hold if the more conventional refinement of trembling-hand perfect equilibrium is used. Furthermore Katz's negative results need not be robust to the introduction of a small probability that contracts become observable, or to repeating the delegation game several times. These results restore the trade-off between the strategic advantage and transaction cost of vertical separation. Finding the conditions under which this trade-off results in equilibrium coexistence awaits future research.

Even if contracts are observable, but can be secretly renegotiated, the precommitment effect of retail contracts disappears, as Caillaud *et al.* (1995) show. Upstream firms will therefore integrate vertically in equilibrium to avoid the contract costs. This strong negative result need however not hold after we slightly change the model. Caillaud *et al.* (1995) claim that if upstream and downstream firms are asymmetrically informed about marginal final good production costs and compete in quantities, renegotiable contracts create a precommitment effect. This restores the trade-off between the precommitment effect and the costs of writing a contract. Whether coexistence of vertical separation and integration result from this trade-off in equilibrium, needs to be explored in future research. A positive side effect of performing such an exercise is that it endogenizes the costs of writing a contract. After the introduction of asymmetric information, the contracting costs are simply the expected informational rents that a separating upstream firm leaves the downstream firm to make the contract compatible with the downstream firm's incentives.

5 Conclusion

In this paper we showed that the existence of asymmetric vertical industry structures in equilibrium depends on the interaction of retailers in the final good market. When oligopoly retailers supply closely substitutable final good quantities, equilibrium coexistence of vertical separation and integration is possible. However, when the retailers are Cournot duopolists or when final goods are supplied to independent markets, vertical separation and integration does not coexist in equilibrium. Gal-Or (1990) shows that with Bertrand competition in the final good market equilibrium coexistence never occurs.

Although the scope for coexistence diminishes when contracts are unobservable or secretly renegotiable, the literature suggests that the trade-off between precommitment effects and contract costs remains after the introduction of asymmetric information between upstream and downstream firms. Whether coexistence actually occurs in equilibrium after these changes to the model, needs to be addressed in future research.

Appendix

This Appendix contains the proofs of the paper's lemmas and propositions.

¥ Proof of Lemma 1: We characterize the final good supply equilibrium, given $N-m$ vertically integrated firms, and m vertically separated firms with wholesale prices $w^m = (w_1, .., w_m)$. If we ignore corner solutions, the reaction functions for the vertically integrated and separated firms are, respectively:

$$q_i(Q_{-i}; w^m, m) = \begin{cases} \frac{1}{2}(\alpha - \delta Q_{-i} - w_i), \text{ for } i = 1, .., m, \text{ and} \\ \frac{1}{2}(\alpha - \delta Q_{-i}), \text{ for } i = m+1, .., N, \end{cases}$$

Summing over $i = 1, .., N$ gives the following:

$$Q^* = \sum_{i=1}^{N} q_i(Q_{-i}; w^m, m) = \frac{1}{2}\left(N\alpha - (N-1)\delta Q^* - \sum_{i=1}^{N} w_i\right),$$

or

$$Q^* = \frac{N\alpha - \sum_{i=1}^{m} w_i}{2 + (N-1)\delta}.$$

After substituting this expression in the firms' reaction functions, we obtain the equilibrium final good quantities, prices, and profits of lemma 1.

¥ Proof of Lemma 2: In stage 2 the vertically separating firm U_i chooses its two-part tariff contract such that it maximizes its profit, given downstream firm D_i's participation constraint, and contracts chosen by others, for $i = 1, .., m$. If we focus on interior solutions, firm U_i's contracting problem is as follows:

$$\begin{aligned} &\max_{(w_i, f_i)} \{w_i q_i^*(w^m; m) + f_i - F\} \\ &\text{s.t. } (P_i^*(w^m, m) - w_i)\, q_i^*(w^m, m) - f_i \geq 0. \end{aligned}$$

It is obvious that the franchise fee is optimally set such that all the downstream firm's profit is extracted:

$$f_i^* = (P_i^*(w^m, m) - w_i)\, q_i^*(w^m, m),$$

which reduces the upstream firm U_i's optimization problem to $(i = 1, .., m)$:

$$\max_{w_i} \{P_i^*(w^m, m) q_i^*(w^m, m) - F\}, \text{ or}$$

$$\max_{w_i} \left[v(w^m, m) + \frac{1-\delta}{2-\delta} w_i \right] \left[v(w^m, m) - \frac{1}{2-\delta} w_i \right] - F.$$

Firm U_i's reaction function for wholesale price w_i is as follows:

$$R_i(w_{-i}; m) = \frac{-\delta^2 (N-1) \left[(2-\delta)\alpha + \delta \sum_{k \neq i} w_k \right]}{2[2 + (N-2)\delta][2 - \delta + (N-1)\delta(1-\delta)]}, \text{ for } m = 1, .., N.$$

After recognizing that the symmetry of the model gives symmetric SPE wholesale prices, this immediately gives the equilibrium wholesale price of lemma 2.[3]

¥ Proof of Proposition 1 (Symmetric vertical structures): To obtain full vertical separation, choose contract cost $F = 0$, such that $F < H(N-1)$ is satisfied since $H(N-1)$ obviously exceeds zero. For full vertical integration, observe that $H(0)$ is clearly finite, and subsequently choose contract cost

[3] Note that the SPE contracts and profits are such that our focus on interior solutions in the proofs of this and the previous lemma is not problematic.

$F \geq H(0)$. When $H(.)$ is increasing in m, $H(0) < H(N-1)$ holds. Therefore inequalities $F < H(N-1)$ and $F \geq H(0)$ are satisfied for the same F, iff $H(0) \leq F < H(N-1)$, and both full vertical separation and integration are SPE strategies. When $H(.)$ is decreasing in m, $H(0) > H(N-1)$ holds. Therefore inequalities $F < H(N-1)$ and $F \geq H(0)$ cannot be satisfied for the same F, and for $H(N-1) \leq F < H(0)$ no symmetric vertical oligopoly exists in SPE. Monotonicity of $H(.)$ implies that intervals $[0, H(N-1)), [H(N-1), H(N-2)), .., [H(1), H(0)), [H(0), \infty)$ do not overlap, which implies uniqueness of the SPE m. This proves proposition 1.

¥ Proof of Proposition 2 (Duopoly): For a duopolistic industry vertical separation and integration do not coexist in equilibrium, since for $N = 2$:

$$H(1) - H(0) = \frac{\alpha\delta^6 \left[32 + 16\delta - 24\delta^2 - 12\delta^3 + \delta^4\right]}{16(2+\delta)^2(2-\delta)^2(4-2\delta-\delta^2)^2} \geq 0, \forall \alpha, \delta.$$

This proves proposition 2.

¥ Proof of Proposition 3 (Oligopoly):

(i) Homogeneous final goods: For an oligopolistic industry ($N \geq 3$) with homogeneous final goods ($\delta = 1$), coexistence of vertical separation and integration is possible in equilibrium, since for $\delta = 1$:

$$H(m+1) - H(m) = \frac{-\alpha(N-1)^2 K}{[(m+1)(N-1)+2]^2[(m+2)(N-1)+2]^2[(m+3)(N-1)+2]^2},$$

with

$$K \equiv 2m^3(N-1)^3 + 3m^2(N-1)^2(3N-1) + 12mN(N-1)^2 + 5N^3 - 13N^2 - N + 1.$$

Note that $5N^3 - 13N^2 - N + 1 > 0$ for $N \geq 3$, which implies that:

$$H(m+1) - H(m) > 0 \text{ for all } m, \text{ if } \delta = 1 \text{ and } N \geq 3.$$

Since the inequality is strict and $H(m+1) - H(m)$ is continuous in δ, we conclude that there is a critical value $\overline{\delta}(N) < 1$ such that for all $\delta \geq \overline{\delta}(N)$ the inequality holds for all m. This proves proposition 3 (i).

(ii) Independent final good markets: For $\delta = 0$ a separating firm's SPE

wholesale price equals zero, $w_i^*(m) = 0$ for all m. SPE revenues of vertically integrating and separating firms therefore equal, and since $F > 0$ the unique SPE is one in which all firms remain vertically integrated, $m^* = 0$. The existence of a positive critical value $\underline{\delta}(N)$ follows directly from continuity of the upstream firms' profit function and strict positivity of the contract cost F. This completes the proof of proposition 3.

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