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Intimidating competitors — Endogenous vertical integration and downstream investment in successive oligopoly[☆]

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Abstract

This paper examines the interplay of endogenous vertical integration and cost-reducing downstream investment in successive oligopoly. Analyzing a linear Cournot model, we establish the following key results: (i) Vertical integration increases own investment and decreases competitor investment (intimidation effect). (ii) Asymmetric integration is a non-degenerate equilibrium outcome. (iii) Compared to a benchmark model without investment, complete vertical separation is a less likely outcome. We argue that these findings generalize beyond the linear Cournot model under reasonable assumptions.

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1. Introduction

Understanding strategic behavior in successive oligopoly is an important objective of industrial organization. A substantial literature has highlighted the links between vertical market structure and pricing in successive oligopoly.¹ The relation between vertical market structure and cost-reducing investments has received comparatively little attention.² In the present paper, we argue that the interplay of endogenous vertical integration and investment decisions is crucial for our understanding of strategic behavior in successive oligopoly. In particular, we show that a firm's vertical integration generates what we call an "intimidation" effect, that is, vertical integration decreases cost-reducing investment by competitors. There is thus a strategic motive for vertical integration that has gone unnoticed in the previous literature. Incorporating endogenous investment decisions into successive oligopoly models also allows us to shed new light on the analysis of equilibrium industry structure and the relation between industry structure and performance, two key issues of the literature on endogenous vertical integration in successive oligopoly.

Our analysis first shows how vertical market structure affects the cost-reducing investments of individual firms. We then use the insights from this analysis to show how vertical structure and cost-reducing investments are determined as jointly endogenous by more primitive variables, such as market size and investment costs. To this end, we consider a simple linear Cournot model in the tradition of [Salinger \(1988\)](#), which we modify to include both endogenous integration and investment decisions.

In this model, two downstream firms face two vertically-separated upstream suppliers. To produce one unit of the final product, downstream firms require one unit of an intermediate good produced by upstream firms. Downstream marginal costs consist of the costs of obtaining the intermediate good plus the costs of transforming the intermediate good into the final product. The timing of the game is as follows. In stage 1, downstream firms decide whether to integrate backwards by acquiring a supplier at fixed cost, thereby getting access to the intermediate good at marginal cost.³ Three conceivable vertical structures can emerge from this stage. Under *integration*, there are two integrated supply chains, whereas under *separation*, there are two separated downstream firms buying the input from two upstream firms. Finally, there is the intermediate case of *asymmetric integration* with an integrated and a separated downstream firm. In stage 2, downstream firms can invest into reducing the costs of transforming the intermediate good into the final product, thereby increasing their transformation efficiency. In stage 3, the wholesale price at which the input good is sold to downstream firms is determined. In stage 4, product market competition takes place.

We first examine the relation between vertical market structure and cost-reducing investment, holding vertical market structure fixed. Our main results for this setting are the following. First, under asymmetric integration the integrated firm invests more into cost reduction than the separated competitor. Second, comparing two structures which differ only with respect to one firm's integration decision, we find that a firm's integration leads this firm to invest more and the competitor to invest less. The latter effect on the competitor—the intimidation effect of vertical

¹ Contributions to this literature include [Ordober et al. \(1990\)](#), [Hart and Tirole \(1990\)](#), [Gaudet and Long \(1996\)](#), [Abiru et al. \(1998\)](#), [Chen \(2001\)](#), [Elberfeld \(2001, 2002\)](#), [Jansen \(2003\)](#), [Linnemer \(2003\)](#), [Dufeu \(2004\)](#), and [Buehler and Schmutzler \(2005\)](#).

² Notable exceptions include [Banerjee and Lin \(2003\)](#) and [Brocas \(2003\)](#).

³ The assumption of fixed integration costs is a simplification that we shall discuss in some more detail below.

integration—implies that there is a strategic incentive to integrate vertically. That is, vertical integration serves as a top dog strategy (Fudenberg and Tirole, 1984) geared towards tapering the competitor's cost-reducing investments. Importantly, this effect does not rely on the existence of strategic substitutes in the product market, even though we work in a Cournot framework.

Next, we analyze the subgame-perfect Nash equilibrium of the whole game, allowing both vertical market structure and cost-reducing investments to be determined endogenously. Here, we obtain the following key results. First, in spite of the initial symmetry, asymmetric integration is a non-degenerate equilibrium outcome of the game. This reflects the strategic-substitutes property of vertical integration decisions: The strategic integration incentive is likely to be larger for a firm facing a separated competitor than for a firm facing an integrated competitor.⁴ As a result, asymmetric equilibria typically involve integrated firms investing more into efficiency than their separated counterparts. Put differently, our analysis suggests that, in asymmetric equilibria, we are likely to observe large integrated and small separated firms. This finding is in line with the market structure of a number of vertically related industries documented in the literature, including the oil industry (Bindemann, 1999), the beer industry in the UK (Slade, 1998a), and the US cable television industry (Chipty, 2001).⁵ Second, compared to a benchmark model without investment, separation is a less likely outcome. This result relates to the intimidation effect of vertical integration: With endogenous investment, unilateral deviation from separation is more attractive than without investment, because vertical integration has the additional benefit of intimidating the competitor.

The driving force behind our results is the *efficiency effect* of integration: Vertical integration reduces the integrating firm's marginal cost, so that the integrating firm becomes a stronger competitor. As a result, the equilibrium outputs and mark-ups of a firm are non-decreasing in its own integration status and non-increasing in the competitor's integration status. As we elaborate in the working paper version of this article, our key results generalize beyond the linear Cournot model whenever this property holds.

To the best of our knowledge, there are only two papers that have focused on the relation of vertical market structure and cost-reducing investment in oligopoly. Holding vertical market structure fixed, Banerjee and Lin (2003) show that downstream oligopolists may invest more into cost-reducing R&D than a downstream monopolist. Intuitively, the result follows from the output-enhancing effect of R&D, which allows the upstream firm to increase its input price, raising rival's costs. Brocas (2003) studies a setting where downstream firms face costs for switching technologies licensed by innovating upstream firms. The prices of licences vary with the size of switching costs: Easily substitutable technologies are licensed at low prices, whereas innovative technologies with high switching costs command high prices. This affects investment incentives, and efficient technologies with low switching costs may disappear. In this setting, both upstream and downstream firms may find it profitable to integrate vertically.

In a broader sense, our paper also relates to the strategic trade literature. Even though this literature does not deal directly with vertical-integration decisions, it exploits the strategic-substitutes property of cost-reducing investments that is crucial for the existence of the intimidation effect. Contrary to our analysis, however, the strategic trade literature uses this property to argue that governments can use strategic policy to influence R&D decisions of firms

⁴ We analyze the strategic-substitutes property of vertical integration decisions in more detail in Buehler and Schmutzler (2005).

⁵ Further examples include, for instance, the gasoline retail market in Vancouver (Slade, 1998b), the Mexican footwear industry (Woodruff, 2002) and the UK package holiday industry (European Commission, 1999).

in other countries in a manner that is favorable to home country firms (Bagwell and Staiger, 1994).

Finally, while our analysis primarily seeks to improve our understanding of the relation between vertical structure and investment in a static setting, it may also be relevant to the understanding of market dynamics. A large literature uses dynamic investment models suggesting how market dominance may emerge in a setting with small initial differences between a leader and a laggard.⁶ Specific emphasis is placed on the idea that leaders with low costs (and thus high demand) often have stronger incentives to reduce their costs even further because this is more worthwhile, given their high demand. Even though the present paper treats only one period of the investment game explicitly, it suggests a mechanism by which integration can create the asymmetry between a leader and a laggard: Without vertical integration, our firms would always choose identical investment levels and thus remain symmetric. The binary nature of the integration decision changes this, as it makes asymmetric industry structures possible, which are then reinforced by cost-reducing investments.

The remainder of the paper is organized as follows. In Section 2, we introduce the model. Section 3 provides a number of auxiliary results on the properties of outputs, mark-ups and profits in the linear Cournot setting. Section 4 considers investment decisions for given vertical structures. Section 5 studies the subgame-perfect equilibrium market structure. In Section 6, we discuss the interplay of endogenous investment and integration decisions and sketch how our analysis generalizes beyond the linear Cournot setting. Section 7 concludes.

2. The model

We carry out our analysis in a modified version of the linear Cournot model proposed by Salinger (1988). Our model differs from Salinger in two key aspects: (i) Vertical market structure is endogenously determined. (ii) Downstream firms make cost-reducing investments.

We present our analysis so that it becomes clear that the driving forces behind our results are not specific to the linear Cournot model.

2.1. Overview

Initially, there are two independent upstream firms, and two independent downstream firms. To produce one unit of the final product, a downstream firm requires one unit of the intermediate good provided by an upstream firm. Fig. 1 summarizes the timing of the game.

In stage 1, downstream firms simultaneously decide whether to integrate backwards by acquiring one of the upstream firms at fixed cost $F > 0$. The decision of firm $i = 1, 2$ is represented by the variable V_i such that $V_i = 1$ if it integrates and $V_i = 0$ if it remains separated. In stage 2, downstream firms simultaneously carry out cost-reducing investments Y_i at cost $K(Y_i) = kY_i^2$, $k > 0$, thereby determining the efficiency at which the intermediate good is transformed into the final product. In stage 3, any remaining separated upstream firms set wholesale quantities for the upstream market, resulting in costs $w_i \geq 0$ for obtaining the input good. In stage 4, downstream firms compete à la Cournot in a product market with linear

⁶ This has been discussed for incremental investment games (Flaherty, 1980), learning by-doing models (Cabral and Riordan, 1994) or switching cost models (Beggs and Klempere, 1992); Athey and Schmutzler (2001) provide an integrated approach.

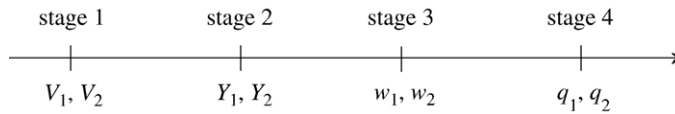


Fig. 1. Timing of the game.

demand, choosing their outputs q_i , $i=1, 2$, with marginal costs determined by the preceding stages of the game.

2.2. Specification

We now describe the specification of our model. Since we will look for the subgame-perfect Nash equilibrium, we begin with the last stage of the game.

2.2.1. Stage 4

In the product market, firms face a linear inverse demand curve $P(Q)=a-Q$, with $Q=q_1+q_2$ and $a>0$. As indicated above, the firms' activities in stages 1, 2 and 3 determine V_i , Y_i , and w_i , thereby affecting the marginal costs c_i of downstream firms in stage 4. Solving the profit maximization problem for given levels of marginal costs yields the following Cournot outputs q_i , mark-ups m_i ,⁷ and profits π_i , respectively⁸

$$q_i(c_i, c_j) = m_i(c_i, c_j) = (a - 2c_i + c_j)/3, \quad (1)$$

$$\pi_i(c_i, c_j) = (a - 2c_i + c_j)^2/9, \quad (2)$$

with $i, j=1, 2, j \neq i$.

2.2.2. Stage 3

In stage 3, the cost of obtaining the input w_i , $i=1, 2$, is determined as the marginal cost of producing the input for an integrated firm or the equilibrium upstream price faced by a separated downstream firm. For simplicity, we assume that the marginal cost of producing the input is constant and normalized to zero.

- (i) Under *integration*, we therefore obtain that input costs are given by $w_i=0$, $i=1, 2$, by assumption. This reflects the intuition that integrated firms obtain the input at marginal cost, avoiding double marginalization.⁹
- (ii) Under *asymmetric integration*, Salinger's (1988) solution concept implies that the integrated firm is inactive in the upstream market (i.e., it does neither sell nor buy in the

⁷ Here and in the following, we refer to absolute mark-ups, that is, the difference between equilibrium prices and marginal costs.

⁸ We are implicitly assuming that an interior solution arises in the Cournot game. It can be shown that this must happen on the equilibrium path if k is sufficiently large for second-order conditions to hold.

⁹ As there are no explicit choices of wholesale prices when both firms are integrated and $w_i=0$ by assumption, the four-stage game reduces to a three-stage game.

upstream market).¹⁰ Consequently, the separated downstream firm must buy the input from the remaining separated upstream firm at the monopoly price. For the integrated firm, in turn, we have $w_i=0$, as the marginal cost of producing the input is normalized to zero.

- (iii) Our treatment of *separation* also follows Salinger (1988): If upstream competition results in a wholesale price w , downstream firms play Cournot competition, resulting in a total quantity $Q(w)$, which translates one-to-one into a corresponding input requirement.

2.2.3. Stage 2

In stage 2, firms decide about their cost-reducing investments. Both firms initially have identical transformation costs $\bar{t}>0$. Denoting firm i 's efficiency improvement by Y_i , ex post transformation costs are given by $t_i=\bar{t}-Y_i$.

Firm i 's marginal costs are thus given by

$$c_i = w_i + t_i = w_i + \bar{t} - Y_i, \quad i, j = 1, 2, i \neq j.$$

2.2.4. Stage 1

In stage 1, downstream firms take vertical integration decisions. For simplicity, we suppose that downstream firms can acquire an upstream firm at fixed cost $F>0$.¹¹ It is important to note that integration decisions affect firm i 's profits through three channels. First, as already discussed, there is the direct efficiency effect that own integration reduces marginal costs. Second, at least if firm i is separated, the integration decision of firm $j \neq i$ has an effect on w_i . Third, integration can potentially affect investment decisions. Thus, firm i 's product market profits are given by the function $\Pi_i(V_i, V_j; Y_i(V_i, V_j), Y_j(V_i, V_j))$. To simplify exposition, we henceforth suppress the arguments V_i and V_j and write product market profits as $\Pi_i(Y_i, Y_j)$, wherever there is no danger of confusion. Where necessary, we use the superscript $v \in \{I, S, AI, AS\}$ to indicate firm i 's vertical structure and the relevant market configuration. That is, $v=I$ and $v=S$ indicate integration and separation, respectively, whereas $v=AI$ and $v=AS$ indicate that the firm under consideration is integrated or separated, respectively, under asymmetric integration.

Downstream firms thus choose $V_i \in \{0, 1\}$ so as to maximize

$$\Pi_i(Y_i, Y_j) - kY_i^2 - V_i F, \quad i, j = 1, 2, i \neq j,$$

where (Y_i, Y_j) is understood to correspond to the subgame-perfect equilibrium choices of investment in the relevant market configuration.

2.3. Product market equilibrium

We now characterize the product market equilibrium in the various market configurations. Table 1 in Appendix A provides a summary of the results.

¹⁰ We critically discuss Salinger's solution concept in Section 2.3 and show in Appendix B that the integrated firm's inactivity in the upstream market is not important for our results.

¹¹ Ideally, acquisition costs would be endogenous, reflecting both the opportunity costs of the upstream firms' being taken over and transaction costs. That is, in a more complex model, acquisition costs would be a function of the firms' efficiency levels and the industry's vertical structure. See Buehler and Schmutzler (2005) for a reduced-form analysis of the role of endogenous acquisition costs in successive oligopoly.

2.3.1. Integration

Under integration, firms are Cournot competitors with costs $c_i = \bar{t} - Y_i$. The equilibrium profits of firm i are therefore given by

$$\Pi_i^I(Y_i, Y_j) = \frac{(\alpha + 2Y_i - Y_j)^2}{9}, \quad i, j = 1, 2, i \neq j, \quad (3)$$

where the superscript I indicates the integration case, and $\alpha \equiv a - \bar{t}$ is our measure of market size.

2.3.2. Asymmetric integration

Under asymmetric integration, we face the problem that an integrated firm needs to make some conjecture about the effect of its activity in the upstream market on both the upstream and the downstream market. The simplest way of dealing with this problem is to adopt Salinger's (1988) solution concept for successive oligopoly models, which imposes that an integrated firm conjectures "Cournot reactions to input sales" and "Bertrand reactions to input purchases" (Schrader and Martin, 1998).¹² These conjectures imply that an integrated firm will withdraw from the upstream market: An integrated firm will not want to sell to the input market,¹³ as the retail price is higher than the input price. Also, an integrated firm will not want to buy from the input market, as the cost of producing the input is lower.

In the main text, we use Salinger's solution concept. As a result, if firm 1 is integrated, we obtain the wholesale price

$$w(Y_1, Y_2) = \frac{\alpha - Y_1 + 2Y_2}{4}.$$

Profits of the integrated and separated firm turn out to be

$$\Pi_i^{AI}(Y_i, Y_j) = \frac{(5\alpha + 7Y_i - 2Y_j)^2}{144}, \quad (4)$$

$$\Pi_i^{AS}(Y_i, Y_j) = \frac{(2\alpha - 2Y_j + 4Y_i)^2}{144}. \quad (5)$$

In Appendix B, we solve the model using an alternative solution concept proposed by Schrader and Martin (1998), which imposes that an integrated firm conjectures Cournot reactions to both input sales and purchases. We show that, with this alternative solution concept, the integrated firm does not withdraw from the input market. Instead, the integrated firm chooses to buy from the input market, even though this involves higher input costs, because making purchases in the input market increases the downstream rival's costs. Yet, as we show in Appendix B, our key results are not affected by the integrated firm's activity in the upstream market.

¹² More specifically, Salinger's solution concept imposes the following assumptions: If an integrated firm sells an extra unit of the intermediate good, it conjectures that other intermediate good producers maintain their outputs. If an integrated firm buys an extra unit of the intermediate good, it conjectures that another intermediate good producer expands its output by one unit and other final good producers maintain their outputs.

¹³ Ordober et al. (1990) make a similar assumption. Hart and Tirole (1990) and Reiffen (1992) criticize this assumption, based on the argument that it amounts to requiring that the integrated firm can commit to refrain from (profitable) undercutting in the upstream market.

2.3.3. Separation

Under separation, both upstream and downstream firms are Cournot competitors. Aggregating downstream Cournot outputs and rearranging yields the inverse upstream demand

$$w(Q) = \frac{2\alpha + Y_i + Y_j - 3Q}{2}. \quad (6)$$

Using Eq. (6), upstream competitors choose their profit-maximizing outputs, thereby determining the upstream price

$$w(Y_i, Y_j) = \frac{2\alpha + Y_i + Y_j}{6}.$$

Profits of downstream firms turn out to be

$$\Pi_i^S(Y_i, Y_j) = \frac{(4\alpha + 11Y_i + 7Y_j)^2}{324}, \quad (7)$$

where the superscript S indicates the separation case.

3. Auxiliary results

We now summarize a number of important properties of the linear Cournot model.

Lemma 1 (output and mark-up).

- (i) The outputs $q_i(c_i, c_j)$, mark-ups $m_i(c_i, c_j)$, and profits $\pi_i(c_i, c_j)$ are non-increasing in own costs c_i and non-decreasing in competitor costs c_j .
- (ii) The outputs $Q_i(Y_i, Y_j)$ and mark-ups $M_i(Y_i, Y_j)$ are non-decreasing in own efficiency Y_i and non-increasing in competitor efficiency Y_j .
- (iii) The output and mark-up of an integrated firm facing a separated competitor are larger than the output and mark-up of a separated firm facing an integrated competitor, i.e.,

$$Q_i^{AI}(Y_i, Y_j) > Q_i^{AS}(Y_i, Y_j) \text{ and } M_i^{AI}(Y_i, Y_j) > M_i^{AS}(Y_i, Y_j).$$

Proof. (i) Follows immediately from Eqs. (1) and (2); (ii) follows from inspection of Q_i^v , $v=I, S, AI, AS$, in Table 1; (iii) follows from the comparison of $Q_i^{AI}(Y_i, Y_j) = (5\alpha + 7Y_i - 2Y_j)/12$ and $Q_i^{AS}(Y_i, Y_j) = (2\alpha - 2Y_j + 4Y_i)/12$ from Table 1. \square

Result (i) is a standard property of the linear Cournot model.

Result (ii) is closely related to result (i): An increase in own efficiency Y_i directly reduces own costs $c_i = w_i + \bar{t} - Y_i$, which works towards higher output and mark-up. However, for a separated firm, this direct effect is moderated by changes in the wholesale price: A separated firm i that becomes more efficient increases its input demand and thus drives up the wholesale price (Banerjee and Lin, 2003), so that the cost reduction does not exactly match the increase in transformation efficiency. Similarly, the negative effect of higher Y_j on M_i and Q_i reflects the competitor's higher efficiency and the induced changes of the wholesale price.

Result (iii) reflects the efficiency effect of vertical integration. To understand the condition $Q_i^{AI}(Y_i, Y_j) > Q_i^{AS}(Y_i, Y_j)$, first note that $Q_i^I(Y_i, Y_j) > Q_i^{AS}(Y_i, Y_j)$: Firm i 's move from separation to integration reduces its own costs due to the elimination of the upstream mark-up, leaving the costs

of the other firm unaffected; hence, firm i 's output increases (and similarly, the mark-up). Next, note that $Q_i^{AI}(Y_i, Y_j) > Q_i^I(Y_i, Y_j)$: The separation of firm i 's competitor increases the competitor's costs and thus firm i 's output (and mark-up). Combining these arguments yields the result.

Our next Lemma collects some properties of the profit functions that are crucial for our main results.

Lemma 2 (investment incentive). *Firm i 's marginal investment incentive satisfies the following properties, with $i, j = 1, 2, i \neq j$:*

- (i) *The investment incentive of an integrated firm facing a separated competitor is higher than that of a separated firm facing an integrated competitor, i.e.,*

$$\frac{\partial \Pi_i^{AI}}{\partial Y_i}(Y_i, Y_j) > \frac{\partial \Pi_i^{AS}}{\partial Y_i}(Y_i, Y_j).$$

- (ii) *A firm's integration has a non-negative effect on its own marginal investment incentive and a non-positive effect on the competitor's investment incentive; hence*

$$\frac{\partial \Pi_i^{AI}}{\partial Y_i}(Y_i, Y_j) \geq \frac{\partial \Pi_i^I}{\partial Y_i}(Y_i, Y_j); \frac{\partial \Pi_i^S}{\partial Y_i}(Y_i, Y_j) \geq \frac{\partial \Pi_i^{AS}}{\partial Y_i}(Y_i, Y_j),$$

where the last inequality requires that firms are not too asymmetric.

- (iii) *The marginal investment incentive $\frac{\partial \Pi_i}{\partial Y_i}(Y_i, Y_j)$ is non-increasing in Y_j .*

Proof. (i) From Table 1, we have $\Pi_i^{AI} = (5\alpha + 7Y_i - 2Y_j)^2 / 144$ and $\Pi_i^{AS} = (2\alpha - 2Y_j + 4Y_i)^2 / 144$. Differentiating with respect to Y_i and Y_j , respectively, yields the result, taking into account that $Y_j < \alpha + 2Y_i$ for positive equilibrium outputs. (ii) Table 1 gives Π_i for each market configuration. Differentiating Π_i and comparing $\partial \Pi_i / \partial Y_i$ in the various market configurations yields the result, where $\partial \Pi_i^S / \partial Y_i \geq \partial \Pi_i^{AS} / \partial Y_i$ requires the additional condition $26\alpha + 85Y_i - 59Y_j > 0$ for $i = 1, 2, j \neq i$. (iii) Follows from inspection of $\partial \Pi_i / \partial Y_i$ in the various market configurations. \square

Result (i) is closely related to result (iii) of Lemma 1, which states that the output and mark-up of an integrated firm facing a separated competitor are larger than the output and mark-up of a separated firm facing an integrated competitor. Since higher mark-up means that demand increases resulting from greater efficiency are more valuable, and higher demand means that mark-up increases are more valuable, the benefits from vertical integration and cost-reducing investment are mutually reinforcing. Put differently, there are *demand/mark-up complementarities* in product market competition. There is, however, a potential countervailing effect: The size of the demand and mark-up increases resulting from higher efficiency could, at least in principle, decrease with vertical integration. However, as noted above, higher downstream efficiency increases the input price due to higher input demand, which, in turn, moderates the output and mark-up increases resulting from higher downstream efficiency for a separated firm. This effect is clearly absent for an integrated firm, at least if it does not buy from the input market. It is thus unsurprising that (i) holds in the linear Cournot model.

Result (ii) states that a firm's investment incentive is non-decreasing in own integration and non-increasing in competitor integration. Note that (ii) implies (i), with similar intuition. The reason that we included (i) as a separate statement is that it often holds outside the linear Cournot model, whereas (ii) tends to be violated more often. Again, the result is driven by demand/mark-up complementarities in the product market. Intuitively, as a firm integrates, the efficiency effect results in higher demand and markup. Further increases in demand and mark-up resulting from cost-reducing investment thus become more worthwhile. By analogous reasoning, the integration

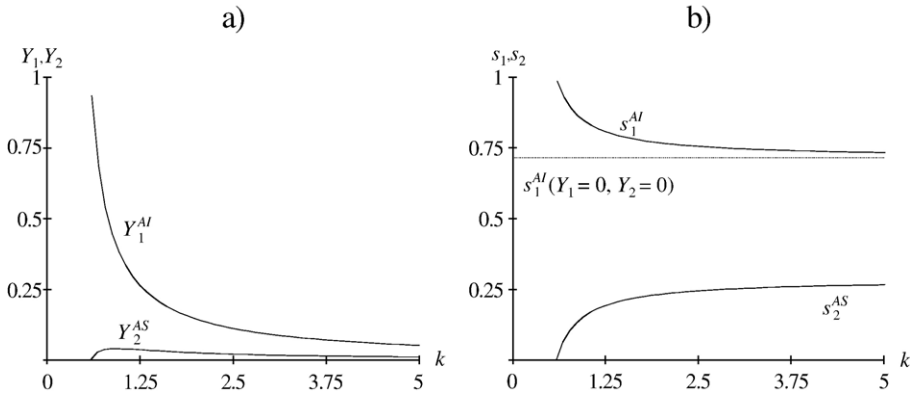


Fig. 2. Investments (Panel a) and market shares (Panel b) under asymmetric integration ($\alpha=1$).

of a competitor reduces a firm's demand and mark-up, thereby reducing the benefits of additional demand and mark-up increases. This is the intimidation effect of integration.

Result (iii) states that investment decisions are strategic substitutes,¹⁴ that is, a firm's investment incentive is lower when the competitor is more efficient. This also follows from demand/mark-up complementarities. To see this, note that increases in Y_i lead to increases in firm i 's output and markup, whereas increases in Y_j lead to decreases of these quantities. The adverse effect of competitors' investments on own output and markup reduces the benefit from the positive effect of own investments on these quantities.¹⁵

4. Investment decisions

In this section, we examine how investment decisions depend on vertical market structure.

4.1. Fixed vertical structure

First, we compare the investments of integrated and separated firms, holding vertical market structure fixed. More specifically, we consider the case of asymmetric integration where firm 1 is integrated and firm 2 is separated. Fig. 2a) depicts the optimal investment levels $Y_1^{AI}(\alpha, k)$ and $Y_2^{AS}(\alpha, k)$ as a function of the cost parameter $k > 4/9$,¹⁶ fixing market size at $\alpha=1$. Fig. 2b) shows the resulting market shares s_1^{AI} and $s_2^{AS} = 1 - s_1^{AI}$, respectively. Clearly, the integrated firm 1 invests more and has a higher market share than the separated firm 2 (i.e., $Y_1^{AI} > Y_2^{AS}$ and $s_1^{AI} > s_2^{AS}$).

To put the result into perspective, consider output decisions when firms are unable to invest into cost reduction (or equivalently, $k \rightarrow \infty$). Fig. 2b) indicates that even when firms cannot invest into cost reduction, the market share of the integrated firm is higher than that of the separated firm, that is, $s_1^{AI}(Y_1=0, Y_2=0) > 0.5$. This reflects the simple fact that the integrated firm has lower marginal costs than the separated firm due to the elimination of a mark-up at the upstream level.

¹⁴ For horizontal oligopolies, this property has been noted, for instance, by Bagwell and Staiger (1994) and Athey and Schmutzler (2001); we also exploit it in Buehler and Schmutzler (2005).

¹⁵ Again, there are potential countereffects of Y_i and Y_j on the derivatives of output and mark-up, but they do not upset the result in the linear Cournot model.

¹⁶ We focus on the case where $k > 4/9$ to assure concavity of the firms' profit functions.

However, this is not the end of the story: If firms can invest into cost reduction, the gap between the two firms widens, since the integrated firm invests more than the separated firm (see Fig. 2b)). We summarize our results for the asymmetric integration case as follows:

Proposition 1. *Under asymmetric integration,*

- (i) *the integrated firm has higher output, mark-up, and market share than the separated firm, even if efficiency levels are exogenous and identical.*
- (ii) *if investment levels are endogenous, the integrated firm invests more than the separated firm ($Y_i^{AI} > Y_i^{AS}$), and the differences in outputs, mark-ups, and market shares increase.*

Proof. (i) Follows immediately from result (iii) of Lemma 1. (ii) The statement on the investment levels follows directly from comparison of the investment levels in the asymmetric integration case in Table 1. For the claim on outputs, first note that the difference between the outputs of the integrated and separated firm is $\alpha/4$ when investment is not allowed (and hence $Y_i=0$). With investment, the difference is $(\alpha + Y_i)/4$, where $Y_i > 0$ is the investment level of the integrated firm. The statements on mark-ups and market shares are similar. \square

Part (i) reflects the efficiency effect of vertical integration, that is, the fact that the integrated firm obtains the input at marginal cost ($w_1=0$), whereas the separated firm pays the monopoly price ($w_2 > w_1$).

Next, consider the statement in (ii) that, if the firms differ only with respect to their vertical integration status, the integrated firm will invest more into cost reduction than the separated firm. Intuitively, the result follows from result (iii) of Lemma 1, which states that the integrated firm has higher equilibrium demand and mark-up than its separated competitor. The demand/mark-up complementarity therefore implies that the integrated firm has higher incentives to invest than the separated competitor, as reflected in condition (i) of Lemma 2. In addition, condition (iii) of Lemma 2 implies that the higher investment of the integrated firm and the lower investment of the competitor are mutually reinforcing. Thus, integrated firms invest more than separated firms.¹⁷

4.2. Changing vertical structure

So far, we have focused on the investment behavior of integrated and separated firms, holding vertical market structure fixed. This comparison was natural to understand the relation between vertical integration and investment. We now consider how changes in vertical structure affect investment behavior. More specifically, we examine how a firm's integration affects the level of own and competitor investment.

Inspection of Table 1 indicates that starting from separation, firm i 's integration increases own investment ($Y_i^{AI} > Y_i^S$) and decreases firm j 's investment ($Y_j^{AS} < Y_j^S$). Starting from asymmetric integration, firm j 's integration has similar effects on investments (i.e., $Y_i^I < Y_i^{AI}$, $Y_j^I > Y_j^{AS}$). The adverse effect on the competitor's investment is what we call the "intimidation effect" of vertical integration. We summarize these findings as follows:

Proposition 2 (intimidation effect). *A firm's vertical integration increases its own investment and decreases the competitor's investment.*

¹⁷ Proposition 1 is related to Linnemer (2003) and Buehler and Schmutzler (2005), which both highlight the efficiency effect of vertical integration. Specifically, Proposition 2 in Buehler and Schmutzler (2005) is essentially the converse of Part (ii) of Proposition 1, stating that more efficient firms are more likely to integrate.

Proposition 2 is crucial for our analysis of integration decisions below, as it points to a strategic benefit of integration that has hitherto gone unnoticed. To see why the result holds, recall that by part (ii) of Lemma 2, a firm's vertical integration increases its own investment incentive, whereas it decreases the competitor's investment incentive. By part (iii) in Lemma 2, the positive effect of vertical integration on own investment and the negative effect on competitor investment are mutually reinforcing. Intuitively, it should therefore be clear that the intimidation effect does not rely on the specifics of the linear Cournot model, but on the underlying properties of this model that are captured by Lemma 2.

5. Equilibrium market structure

In this section, we endogenize integration decisions. Our main result characterizes the equilibrium market structure, using simple reduced-form notation.

Proposition 3 (equilibrium structure). Let $\tilde{\Pi}_i^v = \Pi_i^v - k(Y_i^v)^2$ denote firm i 's net profit. Then, in the linear Cournot model with endogenous investment and integration,

- (i) **separation** occurs if the costs of own integration exceed the benefits for a firm that faces a separated competitor ($\tilde{\Pi}_i^{AI} - \tilde{\Pi}_i^S \leq F$, $i=1, 2$).
- (ii) **integration** occurs if the benefits of own integration exceed the costs for a separated firm facing an integrated competitor ($\tilde{\Pi} >_i^I - \tilde{\Pi}_i^{AS} \geq F$, $i=1, 2$).
- (iii) **asymmetric integration** occurs if the benefits of integration exceed the costs for a firm facing a separated competitor, but not for a firm facing an integrated competitor ($\tilde{\Pi}_i^{AI} - \tilde{\Pi}_i^S \geq F \geq \tilde{\Pi}_i^I - \tilde{\Pi}_i^{AS}$, $i=1, 2$).

The result is an immediate implication of the best-reply conditions. In Appendix C, we restate the conditions of this proposition in terms of the parameters α , k and F of the linear Cournot model. This leads to less transparent expressions, but allows for a simple graphical representation of the equilibrium market structure. Fig. 3 depicts the various types of equilibria as a function of the investment cost parameter k and market size α , fixing the exogenous integration cost at $F=1$.

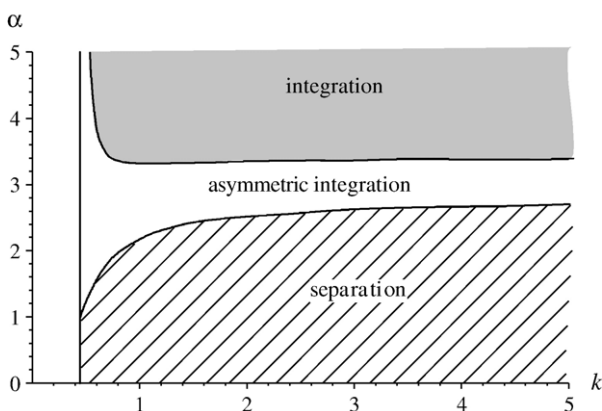


Fig. 3. Equilibrium vertical structure in the linear Cournot model ($F=1$).

Let us first consider the role of market size α . Fig. 3 indicates that if market size is small (in the dashed area), the equilibrium market structure is separation. Intuitively, if the market is small, the benefits from integration are small relative to the given level of fixed cost F , as the increases in demand and mark-up are necessarily limited. Put differently, the market is not sufficiently large to cover the fixed costs of integration. In contrast, if market size is large (in the shaded area), the equilibrium structure is integration, as the increases in demand and mark-up from vertical integration are sufficiently large to cover the integration costs of both firms. For intermediate market sizes, the integration costs of only one firm will be covered, so that asymmetric integration occurs in equilibrium. These results reflect the fact that vertical integration decisions are strategic substitutes. That is, the competitor's integration reduces a firm's own output and mark-up, which makes integration less valuable.¹⁸

Next, consider the role of the investment cost parameter k . Recall that if k is large, the cost of a given efficiency improvement is high. Fig. 3 indicates that there is no one-to-one relationship between the level of k and vertical market structure: A given level of k may be consistent with any of the three equilibrium market structures. More importantly, the effect of k on the equilibrium structure of the industry depends on the relevant market size α : For low values of α , increasing k leads to a change from asymmetric integration to separation; whereas for high values of α , increasing k will lead to a change from asymmetric integration to integration (rather than separation).¹⁹ Thus, the impact of investment costs on vertical market structure crucially depends on the size of the market under study.

Intuitively, the fact that k may have a positive or a negative impact on integration stems from two countervailing effects. On the one hand, as investment costs increase, the role of integration as a relatively cheap substitute for cost-reducing investment becomes more important. Thus, the observation that increasing investment costs may lead from asymmetric integration to full integration for sufficiently high values of α is plausible. On the other hand, with higher investment costs the intimidation effect becomes less important and eventually vanishes altogether. Thus, it becomes less attractive to deviate from a separation equilibrium, so that increasing investment costs may result in a move from asymmetric integration to separation.

6. Discussion and extensions

In this section, we elaborate on the interplay of endogenous investment and integration decisions. Also, we sketch how our analysis can be generalized beyond the linear Cournot model.

6.1. On the role of endogenous investment for equilibrium market structure

As we have noted above, cost-reducing investment plays a crucial role for explaining strategic behavior in successive oligopoly. To further explore how accounting for endogenous cost-reducing investment affects equilibrium market structure, we now compare the equilibrium outcomes of the game described above with the outcomes of a restricted version where firms cannot invest by assumption:

Proposition 4. *With endogenous investment, the parameter region for which separation occurs is smaller than without investment.*

¹⁸ See Buehler and Schmutzler (2005) for a more extensive discussion of this strategic-substitutes property.

¹⁹ For intermediate values of α , the equilibrium involves asymmetric integration independent of k .

The result can be seen from Fig. 3, where the upper bound of the separation regime is upward sloping and the no-investment case corresponds to $k \rightarrow \infty$. Proposition 4 relates to the intimidation effect of integration identified above: With endogenous investment, unilateral deviation from separation is more attractive than without investment, because integration has the additional benefit of intimidating the competitor (i.e., tapering its cost-reducing investment). Thus, in addition to the efficiency effect that the double mark-up is eliminated, another positive effect of integration must be taken into account, which tends to decrease the parameter region for which full separation can be an equilibrium.

There is no analogous result for the boundary between asymmetric integration and integration. In (A2) in Appendix C, we provide a closed-form solution for this boundary, which is a non-monotonic function of k . That is, the effects of endogenizing investment costs depend on the level of investment costs. The intuition for this non-monotonicity for given values of α is similar to the intuition that k may lead to more integration for some values of α and to less integration for others; it reflects the countervailing effects that higher investment costs increase the importance of integration as a substitute for investment but also reduce the importance of the intimidation effect (see Section 5).

6.2. On the role of endogenous vertical market structure for equilibrium investment

For a fixed vertical market structure, the impact of the parameters (α, k) on cost-reducing investment is straightforward. Differentiating the equilibrium investment levels $Y_i^v(\alpha, k)$ in Table 1 with respect to k and α yields

$$\frac{\partial Y_i^v(\alpha, k)}{\partial k} < 0, \quad \frac{\partial Y_i^v(\alpha, k)}{\partial \alpha} > 0.$$

That is, equilibrium investment levels decrease when investment costs increase and increase when market size (and thus per-firm output) increases.

With endogenous vertical market structure, the impact of (α, k) on investment is no longer obvious, as both α and k potentially influence vertical structure which, in turn, affects investment decisions. With respect to changes in α , the endogeneity of vertical market structure does not change much. As explained above, the equilibrium structure first changes from separation to asymmetric integration and then to integration when α increases. It can be shown that total investment typically increases with each integration decision.²⁰ Thus, the indirect effects of increasing α reinforce the direct effects.

With respect to changes in k , the indirect effects are more interesting, as the following result shows.

Proposition 5. *Consider a critical combination of market size and investment costs, (α^*, k^*) , where an increase in k leads to a regime change from asymmetric integration to integration. Then an increase in k in the vicinity of k^* will increase (rather than decrease) the subgame-perfect level of total investment provided that k^* is above some critical value \bar{k} .*

Proof. Consider investments costs (k_1, k_2) close to k^* such that $k_1 < k^* < k_2$. Using Table 1, total investment under asymmetric integration is given by $Y_i^{AS}(\alpha^*, k_1) + Y_j^{AI}(\alpha^*, k_1)$, whereas total

²⁰ More specifically, using Table 1, straightforward calculations show that $Y_i^S + Y_j^S < Y_i^{AI} + Y_j^{AS} < Y_i^I + Y_j^I$ for $k > \frac{10}{21}$.

investment under integration is given by $2Y_i^I(\alpha^*, k_2)$. Therefore, as k_1 and k_2 approach k^* , the difference between total investment under (α^*, k_2) and (α^*, k_1) approaches

$$\alpha^* \left(\frac{4}{9k^*-2} - \frac{-28 + 129k^*}{432(k^*)^2 - 195k^* + 14} \right),$$

which is positive for $k^* > \bar{k} = \frac{10}{21}$. \square

Thus, near the regime boundary, increasing marginal investment costs induces higher (rather than lower) total investments. A similar argument holds for the change from separation to asymmetric integration.

While we do not want to overstate the generality of this point, it illustrates nicely that treating integration and cost-reducing investment as jointly endogenous variables leads to insights that are obscured by treating each variable separately.

6.3. Beyond the linear Cournot case

In the working paper version of this article (Buehler and Schmutzler, 2004), we analyze similar issues in a more general reduced-form setting. With a small set of additional technical conditions, our key argument can briefly be summarized as follows.

Consider an arbitrary successive oligopoly model with the following key features:

- (i) Equilibrium outputs and mark-ups are higher for more efficient firms;
- (ii) Equilibrium outputs and mark-ups are increased by own integration and decreased by competitor integration.

For models with these features, the conclusions of Lemma 2 can be shown to hold. Specifically, the results of this paper for investment incentives continue to hold: Marginal investment incentives are (i) higher for more efficient firms, (ii) increased by own integration, and (iii) reduced by competitor integration. Perhaps more importantly, the intimidation effect of vertical integration on investments still holds, and asymmetric vertical integration continues to be a non-degenerate equilibrium outcome.

7. Conclusions

We have argued that the interplay of endogenous vertical integration and investment decisions is crucial for our understanding of strategic behavior in successive oligopoly. Specifically, our main findings are the following:

First, a firm's vertical integration increases its own investment and decreases the competitor's investment. We call the adverse effect on the competitor's investment the intimidation effect of vertical integration. The intimidation effect implies that there is a strategic integration incentive that has gone unnoticed in the previous literature. In particular, vertical integration may serve as a top dog strategy, tapering the competitor's cost-reducing investment.

Second, asymmetric integration is a non-degenerate equilibrium outcome even if firms are symmetric initially. This result reflects the strategic-substitutes property of vertical-integration

decisions and is consistent with the symmetric vertical market structures documented in the literature for various industries.

Third, compared to a benchmark model without endogenous investment, vertical separation is a less likely outcome. This result again relates to the intimidation effect of vertical integration: With endogenous investment, unilateral deviation from separation is more attractive than without investment, because vertical integration has the additional benefit of intimidating the competitor.

We highlight that our results generalize beyond the Cournot model, provided that integration has a positive effect on own output and mark-up and a negative effect on competitor output and mark-up.

Among the potential limitations of the paper, the assumption of fixed integration costs deserves to be mentioned. One could imagine a richer setting where integration costs depend, for instance, on market structure, reflecting the opportunity costs of the acquisition target. Such a generalization would clearly have some appeal: Even though some aspects of acquisitions costs (including, e.g., administrative efforts), are presumably independent of vertical structure, the latter might influence acquisition costs through its influence on the value of the acquiree. With endogenous acquisition costs, the strategic-substitutes property of integration decisions might be affected (if acquisition costs decrease when a competitor becomes integrated). However, modeling such ideas would require a specific model of acquisition costs, which is beyond the scope of this paper.

Appendix A. Product market equilibrium

Table 1

Product market equilibrium of the linear Cournot model

Separation	Asymmetric integration	Integration
Input prices $w_i^y(Y_i, Y_j)$		
$w_i^S = \frac{2\alpha + Y_i + Y_j}{4}$	$w_i^{AI} = 0, w_i^{AS} = \frac{\alpha - Y_i + 2Y_j}{4}$	$w_i^I = 0$
Outputs and mark-ups $Q_i^y(Y_i, Y_j) = M_i^y(Y_i, Y_j)$		
$Q_i^S = \frac{4\alpha - 7Y_j + 11Y_i}{12}$	$Q_i^{AI} = \frac{5\alpha + 7Y_i - 2Y_j}{12}, Q_i^{AS} = \frac{2\alpha - 2Y_j + 4Y_i}{12}$	$Q_i^I = \frac{\alpha + 2Y_i - Y_j}{3}$
Profits $\Pi_i^y(Y_i, Y_j)$		
$\Pi_i^S = \frac{(4\alpha - 7Y_j + 11Y_i)^2}{144}$	$\Pi_i^{AI} = \frac{(5\alpha + 7Y_i - 2Y_j)^2}{144}, \Pi_i^{AS} = \frac{(2\alpha - 2Y_j + 4Y_i)^2}{144}$	$\Pi_i^I = \frac{(\alpha + 2Y_i - Y_j)^2}{9}$
Investments Y_i^y, Y_j^y		
$Y_i^S = \frac{11\alpha}{81k - 11}$	$Y_i^{AI} = \frac{-14\alpha + 105\alpha k}{432k^2 - 195k + 14}, Y_i^{AS} = \frac{-14\alpha + 24\alpha k}{432k^2 - 195k + 14}$	$Y_i^I = \frac{2\alpha}{9k - 2}$

Appendix B. Alternative solution concept

In this appendix, we use the alternative solution concept proposed by [Schrader and Martin \(1998\)](#) to solve the linear Cournot model. That is, we impose that integrated firms conjecture Cournot reactions to both input sales and purchases. In this setting, we have to account for the potential upstream sales and purchases of an integrated firm. To do this, we add a term $(w - c_i) r_i$ to the profit function of an integrated firm i , where w denotes the input price and r_i is the output

that an integrated firm sells ($r_i > 0$) or buys ($r_i < 0$) in the input market. That is, an integrated firm i chooses downstream output q_i and upstream output r_i so as to

$$\max_{q_i, r_i} (a - q_i - q_j - c_i) q_i + (w - c_i) r_i.$$

Maximizing over q_i yields the Cournot outputs, mark-ups and profits given in Eqs. (1) and (2). That is, in stage 4 of the game both solution concepts yield the same result. This is no longer true for stage 3. To show this, we consider each market configuration in turn. Throughout we impose a market-clearing assumption which requires that aggregate output equals aggregate input.

(i) Under *integration*, market clearing requires $q_1 + r_1 + q_2 + r_2 = q_1 + q_2$, which, using symmetry, immediately implies $r_1 = r_2 = 0$. That is, the product market equilibrium is the same for both solution concepts.

(ii) Under *asymmetric integration*, suppose firm 1 is integrated. Market clearing requires $r_1 + r_2 = q_2$. Using $q_2(c_1, c_2)$ from stage 4, we can invert the market-clearing condition to calculate the derived upstream demand

$$w(r_1, r_2) = \frac{1}{2}\alpha - \frac{1}{2}Y_1 + Y_2 - \frac{3}{2}(r_1 + r_2).$$

Maximizing the profit of the integrated firm over r_1 and the profit of the separated upstream firm over r_2 yields

$$\begin{aligned} r_1(Y_1, Y_2) &= -\frac{1}{12}\alpha - \frac{5}{12}Y_1 + \frac{1}{3}Y_2 < 0, \\ r_2(Y_1, Y_2) &= \frac{5}{24}\alpha + \frac{1}{24}Y_1 + \frac{1}{6}Y_2 > 0, \end{aligned}$$

i.e., the integrated firm will buy from the input market, even though doing so involves higher costs than producing the input internally ($w(Y_1, Y_2) > 0$). Put differently, the integrated firm accepts incrementally higher input costs, because buying from the upstream market raises the separated downstream rival's costs. Substituting back into the relevant functions yields the following equilibrium quantities:

$$\begin{aligned} w(Y_1, Y_2) &= \frac{5\alpha + Y_1 + 4Y_2}{16}, \\ Q_1^{AI}(Y_1, Y_2) &= \frac{7\alpha + 11Y_1 - 4Y_2}{16}, \quad Q_2^{AS}(Y_1, Y_2) = \frac{2\alpha - 6Y_1 + 8Y_2}{16}, \\ \Pi_1^{AI}(Y_1, Y_2) &= \frac{(7\alpha + 11Y_1 - 4Y_2)^2}{256} - \frac{(5\alpha + Y_1 + 4Y_2)(\alpha + 5Y_1 - 4Y_2)}{192}, \\ \Pi_2^{AS}(Y_1, Y_2) &= \frac{(\alpha + 4Y_2 - 3Y_1)^2}{64}. \end{aligned}$$

(iii) Under *separation*, both solution concepts yield the same result, as the difference in the assumptions on the integrated firms' conjectures is irrelevant.

The only difference to the model presented in the text thus concerns the case of asymmetric integration. Straightforward calculations show that the conditions in Lemma 2 still hold when Π_i^{AI} and Π_i^{AS} are replaced by the expressions for the case with upstream sales. Thus, the main mechanisms of the paper, in particular the intimidation effect, are still present if one allows for upstream sales.

Appendix C. Conditions of Proposition 4

In this appendix, we provide the conditions (i)–(iii) of Proposition 3 for the linear Cournot model in explicit form.

(i) Vertical separation occurs in equilibrium iff $\tilde{\Pi}_i^{AI} - \tilde{\Pi}_i^S \leq F$. Substituting from Table 1, we have

$$\left(\frac{(5\alpha + 7Y_i - 2Y_j)^2}{144} - kY_1^2 \right) - \left(\frac{(4\alpha + 11Y_i - 7Y_j)^2}{324} - kY_1^2 \right) \leq F.$$

Using the relevant investment levels (Y_1, Y_2) from Table 1, rearranging yields

$$\alpha^2 k \left(\frac{(144k - 49)(15k - 2)^2}{(432k^2 - 195k + 14)^2} - \frac{(324k - 121)}{(81k - 11)^2} \right) \leq F. \quad (A1)$$

(ii) Vertical integration occurs in equilibrium iff $\tilde{\Pi}_i^I - \tilde{\Pi}_i^{AS} \geq F$. Substituting from Table 1, we have

$$\left(\frac{(4\alpha + 8Y_i - 4Y_j)^2}{144} - kY_1^2 \right) - \left(\frac{(2\alpha - 2Y_j + 4Y_i)^2}{144} - kY_1^2 \right) \geq F.$$

Using the relevant investment levels for each market configuration from Table 1, rearranging yields

$$\alpha^2 k \left(\frac{(9k - 4)}{(9k - 2)^2} - \frac{4(9k - 1)(12k - 7)^2}{(432k^2 - 195k + 14)^2} \right) \geq F. \quad (A2)$$

(iii) Asymmetric integration occurs in equilibrium iff $(\tilde{\Pi}_i^{AI} - \tilde{\Pi}_i^S \geq F \geq \tilde{\Pi}_i^I - \tilde{\Pi}_i^{AS})$. Using Eqs. (A1) and (A2), we immediately have

$$\alpha^2 k \left(\frac{(144k - 49)(15k - 2)^2}{(432k^2 - 195k + 14)^2} - \frac{(324k - 121)}{(81k - 11)^2} \right) \geq F \geq \alpha^2 k \left(\frac{(9k - 4)}{(9k - 2)^2} - \frac{4(9k - 1)(12k - 7)^2}{(432k^2 - 195k + 14)^2} \right).$$

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