北京大学中国经济研究中心
China Center for Economic Research
讨论稿系列
Working Paper Series

E2021003 2021-07-07

Vertical Integration of Multiproduct Monopolists

Wang Hao

Abstract: This note revisits the competition effect of vertical integration. An upstream firm and a downstream firm engage in price- or quantity-choosing game in a market. Each of the firms offers a product series. It is found that the integration of the two firms may not necessarily lower the equilibrium prices because it precludes the "indirect competition" in the market. Therefore, vertical integration could have antitrust concern even in the absence of strategic purpose.

Keywords: Antitrust, Multiproduct, Vertical integration

JEL codes: L1, L4

1. Introduction

We call the integration of firms that produce complements of each other "vertical integration." In the absence of strategic purpose, it is typically suggested that a vertical integration results in lower equilibrium prices and higher social welfare because it internalizes the vertical externalities in pricing. However, the finding is mostly based on models with single-product firms, while most firms in the real world offer at least a product series. In the latter case, the inter-firm product relationships could be complex, so are the competition effects of the integration of the firms.

Cournot (1838) finds that the integration of two monopolists selling complements results in lower prices. Bonanno and Vickers (1988) and Rey and Stiglitz (1988, 1995) find that under certain conditions, vertical separation in an oligopoly leads to higher final prices. Economides and Salop (1992) consider a symmetric linear model in which complementary products can be combined to create "composite goods," and show that "parallel vertical integration" lowers the prices of final composite goods.

On the other hand, vertical integration may be strategically employed to depress competition. It may raise rivals' costs (Salop and Scheffman 1987, Riordan 1998), foreclose competitors (Ordover, Saloner, and Salop 1990, Choi and Yi 2000, Chen 2001, Nocke and Rey 2018), facilitates collusion or cartelization (Riordan and Salop 1995, Chen and Riordan 2007, Nocke and White 2007, Normann 2009), or create "hold-up" problems for rivals (Allain, Chambolle and Rey 2016).

In another related work, Salinger (1991) considers the merger of a two-product monopolist with one of its suppliers. The merger could result in higher prices of both products, though it eliminates the double marginalization for one of its products. The mechanism is based on the second-order conditions of the monopolist's profit-maximization problem. The present note considers the case in which the double marginalizations for all products are eliminated.

The idea of this note can be illustrated by an example. Suppose there is an upstream refinery that produces petrol and diesel, and a downstream manufacturer that produces petrol engine and diesel engine. Consumers purchase fuels and engines from the two firms to obtain motor services. Petrol and petrol engine are complements of each other, so are diesel and diesel engine. However, petrol is actually a “substitute” of diesel engine, because a higher price of diesel engine would increase the demand for petrol. There is “indirect competition” between the two products, which tends to lower the equilibrium prices. If the refinery and engine manufacturer integrate, the indirect competition would be precluded. This effect at least partially offsets the welfare gain from the vertical integration.

Section 2 offers a simple model of vertical integration of multiproduct firms. Section 3 discusses the proposed merger of General Electric and Honeywell (2001). Section 4 concludes.

2. A symmetric linear model

In an industry there are four products, denoted by 1，2，3 and 4 respective. We view 1 and 3 as “upstream” products (which are substitutes of each other), and 2 and 4 as “downstream” products (which are also substitutes of each other). The firms may interact with each other by choosing prices or quantities.

2.1 Price-choosing games

The demand functions for the products are respectively

(1) $$q_1(p_1, p_2, p_3, p_4) = A - \alpha p_1 + \beta p_2 + \gamma p_3 + \delta p_4 ,$$

(2) $$q_2(p_1, p_2, p_3, p_4) = A - \alpha p_2 + \beta p_1 + \gamma p_4 + \delta p_3 ,$$

(3) $$q_3(p_1, p_2, p_3, p_4) = A - \alpha p_3 + \beta p_4 + \gamma p_1 + \delta p_2 ,$$

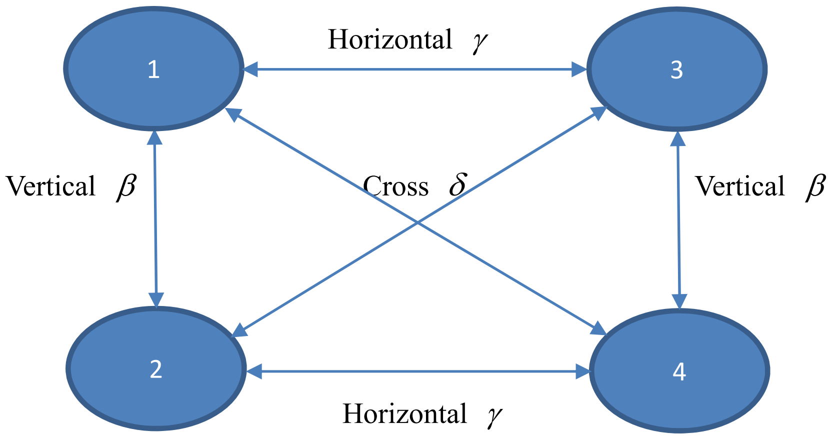
(4) $$q_4(p_1, p_2, p_3, p_4) = A - \alpha p_4 + \beta p_3 + \gamma p_2 + \delta p_1 .$$

The demands are perfectly symmetric, with $q_i(0,0,0,0) = A$, for $i \in \{1,2,3,4\}$, and

(5) $$\frac{\partial q_i}{\partial p_j} = \frac{\partial q_j}{\partial p_i}, \text{ for any } i, j \in \{1,2,3,4\} .$$

The parameters satisfy $A > 0$, $\alpha \geq 0$, $\beta \leq 0$, $\gamma \geq 0$, but the sign of δ is not certain. The product relationships are illustrated by Figure 1.

Figure 1: Product relationships



Among the parameters, β and δ represent the inter-firm product relationships. We call $\beta + \delta$ the "aggregate inter-firm product relationship", with a larger $\beta + \delta$ implying a higher degree of vertical substitution or a lower degree of vertical complementarity.

The products 1 and 2 are complements of each other, so are 3 and 4, with the complementarity measured by $-\beta$. But the "cross product relationship" between the products 1 and 4 (or between 2 and 3) depends on the sign of δ, which could be positive or negative. The marginal production costs of the four products are the same, which are normalized to zero without loss of generality. Because of the symmetry of the model, the socially optimal prices of the products are zero. Consider four market structures.

(i) *Complete separation*: there is an independent firm producing each of the products. The firms' profits are

(6) $$\pi_i(p_i) = q_i p_i, \quad i = 1,2,3,4.$$

Thanks to the symmetry of the model, it is easy to solve for the equilibrium outcome from the first-order conditions of the firms' profit-maximization problems. The outcome is

(7) $$p_i^* = \frac{A}{2\alpha-\beta-\gamma-\delta}, \quad q_i^* = \frac{\alpha A}{2\alpha-\beta-\gamma-\delta}, \quad \pi_i^* = \frac{\alpha A^2}{(2\alpha-\beta-\gamma-\delta)^2}, \quad i = 1,2,3,4.$$

(ii) *Parallel vertical integration*: there is a firm (denoted by *L*) monopolizing the supply of 1 and 2, and another firm (denoted by *R*) monopolizing the supply of 3 and 4. The firms' profits are

(8) $$\pi^L = q_1 p_1 + q_2 p_2, \quad \pi^R = q_3 p_3 + q_4 p_4.$$

The equilibrium outcome is

(9) $$p_1^L = p_2^L = p_3^R = p_4^R = \frac{A}{2\alpha-2\beta-\gamma-\delta},$$

(10) $$q_1^L = q_2^L = q_3^R = q_4^R = \frac{(\alpha-\beta)A}{2\alpha-2\beta-\gamma-\delta},$$

(11) $$\pi^L = \pi^R = \frac{2(\alpha-\beta)A^2}{(2\alpha-2\beta-\gamma-\delta)^2}.$$

Compared to the complete separation, the parallel vertical integration lowers the equilibrium prices if and only if β is negative. The mechanism is similar to that of Bonanno and Vickers (1988) and Rey and Stiglitz (1988, 1995).

(iii) *Parallel horizontal integration*: there is an "upstream" firm (denoted by *U*) monopolizing the supply of 1 and 3, and a "downstream" firm (denoted by *D*) monopolizing the supply of 2 and 4. The firms' profits are

(12) $$\pi^U = q_1 p_1 + q_3 p_3, \quad \pi^D = q_2 p_2 + q_4 p_4.$$

The equilibrium outcome is

(13) $$p_1^U = p_2^D = p_3^U = p_4^D = \frac{A}{2\alpha-\beta-2\gamma-\delta},$$

(14) $$q_1^U = q_2^D = q_3^U = q_4^D = \frac{(\alpha-\gamma)A}{2\alpha-\beta-2\gamma-\delta},$$

(15) $$\pi^U = \pi^D = \frac{2(\alpha-\gamma)A^2}{(2\alpha-\beta-2\gamma-\delta)^2}.$$

Compared to the complete separation, the parallel horizontal integration strictly increases the equilibrium prices if and only if $\gamma > 0$, which is also intuitive since the integration removes the horizontal competition.

(iv) *Monopoly*: A monopolist (denoted by *I*) supplies all the four products. This case can be viewed as the result of a vertical integration of the multiproduct firms *U* and *D* in case (iii). The monopolist's profits are

(16) $$\pi^I = q_1 p_1 + q_2 p_2 + q_3 p_3 + q_4 p_4 .$$

The equilibrium outcome is

(17) $$p_1^I = p_2^I = p_3^I = p_4^I = \frac{A}{2(\alpha - \beta - \gamma - \delta)},$$

(18) $$q_1^I = q_2^I = q_3^I = q_4^I = \frac{A}{2},$$

(19) $$\pi^I = \frac{A^2}{\alpha - \beta - \gamma - \delta}.$$

The vertical integration leads to lower equilibrium prices, i.e.,

(20) $$p^U = p^D = \frac{A}{2\alpha - \beta - 2\gamma - \delta} > \frac{A}{2(\alpha - \beta - \gamma - \delta)} = p^I ,$$

if and only if $\beta + \delta < 0$. We write this outcome as a proposition.

Proposition 1. *The integration of the two multiproduct monopolists U and D is procompetitive if and only if the "aggregate inter-firm product relationship"* $\beta + \delta < 0$.

In this symmetric model, the competition effect of the vertical integration only depends on the product relationships between the two firms. In particular, when $\delta > 0$, the upstream product 1 (or 2) indirectly competes with the downstream product 4 (or 3). In this case, the integration of the *U* and *D* internalizes not only the vertical externality of pricing between 1 and 2 as well as 3 and 4, but also the "horizontal" externality between 1 and 3 as well as 2 and 4. The net effect on the prices are indefinite, depending on which externality dominates.

A positive "aggregate inter-firm product relationship," i.e., $\beta + \delta > 0$, may imply that the integration is actually a "horizontal" one rather than "vertical" one. It is therefore not a surprise for the prices to go up with the integration. From this perspective, there should be a more sophisticated definition of "horizontal" or "vertical" integration when firms offer product series.

The integration of the *U* and *D* is typically profitable, *i.e.*, we have

(21) $$\pi^U + \pi^D = \frac{4(\alpha - \gamma)A^2}{(2\alpha - \beta - 2\gamma - \delta)^2} \leq \frac{A^2}{\alpha - \beta - \gamma - \delta} = \pi^I,$$

with equality if and only if $\beta + \delta = 0$. Hence the vertical integration is least profitable when the "aggregate inter-firm product relationship" is zero.

2.2 Quantity-choosing games

Suppose the (symmetric) inverse demands for the products are

(22) $$p_1(q_1, q_2, q_3, q_4) = B - \eta q_1 - \kappa q_2 - \lambda q_3 - \mu q_4,$$

(23) $$p_2(q_1,q_2,q_3,q_4) = B - \eta q_2 - \kappa q_1 - \lambda q_4 - \mu q_3 ,$$

(24) $$p_3(q_1,q_2,q_3,q_4) = B - \eta q_3 - \kappa q_4 - \lambda q_1 - \mu q_2 ,$$

(25) $$p_4(q_1,q_2,q_3,q_4) = B - \eta q_4 - \kappa q_3 - \lambda q_2 - \mu q_1 .$$

We have $B > 0$, $\eta \geq 0$, $\kappa \leq 0$ and $\lambda \geq 0$, but the sign of μ is not certain. We call $\kappa + \mu$ the "aggregate inter-firm product relationship," with a larger $\kappa + \mu$ implying a higher degree of vertical substitution or a lower degree of vertical complementarity. The production costs are still assumed to be zero.

Since the *complete separation* and *parallel vertical integration* cases are not directly related to the main result, we only consider the *parallel horizontal integration*" and *monopoly* cases here. In the parallel horizontal integration, the profits of the firms are

(26) $$\pi^U = q_1 p_1(q_1,q_2,q_3,q_4) + q_3 p_3(q_1,q_2,q_3,q_4) ,$$

(27) $$\pi^D = q_2 p_2(q_1,q_2,q_3,q_4) + q_4 p_4(q_1,q_2,q_3,q_4) .$$

The equilibrium outcome is

(28) $$q_1^U = q_2^D = q_3^U = q_4^D = \frac{B}{2\eta + \kappa + 2\lambda + \mu} ,$$

(29) $$p_1^U = p_2^D = p_3^U = p_4^D = \frac{(\eta + \lambda)B}{2\eta + \kappa + 2\lambda + \mu} ,$$

(30) $$\pi^U = \pi^D = \frac{2(\eta + \lambda)B^2}{(2\eta + \kappa + 2\lambda + \mu)^2} .$$

If the two firms integration into a monopolist, the merged firm's profits are

(31)
$$\pi^I = q_1 p_1(q_1, q_2, q_3, q_4) + q_2 p_2(q_1, q_2, q_3, q_4) \\ + q_3 p_3(q_1, q_2, q_3, q_4) + q_4 p_4(q_1, q_2, q_3, q_4).$$

The equilibrium outcome is

(32)
$$q_1^I = q_2^I = q_3^I = q_4^I = \frac{B}{2\eta + 2\kappa + 2\lambda + 2\mu},$$

(33)
$$p_1^I = p_2^I = p_3^I = p_4^I = \frac{B}{2},$$

(34)
$$\pi^I = \frac{B^2}{\eta + \kappa + \lambda + \mu}.$$

One can check that the vertical integration of the two firms lowers the equilibrium prices (*i.e.*, $p_i^U = p_i^D > p_i^I$) if and only if $\kappa + \mu < 0$. The previous Proposition still holds. Again, the integration strictly increase the industrial profits as long as $\kappa + \mu \neq 0$.

Finally, as long as the demand functions are symmetric and linear, similar results can be obtained when each firm produces three or more products. I omit the details.

3. The proposed merger of General Electric and Honeywell

General Electric (GE hereafter) and Honeywell are two conglomerates of the United States. The proposed merger of them was approved by 12 jurisdictions including the US, but was blocked by the European Commission (EC hereafter) in July, 2001. GE held a dominant position in the market for large jet aircraft engines, with 43%-65% market share depending on how market share was calculated. Main competitors included Rolls Royce (UK) and Pratt & Whitney (US). Honeywell had a leading position in the avionics and non-avionics aerospace component markets. The EC calculated that Honeywell held a 50% market share overall in the avionics market, followed by 25% of Rockwell Collins (US) and 18% of Thales (France). Hence, the two merging firms had significant market powers in the jet engine and avionics respectively. A more detailed review of the case please see Grant and Neven (2005).

Jet engine and avionics are different parts of an aircraft, which means they are complements of each other. As summarized by Grant and Neven (2005), the EC believes that the proposed merger may bring three unwanted effects. First, it might allow the merged firm to engage in product bundling, with the effect of foreclosing markets for single product line competitors. The view is elaborated by Choi (2008), who shows that the consumer surplus would be higher if the merged entity is prohibited from engaging in "mixed bundling". Second, Honeywell might be able to substantially strengthen its market position if it gains support from GE Capital Aviation Services, a leading aviation lessor and financier. Third, GE and Honeywell have some overlap in large regional and medium corporate jet engine and power systems. The merger would simply preclude the competition in those segments.

This note offers more support to the EC's decision on the case. The jet aircrafts that source parts from GE and Honeywell can be broken down into three categories: large commercial jet aircraft, regional jet aircraft, and corporate jet aircraft, which are substitutes of each other. Different aircrafts are equipped with different jet engines as well as avionics. There is "indirect competition" between GE's engines and Honeywell's avionics. Specifically, because the jet engines for large commercial aircrafts are incompatible with the avionics for regional aircrafts, the two products are actually "substitutes" of each other. If GE lowers its prices of large jet engines, it would lower the prices of large aircrafts and therefore lower the demand for regional aircrafts. It thus lowers the demand for Honeywell's avionics for regional aircrafts. The merger of GE and Honeywell would internalize this “horizontal” externality in pricing, which tends to raise the after-merge prices. The same story can be told about GE’s engines for small aircrafts and Honeywell’s avionics for large aircrafts.

Unquestionably, the proposed merger would also internalize the vertical externalities between compatible engines and avionics, which tends to lower the after-merge prices. An antitrust authority may also consider other possible welfare effects of the merger, like “mixed bundling” or strategic exclusion. The net welfare effect is not crystal clear.

4. Concluding remarks

This note shows that the vertical integration of multiproduct monopolists may result in higher equilibrium prices by precluding “indirect competition”. The finding suggests that the welfare gain from a vertical integration may be less significant than it is in models with single-product firms. From another perspective, when firms offer product series rather than single products, the definition of vertical or horizontal integration might need to be reconsidered.

References

Allain, Marie-Laure, Claire Chambolle, and Patrick Rey. 2016. "Vertical Integration as a Source of Hold-up." *Review of Economic Studies* 83(1): 1-25.

Bonanno, Giacomo, and John Vickers. 1988. "Vertical separation." *Journal of Industrial Economics* 36(3): 257-65.

Chen, Yongmin. 2001. "On vertical mergers and their competitive effects." *RAND Journal of Economics* 32(4): 667-85.

Chen, Yongmin, and Michael H. Riordan. 2007. "Vertical integration, exclusive dealing, and expost cartelization." *RAND Journal of Economics* 38(1): 1-21.

Choi, Jay Pi. 2008. “Mergers with Bundling in Complementary Markets.” *Journal of Industrial Economics* 56(3): 553-77.

Choi, Jay Pil, and Sang-Seung Yi. 2000. "Vertical foreclosure with the choice of input specifications." *Rand Journal of Economics* 31(4): 717-43.

Cournot, Augustin. 1838. “Recherches sur les Principes Mathematiques de la Theorie des Richesses,” Paris, France: Hachette. (English translation by Nathaniel Bacon in Economic Classics, New York: Macmillan, 1897.)

Economides, Nicholas, and Steven C. Salop. 1992. "Competition and integration among complements, and network market structure." *Journal of Industrial Economics* 40(1): 105-23.

Grant, Jeremy, and Damien J. Neven. 2005. "The attempted merger between General Electric and Honeywell: A case study of transatlantic conflict." *Journal of Competition Law and Economics* 1(3): 595-633.

Nocke, Volker, and Lucy White. 2007. "Do vertical mergers facilitate upstream collusion?" *American Economic Review* 97(4): 1321-39.

Nocke, Volker, and Patrick Rey. 2018. "Exclusive dealing and vertical integration in interlocking relationships." *Journal of Economic Theory* 177: 183-221.

Normann, Hans-Theo. 2009. "Vertical integration, raising rivals’ costs and upstream collusion." *European Economic Review* 53(4): 461-80.

Ordover, Janusz A., Garth Saloner, and Steven C. Salop. 1990. "Equilibrium vertical foreclosure." *American Economic Review* 80(1): 127-42.

Rey, Patrick, and Joseph Stiglitz. 1988. "Vertical restraints and producers' competition." *European Economic Review* 32(2): 561-68.

Rey, Patrick, and Joseph E. Stiglitz. 1995. "The Role of Exclusive Territories in Producers' Competition." *RAND Journal of Economics* 26(3): 431-51.

Riordan, Michael H. 1998. "Anticompetitive vertical integration by a dominant firm." *American Economic Review* 88(5): 1232-48.

Riordan, Michael H., and Steven C. Salop. 1994. "Evaluating vertical mergers: A post-Chicago approach." *Antitrust Law Journal* 63: 513-68.

Salinger, Michael A. 1991. “Vertical Mergers in Multi-Product Industries and Edgeworth’s Paradox of Taxation,” *Journal of Industrial Economics* 39(5): 545-56.

Salop, Steven C., and David T. Scheffman. 1987. "Cost-raising strategies." *Journal of Industrial Economics* 36(1): 19-34.