Payoff interdependence and welfare-improving location diversification

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Abstract

We formulate a duopoly model with international location choice in the presence of global common ownership. We theoretically examine how payoff interdependence caused by overlapping ownership such as common and cross ownership affects location and production choices, and resulting welfare. We find that positive payoff interdependence enhances international location diversification, which may improve global welfare.

JEL classification codes: F12, R32, L13

Keywords: overlapping ownership, transport costs, welfare-improving production substitution, spatial Cournot, market-oriented location, cost-oriented location

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Highlights

Oligopolistic firms' competition in an international market is investigated.

Overlapping ownership induces positive payoff interdependence among firms.

Payoff interdependence affects firms' production and location choice.

Payoff interdependence enhances international location diversification.

Welfare may increase with payoff interdependence.

1 Introduction

In this study, we formulate a model in which duopolists choose market- or cost-oriented locations in the presence of positive payoff interdependence, resulting from overlapping ownership such as common and cross ownership. We examine how an increase in the degree of payoff interdependence affects location choice, subsequent competition in the product markets, and welfare. We find that an increase in the degree of positive payoff interdependence enhances international location diversification. This, in turn, induces welfare-improving production substitution —as has been discussed by Lahiri and Ono (1988)—and this effect may dominate the well-known welfare-reducing effect of restricting competition in product markets. In other words, this study reveals the previously unknown welfare-improving effect of positive payoff interdependence among firms.

A distinct feature of contemporary financial markets is the high concentration of the investment industry. Several large institutional investors such as BlackRock, Vanguard, and State Street own nonnegligible shares in most major listed firms globally (Nikkei Market News, 2018/10/24). Moreover, Moreno and Petrakis' (2022) dynamic model shows that all stationary equilibria involve large common investors holding symmetric portfolios, regardless of whether firms face price or quantity competition. Therefore, common ownership will prevail in the long run. If firms are concerned with owners' interests, common ownership will induce positive payoff interdependence among firms. This justifies the utilization of positive payoff interdependence to gauge the extent of common ownership. In other words, in the presence of common ownership, firms are concerned with the profits of other firms including rivals in the same industry. This reduces the incentives for firms to compete, thus having an anti-competitive effect (Azar et al., 2018; Moreno and Petrakis, 2022). Therefore, common ownership has become a central issue in contemporary antitrust policies (Elhauge, 2016; Backus et al., 2021).

Another source of payoff interdependence is passive cross ownership among firms (Reynolds and Snapp, 1986; Farrell and Shapiro, 1990; Gilo et al., 2006). In the presence of mutual share-holding, firms' profits directly link to the other firms' profits. Thus, profit-maximizing firms are concerned with rival firms' profits as long as the firms own shares in the rival firms.

Although the literature emphasizes the anti-competitive and welfare-reducing effects of positive payoff interdependence caused by overlapping ownership such as common and cross ownership (Reynolds and Snapp, 1986; Farrell and Shapiro, 1990; Gilo et al., 2006; Azar et al., 2018), several studies point out the possible welfare-improving effect of overlapping ownership. While overlapping ownership softens competition in product or service markets and raises prices, partial ownership by common owners in the same industry may lead firms to internalize industry-wide externalities and improve welfare. López and Vives (2019) show a possible inverted U-shape relationship between the degree of common ownership and welfare. Common ownership internalizes the positive externality of R&D. This welfare-improving effect may dominate the welfare-harming competition-reducing effect when the degree of common ownership is not too large. In other words, they suggest a nonmonotone relationship between welfare and the degree of common ownership. Sato and Matsumura (2020) investigate a free entry market and find that common ownership internalizes the business-stealing effect; thus, moderate common ownership may improve welfare.[1] They also show that significant common ownership always reduces welfare. Again, a nonmonotone relationship appears. Chen et al. (2024) investigate a vertically related market. They demonstrate that common ownership mitigates the problem of double marginalization and this welfare-improving effect dominates the welfare-harming competition-reducing effect in the downstream market if the competition among downstream firms is weak. Hirose and Matsumura (2022, 2023) investigate the relationship between common ownership and firms' commitments to environmental corporate social responsibility and green transformation. They show that common ownership may improve welfare but it weakens firms'

[1] For a discussion on the business-stealing effect in free entry markets, see Mankiw and Whinston (1986).

incentive for effective emission-reducing commitments and green transformation. Liu and Matsumura (2024) analyze the effects of common ownership in the context of international trade and show that common ownership may improve welfare because common ownership induces global welfare-improving production substitutions, which may dominate the welfare-reducing effect of common ownership.

This study highlights a new positive aspect of payoff interdependence induced by overlapping ownership, such as common ownership or passive cross ownership. We show that a positive payoff interdependence incentivizes the choice for market-oriented locations. The switch from cost- to market-oriented locations induces welfare-improving production substitution. This effect may dominate the competition-restricting and welfare-reducing effects of positive payoff interdependence, thereby improving welfare.

The remainder of this study is organized as follows. Section 2 formulates the model. Sections 3 and 4 present the equilibrium outputs and locations, respectively. Section 5 discusses the welfare implications. Section 6 presents conclusion.

2 The model

We formulate a symmetric three-country, two-market, two-firm model, following Matsumura (2004). There are three countries (A, B, and C) and two firms (1 and 2). A and B have large markets, while C has a small market. For simplicity, we assume that the market size of C is zero, whereas those of A and B are equally large. The inverse demand function of country A (B) is $p^A = a - Q^A (p^B = a - Q^B)$. We adopt the segmented market setup in Dixit (1984). In other words, consumer and independent trader arbitrage is assumed to be prohibitively costly.[2]

Firm j ($j = 1, 2$) chooses q_j^A (quantity for market A) and q_j^B (quantity for market B). Before choosing these quantities, each firm chooses its location. Initially, firm 1 (2) is located

[2] This assumption is not essential. Unless transportation costs for consumers or independent traders are strictly lower than those of firms, arbitrage plays no role in our model.

in country A (B). Each firm chooses whether it stays (market-oriented location) or relocates to country C (a cost-oriented location). Country C has advantages for production and/or international transportation. If firm 1 (2) stays in country A (B), its unit cost for market A (B) will be c and that for market B(A) will be $c+T$. If a firm relocates to country C, its unit cost for markets A and B will be t. We assume that $c < t < c+T$. Without loss of generality, we normalize $c = 0$. These assumptions imply that being located at the home country is the most (least) cost-efficient for the home (foreign) market. We may rationalize these cost structures as follows. The home firm may be able to avoid international transport costs and/or implicit trade barriers. Country C may have efficient international trade facilities, lower labor costs, or efficient regulations. Therefore, being located in country C may reduce production cost and/or international transport costs. As such, relocation may reduce the cost for the foreign market but may raise the cost for the home market because of international trade costs.

The profits of firms 1 (π_1) and 2 (π_2) are, respectively,

$$\pi_1 = (p^A - c_1^A)q_1^A + (p^B - c_1^B)q_1^B, \tag{1}$$

$$\pi_2 = (p^A - c_2^A)q_2^A + (p^B - c_2^B)q_2^B, \tag{2}$$

where c_j^i is firm j's unit cost for market i $(j = 1, 2,\ i = A, B)$.

Following the recent theoretical literature on overlapping ownership (López and Vives, 2019; Vives, 2020), we assume that each firm j has the following objective function:

$$\psi_j = \pi_j + \lambda \pi_k,$$

where π_j is firm j's profit, π_k is its rival's profit, $j,\ k = 1, 2,\ j \neq k$, and λ is the degree of payoff interdependence induced by overlapping ownership.[3]

[3] Prior studies also investigate this type of payoff interdependence using a coefficient of cooperation model (Cyert and Degroot, 1973; Escrihuela-Villar, 2015) and a relative profit maximization model (Escrihuela-Villar and Gutiérrez-Hita, 2019; Hamamura, 2021; Matsumura and Matsushima, 2012; Matsumura et al., 2013).

We restrict our attention to the case in which the solution is interior. In other words, we assume that both firms are active in both markets.[4] Specifically, we assume that $\lambda < 1/2$ and $a > 4T$ to ensure the interior solution.

Global welfare W is the sum of two firms' profits and two countries' consumer surplus. It is obtained as follows

$$W = \pi_1 + \pi_2 + \frac{(Q^A)^2}{2} + \frac{(Q^B)^2}{2}, \tag{3}$$

where $Q^i = q_1^i + q_2^i$ $(i = A, B)$.

The game runs as follows. In the first stage, all firms simultaneously choose their location. In the second stage, all firms simultaneously choose the output for A and B.[5] We use the subgame perfect Nash equilibrium as the equilibrium concept and solve the game via backward induction.

3 Equilibrium given the location choice

First, we investigate the second-stage competition, given the location choices. The first-order conditions of firms 1 and 2 are, respectively,

$$\begin{aligned} p^{i'} q_1^i + (p^i - c_1^i) + \lambda p^{i'} q_2^i &= 0, & (4)\\ p^{i'} q_2^i + (p^i - c_2^i) + \lambda p^{i'} q_1^i &= 0 \quad (i = A, B). & (5) \end{aligned}$$

Substituting $p = a - q_1 - q_2$ into them, we obtain the following reaction functions

$$R_1^i(q_2^i) = \frac{a - c_1^i - (1+\lambda) q_2^i}{2}, \quad R_2^i(q_1^i) = \frac{a - c_2^i - (1+\lambda) q_1^i}{2} \quad (i = A, B). \tag{6}$$

Next, we specify the cost structures that depends on location choices and consider the three types of subgames.

[4] The solution is interior if and only if $\lambda < \bar{\lambda} := (a - 2T)/a$ when both firms do not choose relocation. Therefore, our analysis does not cover the case with a high λ.

[5] Our model is a variant of the so-called location-quantity models. For discussions on the location-quantity model, see Hamilton et al. (1989) and Pal (1998). For discussions on the welfare implications of the location-quantity model, see Matsumura and Shimizu (2005a,b).

3.1 Cost-oriented location

In this subsection, we discuss the subgame in which both firms are located in country C. Substituting $c_1^i = c_2^i = t$ $(i = A, B)$ into (6), we obtain

$$q_1^{iCC} = q_2^{iCC} = \frac{a-t}{3+\lambda}, \quad Q^{iCC} \quad = \quad \frac{2(a-t)}{3+\lambda} \quad (i = A, B). \tag{7}$$

The superscript iCC denotes the equilibrium outcomes in market i when both firms choose cost-oriented locations.

We obtain the following lemma.

Lemma 1 For $i = A, B$ and $j = 1, 2$, (i) q_j^{iCC} and Q^{iCC} decrease with t. (ii) q_j^{iCC} and Q^{iCC} decrease with λ.

Proof See Appendix

These results are intuitive. An increase in both firms' uniform marginal costs reduces each firm's output for each market. An increase in λ leads firms to cooperatively choose their outputs, resulting in smaller outputs.

Let p^{CC}, π^{CC}, and W^{CC} denote the equilibrium price, each firm's profit, and welfare from (3), respectively, when both firms choose cost-oriented locations. We obtain

$$p^{CC} = a - \frac{2(a-t)}{\lambda+3}, \quad \pi^{CC} = \frac{2(a-t)^2(\lambda+1)}{(\lambda+3)^2}, \quad W^{CC} = \frac{4(a-t)^2(\lambda+2)}{(\lambda+3)^2}. \tag{8}$$

From (8), we obtain the following results.

Lemma 2 (i) p^{CC} increases with t and λ. (ii) π^{CC} increases with λ and decreases with t. (iii) W^{CC} decreases with t and λ.

Proof See Appendix

These results are also intuitive. An increase in both firms' uniform marginal costs raises the price, thereby reducing consumer surplus. It also reduces firms' profits and welfare. An increase in λ leads firms to cooperatively choose their outputs, resulting in a higher price, which induces higher profits and lower welfare.

3.2 Market-oriented location

In this subsection, we discuss the subgame in which both firms are located in their home markets. Because of the symmetry between two countries, we focus on the competition in market A. Substituting $c_1^A = 0$ and $c_2^A = T$ into (6), we obtain

$$q_1^{AMM} = q_2^{BMM} = \frac{a(1-\lambda)+T(1+\lambda)}{(3+\lambda)(1-\lambda)}, \tag{9}$$

$$q_2^{AMM} = q_1^{BMM} = \frac{a(1-\lambda)-2T}{(3+\lambda)(1-\lambda)}, \tag{10}$$

$$Q^{AMM} = Q^{BMM} = \frac{2a-T}{3+\lambda}. \tag{11}$$

The superscript iMM denotes the equilibrium outcomes in market i when both firms choose market-oriented locations.

From these equations, we obtain the following lemma.

Lemma 3 (i) q_1^{AMM} increases with T. (ii) q_2^{AMM} and Q^{AMM} decrease with T. (iii) q_1^{AMM} increases with λ if and only if

$$\frac{T}{a} > \frac{(1-\lambda)^2}{5+2\lambda+\lambda^2}.$$

(iv) q_2^{AMM} and Q^{AMM} decrease with λ.

Proof See Appendix

An increase in firm 2's marginal cost reduces firm 2's output for market A (direct cost effect). Thus, q_2^{AMM} decreases with T. Through the strategic interaction, it increases firm 1's output for market A (indirect strategic effect). Thus, q_1^{AMM} increases with T. Under the stability condition, the direct effect dominates the indirect effect. Therefore, the total output decreases with T.

An increase in λ leads firms to cooperatively choose their outputs, resulting in a smaller total output. When λ is higher, the pair of the two firms' output is closer to the joint-profit-maximizing one. Firm 2 has a stronger incentive to reduce its output for market A. compared with firm 1, because it economizes the total production costs by the two firms, and this effect is stronger when T is higher. Because the strategies are strategic substitutes, this effect may increase firm 1's output, especially when T is high. This leads to Lemma 2(iii). The same results hold for market B.

Let p^{MM}, π^{MM}, and W^{MM} denote the equilibrium price, each firm's profit, and welfare, respectively, when both firms choose market-oriented locations. We obtain

$$p^{MM} = \frac{a(1+\lambda)+T}{3+\lambda}, \tag{12}$$

$$\pi^{MM} = \frac{T^2(3\lambda+5)+2a(a-T)(1-\lambda^2)}{(3+\lambda)^2(1-\lambda)}, \tag{13}$$

$$W^{MM} = \left(\frac{2a-T}{3+\lambda}\right)^2 + 2\pi^{MM}. \tag{14}$$

From (12)–(14), we obtain the following results.

Lemma 4 (i) p^{MM} increases with T and λ. (ii) π^{MM} increases with λ. It increases with T if and only if

$$\frac{T}{a} > \frac{1-\lambda^2}{5+3\lambda}.$$

(iii) W^{MM} increases with T if and only if

$$\frac{T}{a} > \frac{2(2-\lambda-\lambda^2)}{5\lambda+11}.$$

(iv) W^{MM} increases with λ if and only if

$$\frac{T}{a} > \frac{(1-\lambda)[\sqrt{(3+\lambda)(1+\lambda)}+\lambda^2-1]}{5\lambda^2+14\lambda+13}.$$

Proof See Appendix

Lemma 4(i) is the same as Lemma 2(i) and their intuition is common. The latter part of Lemma 4(ii) is different from Lemma 2(ii). An increase in T increases the foreign firm's marginal cost only, which induces production substitution from the foreign firm to the home firm. This increases the home firm's profit and reduces the foreign firm's profit. Because the home firm's marginal cost is lower than that of the foreign firm, this production substitution economizes the industry production costs, thereby increasing the total profits in the industry. Because of symmetry, both firms' profits increase with T.

Lemma 4(iii,iv) is different from Lemma 2(iii). An increase in T improves welfare when T is large. As we discussed above, an increase in T induces production substitution, and this production substitution economizes the total costs. This cost saving effect is stronger when T is higher, and this effect dominates a negative effect of consumer surplus when T is high. Similarly, an increase in λ induces the same production substitution and this effect dominates a negative effect of consumer surplus when T is high. This leads to Lemma 4(iii,iv).

3.3 Asymmetric location

In this subsection, we discuss the subgame in which one firm is located in its home market and the other relocates. Without loss of generality, we assume that firm 1 is located in its home market (country A) and firm 2 is located in country C. Substituting $c_1^A = 0$, $c_1^B = T$, and $c_2^A = c_2^B = t$ into (6), we obtain

$$\begin{aligned} q_1^{AMC} &= \frac{a(1-\lambda)+t(1+\lambda)}{(3+\lambda)(1-\lambda)}, && (15)\\ q_2^{AMC} &= \frac{a(1-\lambda)-2t}{(3+\lambda)(1-\lambda)}, && (16)\\ Q^{AMC} &= \frac{2a-t}{3+\lambda}, && (17)\\ q_1^{BMC} &= \frac{a(1-\lambda)-2T+t(1+\lambda)}{(3+\lambda)(1-\lambda)}, && (18)\\ q_2^{BMC} &= \frac{a(1-\lambda)-2t+T(1+\lambda)}{(3+\lambda)(1-\lambda)}, && (19)\\ Q^{BMC} &= \frac{2a-T-t}{3+\lambda}. && (20) \end{aligned}$$

The superscript iMC denotes the equilibrium outcomes in market i when firm 1 chooses a market-oriented location and firm 2 chooses a cost-oriented location.

From these equations, we obtain the following lemma.

Lemma 5 (i) q_1^{AMC} increases with t and is independent of T.

(ii) q_1^{AMC} increases with λ if and only if

$$t > \frac{a(1-\lambda)^2}{\lambda^2 + 2\lambda + 5}.$$

(iii) q_2^{AMC} and Q^{AMC} decrease with t and are independent of T.

(iv) Q^{AMC} decreases with λ, and q_2^{AMC} decrease with λ.

(v) q_1^{BMC} increases with t and decreases with T.

(vi) Q^{BMC} decrease with λ, and q_1^{BMC} decreases with λ if and only if

$$t < \frac{a(1-\lambda)^2 + 4T(1+\lambda)}{\lambda^2 + 2\lambda + 5}.$$

(vii) q_2^{BMC} decreases with t and increases with T.

(viii) q_2^{BMC} increases with λ if and only if

$$t < \frac{-a(1-\lambda)^2 + T(5 + 2\lambda + \lambda^2)}{4(1+\lambda)}.$$

(ix) Q^{BMC} decreases with t and T.

(x) $\partial q_1^{AMC}/\partial\lambda \geq \partial q_2^{AMC}/\partial\lambda$ and $\partial q_2^{BMC}/\partial\lambda \geq \partial q_1^{BMC}/\partial\lambda$.

Proof See Appendix

Lemma 5 is similar to Lemma 3. Each firm's output decreases (increases) with its own cost (the rival's cost). An increase in λ always decreases the higher-cost firm's output and total output. An increase in λ may increase the lower-cost firm's output; this occurs when the cost difference between the firms is high. The intuition underlying Lemma 5 is common with that underlying Lemma 3.

Let p^{AMC}, p^{BMC}, π_1^{MC}, π_2^{MC}, and W^{MC} denote the equilibrium price of market A, that of market B, firm 1's profit, firm 2's profit, and welfare in this subgame. We obtain

$$p^{AMC} = \frac{a(1+\lambda) + t}{\lambda + 3},\ p^{BMC} = \frac{a(1+\lambda) + T + t}{\lambda + 3}, \tag{21}$$

$$\begin{aligned}
\pi_1^{MC} &= \frac{[a(1+\lambda) - T(\lambda+2) + t][a(1-\lambda) - 2T + t(1+\lambda)]}{(3+\lambda)^2(1-\lambda)} \\
&\quad + \frac{[a(1+\lambda) + t][a(1-\lambda) + t(1+\lambda)]}{(3+\lambda)^2(1-\lambda)}, \qquad (22) \\
\pi_2^{MC} &= \frac{[2a(1+\lambda) - 2t(2+\lambda) + T][a(1-\lambda) - 2t]}{(3+\lambda)^2(1-\lambda)} \\
&\quad + \frac{T(1+\lambda)[a(1+\lambda) + T - t(2+\lambda)]}{(3+\lambda)^2(1-\lambda)}, \qquad (23) \\
W^{MC} &= \frac{(T^2 + 2t^2)(5\lambda + 11) + 4a[T - 2(a-t)](\lambda^2 + \lambda - 2)}{2(1-\lambda)(\lambda+3)^2} \\
&\quad - \frac{2tT(2\lambda^2 + 7\lambda + 7)}{2(1-\lambda)(\lambda+3)^2}. \qquad (24)
\end{aligned}$$

We can show that an increase in λ harms consumer surplus (i.e., p^{AMC} and p^{BMC} increase with λ), increases producer surplus (i.e., $\pi_1^{MC}+\pi_2^{MC}$ increases with λ), and may or may not improve welfare. However, we do not delve into a detailed discussion on this matter for the following three reasons. First, we can guess these results from the discussion in the previous subsection and Lemma 5, while the intuitions underlying these results are common with those presented in the previous subsection. Second, the exposition of the analysis is messy due to the asymmetry of the market structure. Finally, and the most importantly, as we will show in the next section, the asymmetric location never appears in pure strategy equilibria, whereas both cost-oriented and market-oriented locations can constitute an equilibrium. Thus, the welfare analysis in the asymmetric location case is less important than that in the cost-oriented and market-oriented location cases.

4 Location choice

In this section, we discuss the location choice in the first stage. There are three possible equilibrium location patterns: (1) Both firms are located in country C (cost-oriented equilibrium, superscript CC), (2) Both firms are located in their home markets (market-oriented equilibrium, superscript MM), (3) One firm is located in its home country and the other firm relocates to country C (asymmetric equilibrium, superscript MC).

The cost-oriented equilibrium exists if $\psi_1^{CC} \geq \psi_1^{MC}$ (i.e., $(1+\lambda)\pi^{CC} \geq \pi_1^{MC} + \lambda\pi_2^{MC}$). By substituting the equilibrium outcomes of π^{CC}, π_1^{MC}, and π_2^{MC} in (8), (22), and (23) respectively, we find that this inequality holds if

$$\begin{aligned} \frac{(1-\lambda)(\lambda+3)^2}{(\lambda^2+3\lambda+4)}(\psi_1^{CC} - \psi_1^{MC}) &= (-2\lambda)t^2 + (T - 2a + T\lambda + 2a\lambda)t \\ &\quad + Ta - T^2 - Ta\lambda \geq 0. \end{aligned} \tag{25}$$

This inequality holds if and only if $t \leq t^C$ where[6]

$$t^C := \frac{T - 2a + T\lambda + 2a\lambda + \sqrt{\Phi_1}}{4\lambda}, \ \Phi_1 := (2a - T)^2(1-\lambda)^2 - 4T^2\lambda. \tag{26}$$

The market-oriented equilibrium exists if $\psi^{MM} \geq \psi_2^{MC}$ (i.e., $(1+\lambda)\pi^{MM} \geq \pi_2^{MC} + \lambda\pi_1^{MC}$). By substituting the equilibrium outcomes of π^{MM}, π_1^{MC}, and π_2^{MC} in (13), (22), and (23) respectively, this inequality holds if

$$\begin{aligned} \frac{(1-\lambda)(\lambda+3)^2}{\lambda^2+3\lambda+4}(\psi^{MM} - \psi_2^{MC}) &= -2t^2 + (T + 2a + T\lambda - 2a\lambda)t \\ &\quad + T^2 - Ta + Ta\lambda \geq 0. \end{aligned} \tag{27}$$

This inequality holds if and only if $t \geq t^M$ where[7]

$$t^M := \frac{T + 2a + T\lambda - 2a\lambda - \sqrt{\Phi_2}}{4}, \ \Phi_2 := (2a - T)^2(1-\lambda)^2 + 4T^2(2+\lambda). \tag{28}$$

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[6] Strictly speaking, the inequality holds if and only if

$$t \in \Big[\frac{T - 2a + T\lambda + 2a\lambda - \sqrt{\Phi_1}}{4\lambda}, \frac{T - 2a + T\lambda + 2a\lambda + \sqrt{\Phi_1}}{4\lambda}\Big].$$

However, we can show that $T - 2a + T\lambda + 2a\lambda - \sqrt{\Phi_1} \leq 0$; thus, we obtain this result. We can also show that $\lim_{\lambda \to 0} t^C = T(a - T)/(2a - T)$.

[7] Strictly speaking, the inequality holds if and only if

$$t \in \Big[\frac{T + 2a + T\lambda - 2a\lambda - \sqrt{\Phi_2}}{4\lambda}, \frac{T + 2a + T\lambda - 2a\lambda + \sqrt{\Phi_2}}{4\lambda}\Big].$$

However, we can show that $(T + 2a + T\lambda - 2a\lambda + \sqrt{\Phi_2})/(4\lambda) \geq T$; thus, we obtain this result.

The asymmetric equilibrium exists if $\pi_1^{MC} + \lambda\pi_2^{MC} \geq (1+\lambda)\pi^{CC}$ and $\pi_2^{MC} + \lambda\pi_1^{MC} \geq (1+\lambda)\pi^{MM}$. Then, the asymmetric equilibrium exists if and only if $t \in [t^C, t^M]$.

We now present a critical result that determines the equilibrium location pattern.

Lemma 6 $t^M < t^C$.

Proof See the Appendix.

Lemma 6 states that the strategies in the first stage are strategic complements. In other words, firm 1's incentive for choosing a market-oriented location is stronger when firm 2 also chooses a market-oriented location than when firm 2 chooses a cost-oriented location. Notice that when $t \in [t^M, t^C]$, firm 1's best reply is choosing a cost-oriented location when firm 2 chooses a cost-oriented location, whereas firm 1's best reply is choosing a market-oriented location when firm 2 chooses a market-oriented location.

We explain the intuition. If firm 2 changes from the cost-oriented location to the market-oriented location (i.e., firm 2 is located in country B), market A (B) becomes more (less) profitable for firm 1 because firm 1 has a cost advantage (disadvantage) for market A (B). Thus, firm 1 has a stronger (weaker) incentive for reducing the cost for market A (B). Therefore, firm 1 is more likely to choose the market-oriented location when firm 2 also chooses the market-oriented location.

Lemma 6 directly determines the following equilibrium location patters.

Proposition 1 (i) If $t < t^M$, the unique equilibrium is the cost-oriented equilibrium. (ii) If $t > t^C$, the unique equilibrium is the market-oriented equilibrium. (iii) If $t \in [t^M, t^C]$, both cost-oriented and market-oriented equilibria exist (multiple equilibria). (iv) The asymmetric location does not constitute a pure strategy equilibrium.

We now discuss how the degree of common ownership affects the equilibrium locations.

Proposition 2 (i) t^C decreases in λ. (ii) t^M decreases in λ.

Proof See the Appendix.

Proposition 2(i) (Proposition 2(ii)) states that the cost-oriented (market-oriented) equilibrium is less (more) likely to exist under common ownership. Suppose that both firms are located in country C. Firm 1's unilateral relocation to country A induces production substitution from firm 1 to firm 2 for market B. The production substitution for market B increases firm 2's profit and this effect is stronger when λ is larger. The production substitution for market A reduces firm 2's profit and increases firm 1's profit. The sum of two firms' profits increases because firm 1's marginal cost for market A is lower than firm 2's. Thus, when λ is large, this production substitution in market A also improves firm 2's payoff. Overall, the deviation incentive from the cost-oriented equilibrium is stronger when λ is larger. Therefore, the cost-oriented equilibrium is less likely to exist when λ is larger. The intuition remains consistent when firm 2 unilaterally relocates to country B. In addition, the mechanism behind Proposition 2(ii) is similar. An increase in λ reinforces the aforementioned market segmentation, thereby leading the market-oriented equilibrium to be more likely to exist.

5 Welfare implications

In this section, we discuss the welfare consequence of the location choice. Proposition 3 compares W^{MM} with W^{CC}.

Proposition 3 (i) $W^{MM} > W^{CC}$ if and only if $t > t^W$ where

$$t^W := a - \frac{\sqrt{\Phi_3}}{2(2-\lambda^2-\lambda)}, \; \Phi_3 := (2-\lambda-\lambda^2)\left[T^2(5\lambda+11)+4a(a-T)(2-\lambda-\lambda^2)\right] > 0. \quad (29)$$

(ii) $t^W < t^C$. (iii) t^W is decreasing in λ.

Proof See the Appendix.

Propositions 2 and 3 imply that the market-oriented location yields greater welfare, compared with the cost-oriented location, even if the cost-oriented location is the unique equilibrium outcome, whereas the inverse is not true. This suggests that firms' incentives for choosing cost-oriented location is excessive for welfare. Proposition 3(iii) states that the payoff interdependence strengthens the welfare advantage of the market-oriented location over the cost-oriented location.

From Lemma 4 and Propositions 2–3, we find that an increase in λ can improve welfare through two routes. First, as Lemma 4(iv) shows, when the equilibrium location is market-oriented, an increase in λ improves welfare when T is high because it induces welfare-improving production substitutions.

Second, Proposition 3(i,ii) implies that the market-oriented location may yield greater welfare than the cost-oriented location even if the cost-oriented location is the unique equilibrium. Proposition 2 suggests that an increase in λ may change the equilibrium outcome from the cost-oriented to the market-oriented one, which improves welfare. In other words, common ownership may stimulate welfare-improving location diversification and improve welfare.

However, it is possible that common-ownership harms welfare. Suppose that the cost-oriented equilibrium appears in equilibrium and the change of λ does not affect the equilibrium pattern. As Lemma 4(iii) shows, common ownership harms welfare. There is another case of welfare-reducing common ownership. Suppose that the market-oriented equilibrium appears in equilibrium and the change of λ does not affect the equilibrium pattern. As Lemma 2(iii) shows, common ownership harms welfare when T is small. In these cases, the output-reduction resulting from common ownership, which has been repeatedly pointed out in the literature, harms welfare.

6 Concluding remarks

In this study, we investigate how payoff interdependence caused by overlapping ownership affects oligopolistic firms' location choices and welfare. We find that a positive payoff interdependence enhances international location diversification, which may improve global welfare.

In this study, we do not consider public policies such as trade, tax, environmental, and privatization policies. Common ownership may affect governments' incentives for formulating these policies.[8] This avenue of research should be explored in future studies. In the present study, we adopted a symmetric duopoly model. Introducing asymmetries into firms' objective functions, cost functions, or demand structure between markets will prove challenging, but it also remains as an avenue for future research.

[8]For example, private firms' objectives affect optimal privatization policies in mixed oligopolies. See Matsumura and Okamura (2015) and Kim et al. (2019).

Appendix

Proof of Lemma 1

From (7), we obtain

$$\frac{\partial q_j^{iCC}}{\partial t} = \frac{-1}{\lambda+3} < 0,\ \frac{\partial Q^{iCC}}{\partial t} = \frac{-2}{\lambda+3} < 0,\ \frac{\partial q_j^{iCC}}{\partial \lambda} = \frac{-(a-t)}{(\lambda+3)^2} < 0,\ \frac{\partial Q^{iCC}}{\partial \lambda} = \frac{-2(a-t)}{(\lambda+3)^2} < 0.$$

This implies Lemma 1(i,ii). Q.E.D.

Proof of Lemma 2

From (8), we find

$$\frac{\partial p^{CC}}{\partial t} = \frac{2}{\lambda+3} > 0, \qquad \frac{\partial p^{CC}}{\partial \lambda} = \frac{2(a-t)}{(\lambda+3)^2} > 0,$$

which implies Lemma 2(i).

Similarly, we obtain

$$\frac{\partial \pi^{CC}}{\partial t} = -\frac{4(\lambda+1)(a-t)}{(\lambda+3)^2} < 0, \quad \frac{\partial \pi^{CC}}{\partial \lambda} = \frac{2(a-t)^2(1-\lambda)}{(\lambda+3)^3} > 0,$$

which implies Lemma 2(ii).

Moreover, we obtain

$$\frac{\partial W^{CC}}{\partial t} = -\frac{8(a-t)(\lambda+2)}{(\lambda+3)^2} < 0, \quad \frac{\partial W^{CC}}{\partial \lambda} = -\frac{4(a-t)^2(\lambda+1)}{(\lambda+3)^3} < 0,$$

which implies Lemma 2(iii). Q.E.D.

Proof of Lemma 3

From (9), (10), and (11), we obtain

$$\frac{\partial q_1^{AMM}}{\partial T} = \frac{1+\lambda}{(3+\lambda)(1-\lambda)} > 0,\ \frac{\partial q_2^{AMM}}{\partial T} = -\frac{2}{(3+\lambda)(1-\lambda)} < 0,\ \frac{\partial Q^{AMM}}{\partial T} = -\frac{1}{3+\lambda} < 0,$$

which implies Lemma 3(i,ii).

Again, from (9), (10), and (11), we obtain

$$\frac{\partial q_1^{AMM}}{\partial \lambda} = \frac{-a(1-\lambda)^2 + (5+2\lambda+\lambda^2)T}{[(3+\lambda)(1-\lambda)]^2},$$
$$\frac{\partial q_2^{AMM}}{\partial \lambda} = -\frac{a(1-\lambda)^2 + 4(1+\lambda)T}{[(3+\lambda)(1-\lambda)]^2} < 0,$$
$$\frac{\partial Q^{AMM}}{\partial \lambda} = \frac{-2a+T}{(\lambda+3)^2} < 0,$$

where $\partial q_1^{AMM}/\partial \lambda > 0$ if and only if the numerator is positive (i.e., $T/a > (1-\lambda)^2/(5+2\lambda+\lambda^2)$ holds). This implies Lemma 3(iii,iv).

Proof of Lemma 4

From (12), we obtain

$$\frac{\partial p^{MM}}{\partial T} = \frac{1}{\lambda+3} > 0, \quad \frac{\partial p^{MM}}{\partial \lambda} = \frac{2a-T}{(3+\lambda)^2} > 0,$$

which implies Lemma 4(i).

From (13), we obtain

$$\frac{\partial \pi^{MM}}{\partial T} = \frac{-2a(1-\lambda^2) + 2T(5+3\lambda)}{(1-\lambda)(\lambda+3)^2},$$
$$\frac{\partial \pi^{MM}}{\partial \lambda} = \frac{2[a(a-T)(1-\lambda)^3 + T^2(6\lambda+3\lambda^2+7)]}{(\lambda-1)^2(\lambda+3)^3} > 0,$$

where $\partial \pi^{MM}/\partial T > 0$ if and only if the numerator is positive (i.e., $T/a > (1-\lambda^2)/(5+3\lambda)$ holds). This implies Lemma 4(ii).

From (13) and (14), we obtain

$$\frac{\partial W}{\partial T} = \frac{4a(-2+\lambda+\lambda^2) + 2T(5\lambda+11)}{(1-\lambda)(\lambda+3)^2}.$$

$\partial W^{MM}/\partial T > 0$ if and only if the numerator is positive (i.e., $T/a > 2(2-\lambda-\lambda^2)/(5\lambda+11)$ holds). This implies Lemma 4(iii).

Similarly, we obtain

$$\frac{\partial W}{\partial \lambda} = \frac{-4a(a-T)(1-\lambda)^2(1+\lambda) + 2T^2(5\lambda^2+14\lambda+13)}{(1-\lambda)^2(\lambda+3)^3}.$$

$\partial W^{MM}/\partial\lambda > 0$ if and only if the numerator is positive (i.e.,

$$\frac{T}{a} > \frac{(1-\lambda)[\sqrt{(\lambda+3)(\lambda+1)}+\lambda^2-1]}{5\lambda^2+14\lambda+13}$$

holds). This implies Lemma 4(iv). Q.E.D.

Proof of Lemma 5

From (15), we obtain

$$\frac{\partial q_1^{AMC}}{\partial t} = \frac{\lambda+1}{(3+\lambda)(1-\lambda)} > 0, \quad \frac{\partial q_1^{AMC}}{\partial T} = 0,$$

which implies Lemma 5(i).

From (15), $\partial q_1^{AMC}/\partial\lambda$ can be written as

$$\frac{\partial q_1^{AMC}}{\partial\lambda} = \underbrace{-\frac{a-t}{(3+\lambda)(1-\lambda)}}_{(-)} + \underbrace{\frac{2(\lambda+1)[a(1-\lambda)+t(1+\lambda)]}{[(3+\lambda)(1-\lambda)]^2}}_{(+)\text{ given } q_1^{AMC}>0}. \tag{30}$$

Therefore, $\partial q_1^{AMC}/\partial\lambda > 0$ if and only if

$$t > \frac{a(1-\lambda)^2}{\lambda^2+2\lambda+5},$$

which implies Lemma 5(ii).

From (16) and (17), we obtain

$$\frac{\partial q_2^{AMC}}{\partial t} = \frac{-2}{(3+\lambda)(1-\lambda)} < 0, \ \frac{\partial q_2^{AMC}}{\partial T} = 0, \ \frac{\partial Q^{AMC}}{\partial t} = \frac{-1}{3+\lambda} < 0, \ \frac{\partial Q^{AMC}}{\partial T} = 0,$$

which implies Lemma 5(iii).

In addition, we obtain

$$\begin{aligned} \frac{\partial Q^{AMC}}{\partial\lambda} &= -\frac{2a-t}{(\lambda+3)^2} < 0 \\ \frac{\partial q_2^{AMC}}{\partial\lambda} &= \frac{-a(1-\lambda)^2-4t(1+\lambda)}{[(3+\lambda)(1-\lambda)]^2} < 0. \end{aligned} \tag{31}$$

Straightforwardly, Q^{AMC} decreases with λ. Additionally, q_2^{AMC} decreases with λ. This implies Lemma 5(iv).

From (18), we obtain

$$\frac{\partial q_1^{BMC}}{\partial t} = \frac{\lambda+1}{(3+\lambda)(1-\lambda)} > 0, \quad \frac{\partial q_1^{BMC}}{\partial T} = -\frac{2}{(3+\lambda)(1-\lambda)} < 0,$$

which implies Lemma 5(v).

Besides, we obtain

$$\begin{aligned} \frac{\partial Q^{BMC}}{\partial \lambda} &= -\frac{2a-T-t}{(3+\lambda)^2} < 0 \\ \frac{\partial q_1^{BMC}}{\partial \lambda} &= \underbrace{-\frac{a-t}{(3+\lambda)(1-\lambda)}}_{(-)} + \underbrace{\frac{2(\lambda+1)[a(1-\lambda)-2T+t(1+\lambda)]}{[(3+\lambda)(1-\lambda)]^2}}_{(+)\ \text{given}\ q_1^{BMC}>0}. \end{aligned} \tag{32}$$

Hence, $\partial q_1^{BMC}/\partial \lambda < 0$ if and only if

$$t < \frac{a(1-\lambda)^2 + 4T(1+\lambda)}{\lambda^2+2\lambda+5}.$$

Thus, Lemma 5(vi) is obtained.

From (19), we obtain

$$\begin{aligned} \frac{\partial q_2^{BMC}}{\partial t} &= -\frac{2}{(3+\lambda)(1-\lambda)} < 0, \\ \frac{\partial q_2^{BMC}}{\partial T} &= \frac{\lambda+1}{(3+\lambda)(1-\lambda)} > 0, \end{aligned}$$

which implies Lemma 5(vii).

Furthermore,

$$\frac{\partial q_2^{BMC}}{\partial \lambda} = \underbrace{-\frac{a-T}{(3+\lambda)(1-\lambda)}}_{(-)} + \underbrace{\frac{2(\lambda+1)[a(1-\lambda)+T(1+\lambda)-2t]}{[(3+\lambda)(1-\lambda)]^2}}_{(+)\ \text{give}\ q_2^{BMC}>0}. \tag{33}$$

Thus, we obtain that q_2^{BMC} increases with λ if and only if

$$t < \frac{-a(1-\lambda)^2 + T(5+2\lambda+\lambda^2)}{4(1+\lambda)}.$$

This implies Lemma 5(viii).

From (20), we obtain

$$\frac{\partial Q^{BMC}}{\partial t} = \frac{\partial Q^{BMC}}{\partial T} = -\frac{1}{3+\lambda}.$$

Thus, Lemma 5(ix) is proven.

From (30) and (31), we obtain

$$\frac{\partial q_1^{AMC}}{\partial \lambda} - \frac{\partial q_2^{AMC}}{\partial \lambda} = \frac{t}{(1-\lambda)^2} \geq 0.$$

The equality holds if and only if $t = 0$. From (32) and (33), we find

$$\frac{\partial q_1^{BMC}}{\partial \lambda} - \frac{\partial q_2^{BMC}}{\partial \lambda} = -\frac{T-t}{(1-\lambda)^2} \leq 0.$$

The equality holds if and only if when $t = T$. Thus, Lemma 5(x) is proven. Q.E.D.

Proof of Lemma 6

According to (27), we show that the inequality $-2t^2+(T+2a+T\lambda-2a\lambda)t+T^2-Ta+Ta\lambda > 0$ holds when $t = t^C$. Note that $-2t^2 + (T + 2a + T\lambda - 2a\lambda)t + T^2 - Ta + Ta\lambda = 0$ when $t = t^M$ and $-2t^2 + (T + 2a + T\lambda - 2a\lambda)t + T^2 - Ta + Ta\lambda > 0$ when $t > t^M$.

From (25), when $t = t^C$, $T^2 - Ta + Ta\lambda = (-2\lambda)t^2 + (T - 2a + T\lambda + 2a\lambda)$ holds. Using this equality, we obtain $-2t^2+(T+2a+T\lambda-2a\lambda)t+T^2-Ta+Ta\lambda = 2t(1+\lambda)(T-t) > 0$ when $t = t^C$. Q.E.D.

Proof of Proposition 2

From (26) , we find

$$\frac{2\lambda\sqrt{\Phi_1}}{T^2} \cdot \frac{\partial t^C}{\partial \lambda} = \frac{-2(2a-T)}{\sqrt{\Phi_1} + (2a-T)(1-\lambda)} + 1,$$

where Φ_1 is presented in (26). Since

$$(2a-T)^2(1+\lambda)^2 > (2a-T)^2(1-\lambda)^2 > (2a-T)^2(1-\lambda)^2 - 4T^2\lambda = \Phi_1,$$

we obtain $(2a - T)(1 + \lambda) > \sqrt{\Phi_1}$, which implies $2(2a - T) > \sqrt{\Phi_1} + (2a - T)(1 - \lambda)$. Therefore, Proposition 2(i) is proven.

We obtain

$$4\sqrt{\Phi_2}\cdot\frac{\partial t^M}{\partial\lambda}=-(2a-T)\big[\sqrt{\Phi_2}-(2a-T)(1-\lambda)\big]-2T^2<0,$$

where $\big[\sqrt{\Phi_2}-(2a-T)(1-\lambda)\big]>0$ given Φ_2 presented in (28). Thus, Proposition 2(ii) is proven. Q.E.D.

Proof of Proposition 3

We obtain

$$\begin{aligned}\big[(\lambda+3)^2(1-\lambda)\big]\cdot(W^{MM}-W^{CC}) &= -4(1-\lambda)(\lambda+2)t^2+8a(1-\lambda)(\lambda+2)t\\ &\quad +T^2(5\lambda+11)-4aT(1-\lambda)(2+\lambda). \qquad (34)\end{aligned}$$

$(W^{MM}-W^{CC})>0$ holds if and only if

$$t\in\Big(a-\frac{\sqrt{\Phi_3}}{2(2-\lambda^2-\lambda)},a+\frac{\sqrt{\Phi_3}}{2(2-\lambda^2-\lambda)}\Big).$$

Apparently, $a+\big\{\sqrt{\Phi_3}/[2(2-\lambda^2-\lambda)]\big\}>a$. Thus, $W^{MM}-W^{CC}>0$ holds if and only if

$$t>a-\frac{\sqrt{\Phi_3}}{2(2-\lambda^2-\lambda)},$$

which implies Proposition 3(i).

We now prove Proposition 3(ii). According to (34), we can show that the inequality

$$-4(1-\lambda)(\lambda+2)t^2+8a(1-\lambda)(\lambda+2)t+T^2(5\lambda+11)-4aT(1-\lambda)(2+\lambda)>0$$

holds when $t=t^C$ if $t^C>t^W$. Note that $-4(1-\lambda)(\lambda+2)t^2+8a(1-\lambda)(\lambda+2)t+T^2(5\lambda+11)-4aT(1-\lambda)(2+\lambda)=0$ when $t=t^W$, and $-4(1-\lambda)(\lambda+2)t^2+8a(1-\lambda)(\lambda+2)t+T^2(5\lambda+11)-4aT(1-\lambda)(2+\lambda)>0$ when $t>t^W$. When $t=t^C$, according to (25), the equality $(-2\lambda)t^2+(T-2a+T\lambda+2a\lambda)+Ta-T^2-Ta\lambda=0$ holds, and thus, $Ta(1-\lambda)=2\lambda t^2-(T-2a+T\lambda+2a\lambda)+T^2$ holds. Using this equality, we find that when $t=t^C$, $-4(1-\lambda)(\lambda+2)t^2+8a(1-\lambda)(\lambda+2)t+T^2(5\lambda+11)-4aT(1-\lambda)(2+\lambda)=$

$T^2(\lambda^2+3)+4t(T-t)(\lambda^2+3\lambda+2)>0$ holds because $T>t$. Therefore, Proposition 3(ii) is proven.

We have

$$\frac{\partial t^W}{\partial \lambda} = -\frac{T^2(5\lambda^2+22\lambda+21)}{4(2-\lambda-\lambda^2)\sqrt{\Phi_3}} < 0,$$

which implies Proposition 3(iii). Q.E.D.

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