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Gray-market trade with product information service in global supply chains*

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Abstract

This paper investigates the economic effects of a product information service when potential consumers, who are segmented by their taste, exist in gray markets. Specifically, we construct an economic model that considers a multinational firm (MNF) who expands business to a country and chooses whether to provide information service regarding product characteristics. If receiving the information, consumers in a specific segment, whose taste suits the characteristics, have positive utility from consuming the product, while those in other segments have no utility. By contrast, consumers in all segments have positive expected utility before consuming the product without information. With these settings, we demonstrate that there arises the equilibrium that the MNF provides no information service when gray-market trade, i.e., parallel trade, is allowed in the country, leading to lower consumer welfare than when it is prohibited. A primary finding in the equilibrium is that such a situation arises especially when potential consumers are less segmented. In this situation, the regulator in the country should ban the parallel imports so as to enhance consumer welfare. The result is counterintuitive and notable, because one might intuitively infer that gray-market trade is less desirable when customers are more minutely segmented and the product information service is thus more specific and necessary.

Keywords: gray market; parallel trade; product information service; customer segmentation; global supply chain

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1. Introduction

Gray-market trade, also referred to as parallel trade, is goods produced genuinely under protection of a patent, copyright, or trademark, placed into circulation in one country, and then legally imported into another without the original manufacturer's authorization. The global system of intellectual property rights (IPR), which is established in the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in the World Trade Organization (WTO), permits each country to determine its own legal regime on whether parallel imports are allowed or not. Accordingly, regulation of gray markets has been the subject of considerable controversy in the international trade-policy arena.

Given the ongoing policy debate, this paper investigates the economic effects of a product information service in gray markets when potential consumers in an importing country are segmented by their taste and thus need product information. Specifically, we construct an economic model that considers a multinational firm (MNF) who expands business to a country and chooses whether to provide information service regarding product characteristics. If receiving the information, consumers in a specific segment have positive utility from consuming the product, while those in other segments have no utility. By contrast, consumers in all segments have positive expected utility before consuming the product without information. With these settings, we demonstrate that there arises the equilibrium that the MNF provides no information service if gray-market trade, i.e., parallel trade, is allowed in the country, leading to lower consumer welfare. A primary finding in the equilibrium is that such a situation arises when potential consumers are less segmented. In this situation, the regulator in the importing country should ban the parallel imports so as to enhance consumer welfare. Intuitively, one might infer that gray-market imports are less desirable, particularly when customers are more minutely segmented and a product information service is thus more specific and necessary. Surprisingly, however, our result suggests the contrary to the intuition and is thus notable.

An intuition behind this result is laid out as follows. If customers are relatively minutely segmented by their taste, the MNF cannot derive sufficient expected valuation of the product from potential consumers in the absence of information service. Hence, the MNF is willing to provide the information service even though a competitor, i.e., a parallel importer (PI), free-rides on it. Eventually, only consumers who have taste that suits the product can buy the product at a lower price thanks to duopoly by the MNF and the PI, implying that the regulator need not prohibit parallel imports. By contrast, when potential consumers are less segmented, the MNF can derive sufficient expected valuation even without conveying product information. Without receiving the information, consumers, whose taste does not suit the product, wish to buy the good because they overestimate the expected utility from consuming the product. Hence, the MNF may strategically provide no product information and thereby derive larger demand, even though lower expected valuation of the product prevents the MNF from charging a higher price. As a consequence, consumer welfare deteriorates because consumers whose taste does not fit the characteristics buy the product in equilibrium. In such circumstances, the regulator of the country should rather prohibit parallel imports in order to have the MNF convey product information, although the

MNF monopolizes the market of the country.

Cohen and Mallik (1997) give a comprehensive review of previous models for the management of global supply chain network and material control decisions, and provide empirical evidence based on economic data measuring the extent of intrafirm globalization. Among earlier studies relating to global supply chains, research that examines the economic effects of gray-market imports dates back at least to Bucklin (1993), who constructs a management science model to identify the economic impact of international parallel trading. His model views the problem from the perspective of the international firm managing its independent channel members in two countries and confronted with a gray market. He demonstrates that the damage from the global gray markets is insufficient to warrant prohibition by public agency even though it may make channel management a painful exercise. Ahmadi and Yang (2000) examine parallel trade when customers are segmented within an importing country. In their model, parallel importation becomes another channel for the authentic products and creates a new product version that enables the manufacturer to price discriminate. Furthermore, parallel imports also generate a third and new segment that would not have bought this product before. Eventually, parallel imports may help the original manufacturer to extend the global reach of its product and boost its global profit, implying that the manufacturer should allow parallel imports under some circumstances. More recently, Su and Mukhopadhyay (2012) investigate gray trading between a dominant retailer and a number of fringe retailers by constructing a model that captures dynamic relationships of a supply chain populated by the two types of retailers. Their analysis examines how such a channel can be coordinated and the gray market activities be prevented. Consequently, they propose a dynamic quantity discount contract or a revenue-sharing contract that the manufacturer can use to fight the gray market activity. Dasu et al. (2012) model mechanisms by which the uncertainty surrounding inventory ordering decisions drives gray markets. They first present a simple stochastic supply chain model composed of a producer and a retailer and then develop the model to add a distributor whereby the distributor and authorized retailer have the option of diverting inventory to a gray market. Their analysis sheds light on three issues: impacts of diversion on the various supply chain participants, strategies producers could use to combat or exploit gray markets, and considerations for authorized retailers trying to set optimal order quantities in the presence of a gray market.[1]

The above literature overview suggests that little research discusses problems that

[1] From an international operational viewpoint, Teng et al. (2001) examine the optimal investment strategy of entering into a foreign market for not only an MNF but also a host country when the former has a number of strategies such as foreign direct investment, joint venture, and exclusive licensing. In their model, a host government also has the choice to introduce a suitable entry strategy into its local market, with the objective of maximizing its tax revenue or national social welfare. Moreover, significant production economic studies address multinational transfer pricing problem in global supply chain context (e.g., Johansen, 1996; Li and Balachandran, 1997; Pfeiffer, 1999; Vidal and Goetschalckx, 2001; Gjerdrum et al., 2002; Lakhal et al., 2005; Lakhal, 2006; Hammami et al., 2008; Rosenthal, 2008; Villegas and Ouenniche, 2008; Lantz, 2009; Perron et al., 2010; Matsui, 2012).

emerge when parallel traders free-ride on the marketing and service investments of authorized distributors.[2] To the best of the author's knowledge, no study has constructed a formal model describing informational free riding by PIs, even though free-riding of promotional and service efforts incurred by an original manufacturer is a frequently observed phenomenon in reality.[3] Accordingly, this paper aims to establish a rigorous model describing the free-riding by PIs. Moreover, while previous studies have mainly examined the inter-country segmentation of markets, our study introduces intra-country segmentation of consumers. Traditionally, customer segmentation within a country has been an issue of concern mainly in the marketing literature (e.g., Gerstner and Holthausen, 1986; Ahmadi and Yang, 2000) rather than economic studies. Therefore, the welfare impact of parallel imports under the presence of customer segmentation has not been investigated. Given this research stream, the current study also contributes to the extant literature by addressing such an unexplored issue.

The rest of this paper is laid out as follows. Section 2 presents settings and assumptions of our economic model. With the arrangements, we analyze a noncooperative game model to derive subgame perfect Nash equilibrium (SPNE), followed by the presentation of operational implications in Section 3. Section 4 discusses the implications of our model from the perspective of supply chain management under global complexity. Lastly, Section 5 presents concluding remarks.

2. Assumptions and settings

This section delineates assumptions and settings employed in our model. Fig. 1 illustrates the supply chain structure presumed, and Table 1 lists the variables that will be used. We suppose the situation that a multinational firm (MNF), which manufactures a specific product and sells it in country A, attempts to expand its business to country B. In country B, there is a regulator who determines whether to permit parallel imports. When parallel imports are permitted in country B, a parallel importer (PI) buys a certain amount of the product in the market of country A, and subsequently sells it in country B. We additionally assume that both the MNF and the PI are owned by residents outside country B.

[Fig. 1]

[Table 1]

Because information of the product sufficiently prevails in country A, consumers in the

[2] Traditionally, industrial organization studies have examined economic outcomes of information service externalities and the resulting free-riding by distributors in the context of vertical restraints (e.g., Telser, 1960; Mathewson and Winter, 1984; Winter, 1993; Matsui, 2011).

[3] For example, Tarr (1985) states that free riding is an important factor in the parallel trade of perfumes. Nonetheless, Li and Maskus (2006, p. 446) document that: "There are other potential sources of PI, including free riding on market investments and the existence of varying price controls across nations. The former has not received formal attention in the literature, ..."

country confront no uncertainty to purchase and consume the product. Presume that the inverse demand function in country A is:

$$p^A = \alpha - \beta q^A, \tag{1}$$

where p^A represents the price in country A, q^A the demand of consumers in the country, and α and β are positive constants. We may restate Eq. (1) as the following demand function:

$$q^A = (\alpha - p^A)/\beta. \tag{2}$$

Meanwhile, we assume that the MNF may choose whether to provide information service of the product in country B, where the product information has not yet prevailed. If the MNF does not supply a product information service, consumers in country B do not learn characteristics of the product. Specifically, we suppose a space of n (≥ 2) dimensions, each of which has a segment $[0, a]$, where consumers in country B uniformly lie with the density of $1/n$.[4] Consumers in segment i ($i = 1, 2, ..., n$) obtain positive utility from consuming a unit of the product only when state i is realized. Otherwise, their utility falls to 0. For model tractability, we assume that the probability that each state is realized is identical, i.e., $1/n$.

We assume that the valuation of a unit of the product varies among consumers. The valuation is distributed between $[0, v]$ along the segment of $[0, a]$. That is, consumers at coordinate x ($0 \leq x \leq a$) in dimension i obtains utility of vx/a from consuming a unit of the product when state i is realized.[5] On the contrary, utility of the product for any consumer in dimension i is 0 if a state other than state i is realized. Through the information service, the MNF induces consumers to learn which state has been realized. Fig. 2 describes the distribution of consumers in segment i in country B.

[Fig. 2]

Given the consumer segmentation, we may obtain the demand schedule in country B. When the MNF chooses to provide the information service, consumers only in segment i obtain positive utility from consuming the product, whereas consumers in other segments have no utility. Let p^B denote the price of the product in country B. Because consumers in segment i who satisfy $vx/a \geq p^B$ ($\leftrightarrow x \geq ap^B/v$) buy a unit of the product, and the density of consumers is $1/n$, total demand in country B, Q^B, amounts to $(a - ap^B/v)/n$. Eventually, the inverse demand function in the presence of the information service is:

[4] This setting signifies that the total number of consumers in the country is a regardless of the number of customer segments. Additionally, we assume that a is not necessarily an integer because consumers are continuously distributed on each segment.

[5] Previous production economic studies employ this setting that potential customers are uniformly distributed with respect to their valuation of the product and thus the demand schedule is linear to investigate noncooperative games played by oligopolistic firms (e.g., Xia and Gilbert, 2007; Xie and Wei, 2009; Matsui, 2010).

$$p^B = v - vnQ^B / a\,. \tag{3}$$

On the other hand, if the MNF provides no service, consumers do not learn which state has been realized. Therefore, consumers in all n segments have positive expected utility from consuming a unit of the product. The expected utility for a consumer at coordinate x in a segment is calculated as: $(1/n) \times v \times x/a + ((n-1)/n) \times 0 \times x/a = vx/(an)$. Hence, consumers who satisfy $vx/(an) \geq p^B$ ($\leftrightarrow x \geq anp^B/v$) in each segment buy the product, implying that demand from one of n segments is $(a - anp^B/v)/n$. Because consumers who satisfy this in all n segments buy the product, multiplying this by n yields total demand as $Q^B = a - anp^B/v$. Accordingly, the inverse demand function is:

$$p^B = v/n - vQ^B/(an)\,. \tag{4}$$

Eqs. (3) and (4) signify that the form of the demand function depends on whether the MNF provides customers with product information or not. Fig. 3 illustrates how the demand lines move as the consumers become segmented, i.e., n increases. This figure also indicates that information service provision by the MNF induces the demand more inelastic under the presence of customer segmentation. Facing inelastic demand resulting from the information provision, the MNF will have an incentive to drive up the retail price. Notice that the PI free-rides on the service provided by the MNF if parallel imports are admitted because the PI also faces the inelastic demand function caused by MNF's information service, as shown in Fig. 3.

[Fig. 3]

Fig. 4 illustrates the timeline of the events. At the initial stage, the regulator in country B determines whether parallel imports are permitted or not. Note that because the MNF is affiliated with another country other than B, the regulator aims to maximize consumer welfare in the country denoted by *CS*, not including other factors such as corporate tax revenue from the MNF. If the regulator prohibits parallel imports, the MNF chooses selling quantity, q^A, for consumers in country A at stage 2. Subsequently, it determines whether to provide the information service or not in country B at stage 3 and chooses selling quantity, q_{MNF}, for consumers as the monopolist at stage 4. On the other hand, if the regulator in Country B permits parallel imports at stage 1, the MNF chooses selling quantity for consumers, q^A, and for the PI, q_{PI}, in country A at stage 2. Subsequently, the MNF determines whether it provides the information service or not at stage 3. At stage 4, the MNF and the PI are engaged in Cournot competition to sell the product for consumers in country B. Along the timeline, we solve the game backwardly in the following section to derive SPNE.

[Fig. 4]

Given the timeline, we next formulate the objective functions. Total profit for the MNF earned in countries A and B is:

$$\pi_{MNF} = \left(p^A - c\right)Q^A + \left(p^B - c\right)q_{MNF}, \tag{5}$$

where c is marginal cost, Q^A is supply quantity by the MNF in country A and q_{MNF} is that in country B. On the other hand, profit for the PI is:

$$\pi_{PI} = \left(p^B - p^A\right)q_{PI}. \tag{6}$$

When the PI exists, supply from the MNF in country A is equal to the sum of the demand by consumers in the country and that by the PI while demand from consumers in country B is total supply by the MNF and the PI.

$$Q^A = q^A + q_{PI} \tag{7}$$
$$Q^B = q_{MNF} + q_{PI} \tag{8}$$

In contrast, when the PI is absent, supply in country A is equal to demand from its residents while demand in country B is equal to the supply by the MNF.

$$Q^A = q^A \tag{9}$$
$$Q^B = q_{MNF} \tag{10}$$

Next, consumer surplus in country B when the information is available is stated as:

$$CS = \frac{1}{n}\int_{ap_B/v}^{a}\left(\frac{vx}{a} - p_B\right)dx = \frac{a\left(v - p_B\right)^2}{2nv}. \tag{11}$$

When they receive no information, only consumers in one segment obtain positive utility from the product while those in the other n–1 segments have no utility. Expected consumer surplus is thus:[6]

$$CS = \frac{1}{n}\int_{anp_B/v}^{a}\left(\frac{vx}{a} - p_B\right)dx + \frac{n-1}{n}\int_{anp_B/v}^{a}\left(0 - p_B\right)dx = \frac{a\left(v - np_B\right)^2}{2nv}. \tag{12}$$

Before solving the model, we additionally assume that the next inequality holds:

[6] Alternatively, we may state consumer surplus by calculating the area bounded by the demand line, the vertical axis, and the price line presented in Fig. 3 as: $CS = (v–p^B)Q^B/2$ and $CS = (v/n–p^B)Q^B/2$. One may confirm that Eqs. (11) and (12) are equivalent to these two values, respectively.

$$v > \alpha > c. \tag{13}$$

The inequalities $v > c$ and $\alpha > c$ guarantee that markets for the product exist in both of the countries, because the maximum valuation of the product in each country exceeds marginal cost. In addition, $v > \alpha$ is a necessary condition for a PI to exist in our supply chain. As will be shown later, if $\alpha \geq v$, the PI cannot earn positive profit by reselling the products from the MNF to consumers in country B. In such circumstances, the PI does not enter the market and thus no regulatory implication will be drawn as to whether the regulator in the country permits parallel imports or not. Moreover, we assume that demand from consumers in country A is sufficiently large so that $(\alpha–c)/\beta > 5a/9$ holds. This condition precludes the possibility that the MNF charges an extremely high price and sells products only to consumers in country B, while supplying no products to consumers in country A in equilibrium.

3. Model analysis

In our dynamic game, the regulator faces the alternative of permitting or prohibiting parallel imports at stage 1, and the MNF faces the alternative of providing the information service or not at stage 3. Accordingly, we need to solve the game classified by the state resulting from the choices by the regulator and the MNF. Then, we will compare economic outcomes among the states.

Henceforth, we attach the following superscripts that identify the state to equilibrium variables. Superscript *PI* represents the state in which the regulator permits parallel imports, while *NPI* represents that he/she bans parallel imports. Moreover, superscript *INF* signifies the state that the MNF provides the information service, whereas *NINF* signifies otherwise. Therefore, there are four potential equilibrium states in total that must be examined: (*PI*, *INF*), (*PI*, *NINF*), (*NPI*, *INF*), and (*NPI*, *NINF*). The next proposition describes the SPNE in each of the four states. (All proofs are in the Appendix.)

Proposition 1.

State I: (PI, INF)

If the regulator permits parallel imports and the MNF provides the information service, equilibrium outcomes are summarized as follows.

$$q_{MNF}^{(PI,INF)} = a\left(v\left(3n\left(2v+\alpha\right)+5a\beta\right)-c\left(9nv+5a\beta\right)\right)/\left(2nv\left(9nv+5a\beta\right)\right)$$

$$q_{PI}^{(PI,INF)} = 3a\left(v-\alpha\right)/\left(9nv+5a\beta\right)$$

$$q^{A(PI,INF)} = \left(9nv\left(\alpha-c\right)+10a\alpha\beta-5a\beta\left(v+c\right)\right)/\left(\beta\left(18nv+10a\beta\right)\right)$$

$$p^{B(PI,INF)} = \left(3nv\left(2v+\alpha+3c\right)+5a\beta\left(v+c\right)\right)/\left(2\left(9nv+5a\beta\right)\right)$$

$$p^{A(PI,INF)} = \left(9nv(\alpha + c) + 5a\beta(v + c)\right)/\left(18nv + 10a\beta\right)$$

$$\pi_{MNF}^{(PI,INF)} = v\left(9n^2\alpha^2 + 2an(2v + 5\alpha)\beta + 5a^2\beta^2\right)/\left(4n\beta(9nv + 5a\beta)\right) - c\left(2v(n\alpha + a\beta) - c(nv + a\beta)\right)/\left(4nv\beta\right)$$

$$\pi_{PI}^{(PI,INF)} = 9anv(v - \alpha)^2/(9nv + 5a\beta)^2$$

$$CS^{(PI,INF)} = a\left(v(3n(4v - \alpha) + 5a\beta) - c(9nv + 5a\beta)\right)^2/\left(8nv(9nv + 5a\beta)^2\right)$$

State II: (PI, NINF)

If the regulator permits parallel imports and the MNF does not provide the information service, equilibrium outcomes are summarized as follows.

Case II-(i): when $n \le v/\alpha$

$$q_{MNF}^{(PI,NINF)} = a\left(v(6v + 3n\alpha + 5an\beta) - cn(9v + 5an\beta)\right)/\left(2v(9v + 5an\beta)\right)$$

$$q_{PI}^{(PI,NINF)} = 3a(v - n\alpha)/(9v + 5an\beta)$$

$$q^{A(PI,NINF)} = \left(9v(\alpha - c) + 10an\alpha\beta - 5a\beta(v + cn)\right)/\left(\beta(18v + 10an\beta)\right)$$

$$p^{B(PI,NINF)} = \left(3v(2v + n\alpha + 3cn) + 5an\beta(v + cn)\right)/\left(n(18v + 10an\beta)\right)$$

$$p^{A(PI,NINF)} = \left(9v(\alpha + c) + 5a\beta(v + cn)\right)/\left(18v + 10an\beta\right)$$

$$\pi_{MNF}^{(PI,NINF)} = v\left(4av\beta + n\left(9\alpha^2 + 10a\alpha\beta + 5a^2\beta^2\right)\right)/\left(4n\beta(9v + 5an\beta)\right) - c\left(2v(\alpha + a\beta) - c(v + an\beta)\right)/\left(4v\beta\right)$$

$$\pi_{PI}^{(PI,NINF)} = 9av(v - n\alpha)^2/\left(n(9v + 5an\beta)^2\right)$$

$$CS^{(PI,NINF)} = a\left(v(12v + 5an\beta - 3n\alpha) - cn(9v + 5an\beta)\right)^2/\left(8nv(9v + 5an\beta)^2\right)$$

Case II-(ii): when $v/\alpha < n \le v/c$

The PI does not enter the market because it cannot earn a positive profit.

$$q_{MNF}^{(PI,NINF)} = a(v - cn)/(2v)$$

$$q_{PI}^{(PI,NINF)} = 0$$

$$q^{A(PI,NINF)} = (\alpha - c)/(2\beta)$$

$$p^{B(PI,NINF)} = (v + cn)/(2n)$$

$$p^{A(PI,NINF)} = (\alpha + c)/2$$

$$\pi_{MNF}^{(PI,NINF)} = (\alpha - c)^2/(4\beta) + a(v - cn)^2/(4nv)$$

$$\pi_{PI}^{(PI,NINF)} = 0$$

$$CS^{(PI,NINF)} = a(v - cn)^2/(8nv)$$

Case II-(iii): when n > v/c

The MNF, as well as the PI, cannot earn a positive profit in country B. Therefore, the PI does not enter the market and the MNF sells products only in country A.

$$q_{MNF}^{(PI,NINF)} = 0$$

$$q_{PI}^{(PI,NINF)} = 0$$

$$q^{A(PI,NINF)} = (\alpha - c)/(2\beta)$$

$$p^{A(PI,NINF)} = (\alpha + c)/2$$

$$\pi_{MNF}^{(PI,NINF)} = (\alpha - c)^2/(4\beta)$$

$$\pi_{PI}^{(PI,NINF)} = 0$$

$$CS^{(PI,NINF)} = 0$$

State III: (NPI, INF)

If the regulator bans parallel imports and the MNF provides the information service, equilibrium outcomes are summarized as follows.

$$q_{MNF}^{(NPI,INF)} = a(v - c)/(2nv)$$

$$q^{A(NPI,INF)} = (\alpha - c)/(2\beta)$$

$$p^{B(NPI,INF)} = (v + c)/2$$

$$p^{A(NPI,INF)} = (\alpha + c)/2$$

$$\pi_{MNF}^{(NPI,INF)} = (\alpha - c)^2/(4\beta) + a(v - c)^2/(4nv)$$

$$CS^{(NPI,INF)} = a(v - c)^2/(8nv)$$

State IV: (NPI, NINF)

If the regulator bans parallel imports and the MNF does not provide the information service, equilibrium outcomes are summarized as follows.

Case IV-(i): when $n \leq v/c$

$$q_{MNF}^{(NPI,NINF)} = a(v - cn)/(2v)$$

$$q^{A(NPI,NINF)} = (\alpha - c)/(2\beta)$$

$$p^{B(NPI,NINF)} = (v + cn)/(2n)$$

$$p^{A(NPI,NINF)} = (\alpha + c)/2$$

$$\pi_{MNF}^{(NPI,NINF)} = (\alpha - c)^2/(4\beta) + a(v - cn)^2/(4nv)$$

$$CS^{(NPI,NINF)} = a(v - cn)^2/(8nv)$$

Case IV-(ii): when $n > v/c$

The MNF cannot earn a positive profit in country B. Therefore, it sells products only in country A.

$$q_{MNF}^{(NPI,NINF)} = 0$$

$$q^{A(NPI,NINF)} = (\alpha - c)/(2\beta)$$

$$p^{A(NPI,NINF)} = (\alpha + c)/2$$

$$\pi_{MNF}^{(NPI,NINF)} = (\alpha - c)^2/(4\beta)$$

$$CS^{(NPI,NINF)} = 0$$

Table 2 summarizes the equilibrium profit and consumer surplus based on Proposition 1. Case II-(ii) of State II in the proposition implies that the MNF monopolizes the market in country B when $v/\alpha < n \leq v/c$ even though the regulator permits parallel imports. Because the existence of the PI indicates that double marginalization occurs in our setting, no information provision under a relatively low maximum evaluation in country B (v) as compared with that in country A (α) prevents the PI from earning a positive profit. Hence, notice that the PI disappears from the gray market not only when the regulator prohibits parallel imports, but also when the PI cannot earn positive profits and thus voluntarily ceases to trade in the gray market. Furthermore, in Case II-(iii) of State II and Case IV-(ii) of State IV, the MNF also cannot earn a positive profit in country B because the maximum expected evaluation by a consumer, v/n, is lower than marginal cost, c.

[Table 2]

The next corollary follows directly from Proposition 1.

Corollary 1.

$\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}$ *holds, meaning that the MNF always provides the information service when the regulator prohibits parallel imports and the MNF thus monopolizes the market in country B.*

Corollary 1 suggests that the MNF always provides the information service when the PI does not operate. That is, if there is no free rider with respect to the information service, the MNF always has an incentive to provide the information service. With the use of the proposition and the corollary, we obtain the following three propositions, which are the central findings of this research. We separately present each of the propositions followed by an explanation of the results.

Proposition 2.

Suppose that the following Inequalities (P1), (P2), and (P3) hold:

$$n \le v/\alpha, \tag{P1}$$

$$3v(v-n\alpha)/((n-1)(9v+5an\beta)) < c < v(21v-3n\alpha+10an\beta)/((n+1)(9v+5an\beta)), \tag{P2}$$

$$5v^2\left(2n\alpha(9v-5a\beta)-(n+1)(9n\alpha^2-5av\beta)\right)-c(2v-(n+1)c)(9nv+5a\beta)(9v+5an\beta)>0. \tag{P3}$$

Then, the following inequalities hold:

$$\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}, \tag{P4}$$

$$\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}, \tag{P5}$$

$$CS^{(NPI,\,INF)} > CS^{(PI,\,NINF)}, \tag{P6}$$

meaning that (NPI, INF) constitutes the unique SPNE.

We may interpret Proposition 2 as follows. Inequality (P4) means that profits for the MNF improve by stopping the information service because the PI free rides on the service. Hence, the MNF provides no information at stage 3 if the regulator admits parallel imports, leading to the equilibrium state (*PI*, *NINF*). Meanwhile, Inequality (P5) indicates that the MNF has an incentive to provide information if the regulator prohibits parallel imports because the service is never free ridden, resulting in the equilibrium state (*NPI*, *INF*). Therefore, the candidates for the SPNE after stage 3 are (*PI*, *NINF*) and (*NPI*, *INF*) when $n \le v/\alpha$, meaning that the regulator can select one of the two equilibria at stage 1. Inequality (P6) ensures that consumer surplus is greater in state (*NPI*, *INF*) than in (*PI*, *NINF*). In summary, the regulator should ban parallel imports when Inequalities (P1), (P2), and (P3) hold so as to maximize consumer welfare.

Proposition 3.

Suppose that the following Inequalities (P7) and (P8) hold:

$$v/\alpha < n \leq v/c, \tag{P7}$$

$$5nv(v-\alpha)^2 - c(n-1)(2v-(n+1)c)(9nv+5a\beta) > 0. \tag{P8}$$

Then, the following inequalities hold:

$$\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}, \tag{P9}$$

$$\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}, \tag{P10}$$

$$CS^{(NPI,\,INF)} > CS^{(PI,\,NINF)}, \tag{P11}$$

meaning that (NPI, INF) constitutes the unique SPNE.

The logic underlying Proposition 3 is similar to that behind Proposition 2. Proposition 3 proves that (*NPI*, *INF*) constitutes the unique SPNE when $v/\alpha < n \leq v/c$ because of Inequalities (P9), (P10), and (P11), which are identical to Inequalities (P4), (P5), and (P6), implying that the regulator should ban parallel imports if Inequalities (P7) and (P8) are satisfied. Furthermore, notice that the number of prerequisites required for each proposition to hold is small as *n* increases. Namely, only one prerequisite (i.e., Inequality (P8)) is required in Proposition 3 for the three inequalities to hold, whereas two prerequisites (i.e., Inequalities (P2) and (P3)) are required in Proposition 2. Hence, as *n* increases, (*NPI*, *INF*) is more likely to be chosen as the combination of the optimal strategies. However, as the next proposition shows, if *n* exceeds *v*/*c*, the state in which the regulator prohibits parallel trade never arises in equilibrium.

Proposition 4.

Suppose that the following Inequality (P12) holds:

$$n > v/c. \tag{P12}$$

Then, the next inequalities hold:

$$\pi_{MNF}^{(PI,INF)} > \pi_{MNF}^{(PI,NINF)}, \tag{P13}$$

$$\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}, \tag{P14}$$

$$CS^{(PI,\,INF)} > CS^{(NPI,\,INF)}, \tag{P15}$$

implying that (PI, INF) constitutes the unique SPNE.

Contrary to Propositions 2 and 3, Proposition 4 suggests that no SPNE arises in which the regulator bans parallel imports when $n > v/c$ regardless of the values of other exogenous variables. Indeed, observe that Proposition 4 needs no supplementary prerequisite other than Inequality (P12) to hold. Consequently, as long as *n* exceeds *v*/*c*, the regulator's decision to permit parallel imports always constitutes the SPNE.

Overall, Propositions 2 and 3 suggest that there arises the possibility that consumer welfare is maximized by banning parallel imports if $n \leq v/c$. The following remark summarizes the above central finding in the current research.

Remark 1.
When n (number of consumer segments) exceeds the threshold value, v/c, consumer surplus in the presence of the PI is always greater than that in the absence of the PI. Accordingly, the regulator need not ban parallel imports. However, when consumers are roughly segmented so that n is less than v/c, the possibility that consumer surplus is enhanced by prohibiting parallel imports arises. In such circumstances, the regulator should ban parallel imports.

The former half of Remark 1 is an unsurprising result; it suggests the well-known outcome of Cournot competition that consumer welfare is more enhanced when the PI as a competitor exists than when the MNF monopolizes the market. Rather, a remarkable result that we should highlight is the latter half of the remark. Intuitively, we might conjecture that regulators should prohibit parallel imports and allow the manufacturer to monopolize the market when consumers are more segmented and the product service is thus more specific and necessary for consumers. However, Remark 1 suggests the contrary.

The logic behind this counterintuitive outcome is summarized as follows. Proposition 4 indicates that the MNF cannot derive sufficient consumer surplus without conveying product information when customers are more minutely segmented so that the number of segments, n, exceeds the threshold value, v/c, as illustrated in Fig. 5. Under these circumstances, the MNF voluntarily provides the information service even though the PI free rides on the service in this situation. Without the information service, even a consumer who draws maximum utility from the product will not buy it. Consequently, consumers receive product information and those only in the correct segment buy the product in the SPNE, leading to desirable consumer welfare. Conversely, when customers are relatively roughly segmented so that n is below v/c, as in Propositions 2 and 3, the MNF can draw sufficient high expected consumer valuation even without the information service provision. Hence, the MNF may prefer no service provision, meaning that low margin and high volume policy becomes the dominant strategy for the MNF. As a consequence, consumers in segments that have no utility in reality overestimate the expected valuation, purchasing the product. In such circumstances, the regulator in country B should prohibit parallel imports to induce the MNF to have an incentive for provision of product information, because consumers cannot receive the information as long as the PI acts as the competitor and free-rides the information service.

[Fig. 5]

4. Implications

In the previous sections, we investigated the economic outcomes of gray market activities on global supply chains using an analytical model. While we used a modeling approach, many previous operations management studies have adopted empirical or case study approaches to investigate gray markets from the viewpoint of supply chain management (SCM). Accordingly, we explore the implications of our results in the context of SCM by associating our approach with empirical insights from the literature. Recall that one unique characteristic of our framework is that we focus on the information service aspect

attached to manufactured products, but not only the flow of products, in the presence of customer segmentation. As a result, our model demonstrates that a multinational strategically exploits customer segmentation by providing information services in the gray market. As previous empirical studies reviewed in this section demonstrate, manufacturing firms use services in order to differentiate products and to segment consumers. Furthermore, previous case studies have provided evidence that multinationals even use gray markets to segment customers. Therefore, our theoretical result is consistent with empirical findings in the literature and is closely related to SCM practice in this respect.

To evaluate our results from an SCM perspective, remember that Gunasekaran et al. (2001) develop a comprehensive framework for measuring strategic, tactical and operational level performance in a supply chain. In particular, they state that "supply chain management (SCM) is a key strategic factor for increasing organizational effectiveness and for better realization of organizational goals such as enhanced competitiveness, better customer care and increased profitability" (Gunasekaran et al. 2001, p. 71). We should note that "customer care", which is expected to include information services, is one objective of a successful SCM. Moreover, Gunasekaran et al. (2004) suggest that reduced barriers to international trade and improvements in information availability lead to the growth and development of SCM. Clearly, a reduction in international trade barriers generates gray markets as well as the development of global SCM, because it provides more arbitrage opportunities.

In reality, a wide variety of industries (such as information technology (IT), perfumeries, watchmaking, etc.) are subject to parallel trade. Estimates of unauthorized imports into the European Union, a rapidly growing unified market with eroded trade barriers, include 10–20% of musical recordings, 5–10% of clothing, 5% of consumer electronics, up to 13% of cosmetics and perfumes, and up to 15% of soft drinks (Maskus, 2000). Antia et al. (2006) report that gray market sales total more than $20 billion in the IT sector alone. Gray market sales sometimes even outstrip authorized sales. Cell phones purchased on the gray market account for 70% of total cell phone sales in Malaysia, and sales of gray market personal computers outnumber authorized sales by two to one in India (Antia et al., 2004). With such large numbers, it is obvious that parallel importation is an organized effort in supply chains, because parallel importation can be conducted either by authorized dealers who directly receive products from manufacturers or by third-party agents who purchase from authorized dealers.

Because parallel imports compete with authorized products, they have traditionally been viewed negatively, and manufacturers make great efforts to restrict their flow. To assess the negative impacts of gray markets on multinationals, Antia et al. (2004) conduct surveys on gray market management, offering direct evidence of the impact of gray market activity on the declining level of service provided by authorized distributors, the erosion of trust in channel relationships, the undermining of manufacturers' pricing strategies, the damage to territory exclusivity and the dilution of brand strength. More specifically, various companies have experienced substantial damage to their profits (Beanie Babies and Ty Inc.), brand equity (Tommy Hilfiger Corp.), market position (Yashica cameras in India) or all three (Caterpillar, Volvo, Mercedes, Chanel, IBM, HP and Swatch, among others), because they

could not stop gray markets. Antia et al. (2004) also show that because the problem is so substantial, multinational companies such as Motorola, 3Com, HP, DuPont and 3M devote full-time managers and staff to dealing with gray market issues.

Previous studies on SCM have proposed prescriptions on how to cope with gray market activities. Antia et al. (2004) suggest that once the nature of the problems has been identified, managers can apply a framework based on what can be called the 3 Ss—sensing, speed and severity—in order to manage gray market activity. Moreover, Antia et al. (2006) examine whether and how severe enforcement deters gray marketing. Their results suggest that none of the three characteristics of enforcement—severity, certainty, and speed—has deterrent value alone. Rather, deterrence is most likely to occur only when the multiple facets of enforcement are used in combination: i.e., when the penalties for gray market violations are severe, when manufacturers are able to detect violations or to mete out punishments in a timely fashion, or both.

However, note that the gray markets are not always bad for every member comprising a supply chain. That is, gray markets are often an effective way to manage distribution channels, to segment markets, to reach untapped markets and to adjust to changes in market conditions. Indeed, a substantial number of empirical studies show that parallel importation can be beneficial to manufacturers by facilitating market segmentation, because price-sensitive market segments may value the lower-valued parallel import, expanding the overall market for the manufacturer's product (e.g., Cavusgil and Sikora, 1988; Yang et al., 1998; Myers and Griffith, 1999; Antia et al., 2004). Moreover, Antia et al. (2004, pp. 66–67) state that "[i]t is sometimes difficult to segment a market within an existing distribution channel structure. Gray markets allow firms to segment their customer base more profitably than they could if they used only a narrow base of distributors or grappled with the channel conflict, customer confusion and brand dilution that come from selling through a multichannel network of authorized dealers." In fact, IBM used a dual-channel strategy to sell profitably in high-end markets while still reaching more price-sensitive consumers with gray market products; this approach helped the company to meet sales targets, to generate revenues and to create scale economies in production (Antia et al., 2004). Because this segmentation can be based on service levels as well as price, our analytical results are congruent with the previous empirical finding.

As a wide range of products such as IT products or fashion products are differentiated considerably today, it is essential for manufacturing firms to manage information services in global supply chains, which adds to the complexity of SCM. Our model assumes that multinationals may create segmentation among consumers through service provision. In this respect, our framework is closely related to the growing complexity in supply chains associated with services attached to products. Our results suggest that because multinationals may strategically exploit the market segmentation within an importing country, regulatory policy regarding whether or not to approve gray market trade there should reflect such strategic behavior under the presence of supply chain complexity.

5. Concluding remarks

This paper investigates the economic influence of gray-market trade when potential consumers in an importing country are segmented by their taste. We demonstrate that there arises the equilibrium that the MNF provides no information service if gray-market imports are allowed in the country, leading to lower consumer welfare. A major finding in the equilibrium is that such a situation arises, especially when potential consumers are less segmented. Intuitively, one might infer that regulators should ban the parallel imports, particularly when customers are more minutely segmented and the product information service is thus necessary. However, our result suggests the contrary to the intuition and is notable in this respect. When consumers are more segmented, the MNF is willing to convey product information because it cannot draw sufficient expected valuation of the product from potential consumers without the information provision. Conversely, when consumers are less segmented, the MNF is unwilling to provide the information service, thereby inducing consumers in all segments to overestimate the expected utility.

These results draw the following economic implication. When consumers are relatively roughly segmented, there arise circumstances where the public agency in the importing country should ban parallel imports to enhance consumer welfare. By contrast, the agency may admit parallel imports if segmentation of potential consumers is substantial, leaving trade of the products to free competition.

Although previous literature has focused on the inter-country market segmentation to discuss welfare consequences of parallel trade, customer segmentation within a recipient country of imports has not been explored sufficiently. Moreover, no prior study has built a formal economic model of information free-riding by PIs. Also in these respects, the current study has overall contributed to the extant literature, providing insights into product information services.

Appendix

Proof of Proposition 1.

State I: (PI, INF)

Total profit for the MNF earned in countries A and B is stated as Eq. (5). Profit for the PI is Eq. (6). Because the MNF and the PI are engaged in Cournot competition in country B at stage 4, consumers' demand in country B is equal to total supply by the MNF and the PI, as stated in Eq. (8). Because the MNF provides information in this state, demand in country B is represented by Eq. (3). By substituting Eq. (8) into Eq. (3), we get:

$$p^B = v - vn(q_{MNF} + q_{PI})/a. \tag{A1}$$

Replacing p^B in Eqs. (5) and (6) with Eq. (A1) and simultaneously solving the first-order conditions, i.e., $\partial\pi_{MNF}/\partial q_{MNF} = 0$ and $\partial\pi_{PI}/\partial q_{PI} = 0$, we obtain the following Cournot-Nash equilibrium.

$$q_{MNF} = a\left(v - 2c + p^A\right)/(3nv) \tag{A2}$$

$$q_{PI} = a\left(v + c - 2p^A\right)/(3nv) \tag{A3}$$

One may confirm that the second-order conditions for maximization are met. Using Eqs. (A1), (A2), and (A3), we reevaluate profits of Eqs. (5) and (6) as follows.

$$\pi_{MNF} = \left(p^A - c\right)Q^A + a\left(p^A + v - 2c\right)^2/(9nv) \tag{A4}$$

$$\pi_{PI} = a\left(v + c - 2p^A\right)^2/(9nv) \tag{A5}$$

Because Q^A represents the supply quantity by the MNF in country A, it is balanced with demand from consumers in country A (Eq. (2)) and demand from the PI (Eq. (A3)) as follows.

$$Q^A = q^A + q_{PI} = \left(\alpha - p^A\right)/\beta + a\left(v + c - 2p^A\right)/(3nv). \tag{A6}$$

After substitution of Eq. (A6) into (A4), we maximize MNF's profit with respect to p^A at stage 2. This gives the equilibrium retail price in country A as:

$$p^A = \left(9nv(\alpha + c) + 5a\beta(v + c)\right)/(18nv + 10a\beta). \tag{A7}$$

Replacing p^A in Eqs. (2), (A2), (A3), and (A6) with Eq. (A7) yields:

$$q_{MNF} = a\left(v(3n(2v + \alpha) + 5a\beta) - c(9nv + 5a\beta)\right)/(2nv(9nv + 5a\beta)) \tag{A8}$$

$$q_{PI} = 3a(v - \alpha)/(9nv + 5a\beta) \tag{A9}$$

$$q^A = \left(9nv(\alpha - c) + 10a\alpha\beta - 5a\beta(v + c)\right)/(\beta(18nv + 10a\beta)) \tag{A10}$$

$$Q^A = \left(9nv\alpha + a\beta(v + 4\alpha) - c(9nv + 5a\beta)\right)/(2\beta(9nv + 5a\beta)). \tag{A11}$$

Further substituting Eqs. (A7), (A8), (A9) and (A11) into Eqs. (A1), (A4) and (A5) gives p^B, π_{MNF}, and π_{PI} in equilibrium. Substituting p^B in equilibrium into Eq. (11) gives equilibrium

consumer surplus in country B.

State II: (PI, NINF)

Profits for the MNF and for the PI are respectively stated as Eqs. (5) and (6). Because the MNF and the PI are engaged in quantity competition in country B at stage 4, Eq. (8) holds in this case. Because the MNF provides no information in country B, the inverse demand is Eq. (4). By substituting Eq. (8) into Eq. (4), we have:

$$p^B = v/n - v(q_{MNF} + q_{PI})/(an). \tag{A12}$$

Replacing p^B in Eqs. (5) and (6) with Eq. (A12) and simultaneously solving the first-order conditions for maximization of profits for the MNF and the PI, i.e., $\partial\pi_{MNF}/\partial q_{MNF} = 0$ and $\partial\pi_{PI}/\partial q_{PI} = 0$, gives the Cournot-Nash equilibrium as:

$$q_{MNF} = a\left(v - 2cn + np^A\right)/(3v) \tag{A13}$$

$$q_{PI} = a\left(v + cn - 2np^A\right)/(3v). \tag{A14}$$

We reevaluate profits of Eqs. (5) and (6) by using Eqs. (A12), (A13), and (A14).

$$\pi_{MNF} = \left(p^A - c\right)Q^A + a\left(np^A + v - 2cn\right)^2/(9nv) \tag{A15}$$

$$\pi_{PI} = a\left(v + cn - 2np^A\right)^2/(9nv) \tag{A16}$$

Supply in country A is equal to demand in the country, which is the total of Eqs. (2) and (A14), namely,

$$Q^A = q^A + q_{PI} = \left(\alpha - p^A\right)/\beta + a\left(v + cn - 2np^A\right)/(3v). \tag{A17}$$

After substituting Eq. (A17) into Eq. (A15), we maximize it with respect to p^A at stage 2. The equilibrium price in country A is:

$$p^A = \left(9v(\alpha + c) + 5a\beta(v + cn)\right)/(18v + 10an\beta). \tag{A18}$$

Replacing p^A in Eqs. (2), (A13), (A14), and (A17) with Eq. (A18) yields:

$$q_{MNF} = a\left(v(6v + 3n\alpha + 5an\beta) - cn(9v + 5an\beta)\right)/\left(2v(9v + 5an\beta)\right) \tag{A19}$$

$$q_{PI} = 3a(v - n\alpha)/(9v + 5an\beta) \tag{A20}$$

$$q^A = \left(9v(\alpha - c) + 10an\alpha\beta - 5a\beta(v + cn)\right)/\left(\beta(18v + 10an\beta)\right) \tag{A21}$$

$$Q^A = \left(9v(\alpha - c) + a\beta(v + 4n\alpha - 5cn)\right)/\left(2\beta(9v + 5an\beta)\right) \tag{A22}$$

Substituting Eqs. (A18), (A19), (A20), and (A22) into Eqs. (A12), (A15), and (A16) gives p^B, π_{MNF}, π_{PI} in equilibrium. Further substituting equilibrium value of p^B into Eq. (12) gives *CS*. Notice here that q_{PI} (Eq. (A20)) takes a nonnegative value only if $n \le v/\alpha$. Therefore, equilibrium variables when $n \le v/\alpha$ are summarized as Case II-(i).

When $n > v/\alpha$, the PI does not enter the market because Eq. (A20) cannot be positive.

Accordingly, the equilibrium is drawn as the monopoly by the MNF. Hence, see the below proof of Case IV-(i) in State IV for an illustration for the solving process because equilibrium variables are the same. As shown in Case IV-(i) of State IV, MNF's supply quantity in country B is calculated as:

$$q_{MNF} = a(v - cn)/(2v). \tag{A23}$$

We need to note that q_{MNF} takes a nonnegative value only if $n \leq v/c$. Therefore, when $v/\alpha < n \leq v/c$, equilibrium variables are summarized as Case II-(ii) similar to Case IV-(i) in State IV.

When $n > v/c$, not only the PI but also the MNF do not enter the market in country B because q_{MNF} cannot be positive; namely, the MNF sells products only in country A. Hence, see the below proof of Case IV-(ii) in State IV for the description of the solving process because equilibrium variables are identical. The outcomes are presented as Case II-(iii).

State III: (NPI, INF)

Eq. (5) describes the profit for the MNF. We substitute the demand function under information provision represented by Eq. (3) into Eq. (5). Because there is no PI, only the MNF supplies products in country B and Eq. (10) holds. Solving the first-order condition, $\partial \pi_{MNF}/\partial q_{MNF} = 0$, gives the equilibrium quantity as:

$$q_{MNF} = a(v - c)/(2nv). \tag{A24}$$

Because there is no PI, Eq. (9) is satisfied. Reevaluation of MNF's profit of Eq. (5) with using Eqs. (2), (3), (9), (10), and (A24) and maximization of it on p^A give the equilibrium retail price:

$$p^A = (\alpha + c)/2. \tag{A25}$$

Substituting Eqs. (10), (A24), and (A25) into Eqs. (2) and (3) yields:

$$p^B = (v + c)/2 \tag{A26}$$

$$q^A = (\alpha - c)/(2\beta). \tag{A27}$$

Further substitution of Eq. (A27) into (9) gives:

$$Q^A = (\alpha - c)/(2\beta). \tag{A28}$$

Finally, substituting Eqs. (A24), (A25), (A26), and (A28) into (5) and (11) derives π_{MNF} and CS in equilibrium.

State IV: (NPI, NINF)

Eq. (5) illustrates the profit for the MNF. We substitute the demand function without an information service described by Eq. (4) into Eq. (5). Because there is no PI, Eq. (10) is satisfied. Solving the first-order condition, i.e., $\partial \pi_{MNF}/\partial q_{MNF} = 0$, gives:

$$q_{MNF} = a(v - cn)/(2v). \tag{A29}$$

Because there is no PI, Eq. (9) holds. Substitution of Eqs. (2), (4), (9), (10), and (A29) into Eq. (5) and maximization of it on p^A gives:

$$p^A = (\alpha + c)/2. \tag{A30}$$

Substituting Eqs. (10), (A29) and (A30) into Eqs. (2) and (4) yields the equilibrium variables as:

$$p^B = (v + cn)/(2n) \tag{A31}$$

$$q^A = (\alpha - c)/(2\beta). \tag{A32}$$

Further substitution of Eq. (A32) into (9) gives:

$$Q^A = (\alpha - c)/(2\beta). \tag{A33}$$

Substituting Eqs. (A29), (A30), (A31), and (A33) into (5) and (12) derives π_{MNF} and *CS* in equilibrium. Observe that q_{MNF} takes a nonnegative value only if $n \leq v/c$ according to Eq. (A29). Hence, equilibrium variables are summarized as Case IV-(i) when $n \leq v/c$.

On the other hand, the MNF does not enter the market in country B when $n > v/c$, i.e., $q_{MNF} = 0$. Accordingly, MNF's profit is restated as:

$$\pi_{MNF} = (p^A - c)Q^A. \tag{A34}$$

After substitution of Eqs. (1) and (9) into Eq. (A34), maximization of the equation with respect to q^A yields:

$$q^A = (\alpha - c)/(2\beta). \tag{A35}$$

Reevaluation of Eqs. (1) and (A34) using Eqs. (9) and (A35) gives equilibrium variables, as shown in Case IV-(ii). □

Proof of Corollary 1.

When $n \leq v/c$, Proposition 1 indicates that:

$$\pi_{MNF}^{(NPI,INF)} - \pi_{MNF}^{(NPI,NINF)} = ac(n-1)(2v - (n+1)c)/(4nv) > 0.$$

On the other hand, when $n > v/c$, the proposition suggests that:

$$\pi_{MNF}^{(NPI,INF)} - \pi_{MNF}^{(NPI,NINF)} = a(v - c)^2/(4nv) > 0.$$

Therefore, $\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}$ is met. □

Proof of Proposition 2.

Using Proposition 1, we can conduct an equivalent transformation of Inequality (P6) as

follows:

$$CS^{(NPI,\,INF)} > CS^{(PI,\,NINF)},$$

$$\leftrightarrow\ a(v-c)^2/(8nv) > a\left(v(12v+5an\beta-3n\alpha)-cn(9v+5an\beta)\right)^2/\left(8nv(9v+5an\beta)^2\right),$$

$$\leftrightarrow\ 3v(v-n\alpha)/((n-1)(9v+5an\beta)) < c < v(21v-3n\alpha+10an\beta)/((n+1)(9v+5an\beta)),$$

suggesting that Inequalities (P2) and (P6) are equivalent. Likewise, equivalent transformation of $\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}$ draws Inequality (P3) by using Proposition 1.

$$\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}$$

$$\leftrightarrow\ 5v^2\left(2n\alpha(9v-5a\beta)-(n+1)(9n\alpha^2-5av\beta)\right)-c(2v-(n+1)c)(9nv+5a\beta)(9v+5an\beta)>0$$

Hence, Inequalities (P3) and (P4) are equivalent. Moreover, Inequality (P5) holds due to Corollary 1. Therefore, Inequalities (P4), (P5), and (P6) hold given the conditions of Inequalities (P1), (P2), and (P3). Inequalities (P4) and (P5) indicate that Nash equilibria in subgames after stage 3 are (*PI*, *NINF*) and (*NPI*, *INF*). At stage 1, the regulator chooses the latter as SPNE of the whole game due to Inequality (P6).

Lastly, we should verify that exogenous parameters that satisfy Inequalities (P1), (P2) and (P3) actually exist. It suffices to present a set of parameters that satisfies a series of the inequalities. One may confirm that (n, v, a, α, β, c) = (2, 22, 1, 10, 1, 1) satisfy the Inequalities (P1), (P2) and (P3) and derive the equilibrium as:

$$(\pi_{MNF}^{(PI,NINF)}, \pi_{MNF}^{(PI,INF)},\ \pi_{MNF}^{(NPI,INF)}, \pi_{MNF}^{(NPI,NINF)},\ CS^{(NPI,\,INF)},\ CS^{(PI,\,NINF)})$$

$$= (22.51, 22.31, 22.76, 22.52, 1.253, 1.209),$$

which also satisfy Inequalities (P4), (P5), and (P6). This numerical example indicates that circumstances that this proposition holds exist. □

Proof of Proposition 3.

Using Proposition 1, we can conduct an equivalent transformation of Inequality (P11) as follows.

$$CS^{(NPI,\,INF)} > CS^{(PI,\,NINF)},$$

$$\leftrightarrow\ a(v-c)^2/(8nv) > a(v-cn)^2/(8nv),$$

$$\leftrightarrow ac(n-1)(2v-(n+1)c)/(8nv) > 0.$$

Moreover, observe that $ac(n-1)(2v-(n+1)c) \geq ac^2(n-1)^2 > 0$ holds because $v \geq cn$ (Inequality (P7)). Hence, Inequality (P11) is automatically satisfied in the presence of Inequality (P7).

Similarly, equivalent transformation of $\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}$ (Inequality (P9)) draws Inequality (P8) by using Proposition 1.

$$\pi_{MNF}^{(PI,NINF)} > \pi_{MNF}^{(PI,INF)}$$

$$\leftrightarrow \ 5nv(v-\alpha)^2 - c(n-1)(2v-(n+1)c)(9nv+5a\beta) > 0,$$

suggesting that Inequalities (P8) and (P9) are equivalent. Moreover, Corollary 1 suggests that Inequality (P10) holds. Therefore, Inequalities (P9), (P10), and (P11) hold given the conditions of Inequalities (P7) and (P8). Inequalities (P9) and (P10) suggest that Nash equilibria in subgames after stage 3 are (*PI*, *NINF*) and (*NPI*, *INF*). At the initial stage, the regulator selects the latter as SPNE of the whole game due to Inequality (P11).

Finally, we check that the region that satisfies Inequalities (P7) and (P8) actually exists. It suffices to show one set of parameters that satisfy the two inequalities. One may confirm that (n, v, a, α, β, c) = (3, 22, 1, 10, 1, 0.5) satisfy Inequalities (P7) and (P8) and derive the equilibrium as:

$$(\pi_{MNF}^{(PI,NINF)}, \pi_{MNF}^{(PI,INF)}, \ \pi_{MNF}^{(NPI,INF)}, \pi_{MNF}^{(NPI,NINF)}, CS^{(NPI,\,INF)}, CS^{(PI,\,NINF)})$$

$$= (24.15, 24.01, 24.31, 24.15, 0.8754, 0.7959),$$

which in turn satisfy Inequalities (P9), (P10), and (P11). This example proves that the domain of exogenous parameters where this proposition holds exists. □

Proof of Proposition 4.

When $n > v/c$ (Inequality (P12)), the following equation holds from Proposition 1:

$$\begin{aligned}
&\pi_{MNF}^{(PI,INF)} - \pi_{MNF}^{(PI,NINF)} \\
&= a(v-\alpha)(54nv\alpha + 5a(v+5\alpha)\beta - 6c(9nv+5a\beta))/(4(9nv+5a\beta)^2) \\
&\quad + a(v(3n(2v+\alpha)+5a\beta) - c(9nv+5a\beta))^2/(4nv(9nv+5a\beta)^2).
\end{aligned} \tag{A36}$$

Because $v > \alpha > c$ from Eq. (13), $54nv\alpha + 5a(v+5\alpha)\beta - 6c(9nv+5a\beta) > 6(\alpha-c)(9n\alpha+5a\beta) > 0$ is met, namely, the first term of Eq. (A36) is positive. Because the second term is obviously positive, Eq. (A36) is positive overall. Therefore, $\pi_{MNF}^{(PI,INF)} > \pi_{MNF}^{(PI,NINF)}$ (Inequality (P13)) holds, indicating that the MNF provides information at stage 3 if the regulator permits parallel imports. Moreover, Corollary 1 suggests that $\pi_{MNF}^{(NPI,INF)} > \pi_{MNF}^{(NPI,NINF)}$ (Inequality (P14)). Hence, candidates for SPNE are (*PI*, *INF*) and (*NPI*, *INF*). Proposition 1 and the assumption that $-c > -\alpha$ yield the next inequality:

$$\begin{aligned}
&CS^{(PI,INF)} - CS^{(NPI,INF)} \\
&= 3av(v-\alpha)(21nv - 3n\alpha + 10a\beta)/(8(9nv+5a\beta)^2) - 3ac(v-\alpha)/(4(9nv+5a\beta)) \\
&> 3a(v-\alpha)^2(21nv+10a\beta)/(8(9nv+5a\beta)^2) > 0,
\end{aligned}$$

indicating that $CS^{(PI,INF)} > CS^{(NPI,INF)}$ (Inequality (P15)) holds. Therefore, the regulator selects (*PI*, *INF*) as SPNE when $n > v/c$ regardless of the values of other exogenous

parameters. □

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Table 1 Notations

a	total number of consumers in country B
v	maximum evaluation of a unit of the product for consumers in country B
α	maximum evaluation of a unit of the product for consumers in country A
β	slope of the inverse demand function in country A
n	number of segments of consumers in country B
A	superscript that denotes country A
B	superscript that denotes country B
MNF	subscript that denotes the MNF
PI	subscript that denotes the PI
q^A	demand from consumers in country A
q_{MNF}	MNF's selling quantity in country B
q_{PI}	PI's purchase quantity in country A and selling quantity in country B
Q^A	total supply quantity in country A
Q^B	total demand quantity in country B
p^A	price in country A
p^B	price in country B
CS	consumer surplus in country B
π_{MNF}	profit for the MNF
π_{PI}	profit for the PI
(PI, INF)	superscript denoting the state that the regulator permits parallel imports and the MNF provides information service
(PI, $NINF$)	superscript denoting the state that the regulator permits parallel imports and the MNF does not provide information service
(NPI, INF)	superscript denoting the state that the regulator bans parallel imports and the MNF provides information service
(NPI, $NINF$)	superscript denoting the state that the regulator bans parallel imports and the MNF does not provide information service

Table 2 Summary of equilibrium consumer surplus and profit for the MNF

Which range does the number of segments fall in?	Does the regulator admit parallel imports?	Does the MNF provide the information service?	CS	π_{MNF}
$n \le v/\alpha$	Yes	Yes	$a\left(v\left(3n\left(4v-\alpha\right)+5a\beta\right)-c\left(9nv+5a\beta\right)\right)^2/\left(8nv\left(9nv+5a\beta\right)^2\right)$	$v\left(9n^2\alpha^2+2an\left(2v+5\alpha\right)\beta+5a^2\beta^2\right)/\left(4n\beta\left(9nv+5a\beta\right)\right)$ $-c\left(2v\left(n\alpha+a\beta\right)-c\left(nv+a\beta\right)\right)/\left(4nv\beta\right)$
		No	$a\left(v\left(12v+5an\beta-3n\alpha\right)-cn\left(9v+5an\beta\right)\right)^2/\left(8nv\left(9v+5an\beta\right)^2\right)$	$v\left(4av\beta+n\left(9\alpha^2+10a\alpha\beta+5a^2\beta^2\right)\right)/\left(4n\beta\left(9v+5an\beta\right)\right)$ $-c\left(2v\left(\alpha+a\beta\right)-c\left(v+an\beta\right)\right)/\left(4v\beta\right)$
	No	Yes	$a\left(v-c\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-c\right)^2/\left(4nv\right)$
		No	$a\left(v-cn\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-cn\right)^2/\left(4nv\right)$
$v/\alpha < n \le v/c$	Yes	Yes	$a\left(v\left(3n\left(4v-\alpha\right)+5a\beta\right)-c\left(9nv+5a\beta\right)\right)^2/\left(8nv\left(9nv+5a\beta\right)^2\right)$	$v\left(9n^2\alpha^2+2an\left(2v+5\alpha\right)\beta+5a^2\beta^2\right)/\left(4n\beta\left(9nv+5a\beta\right)\right)$ $-c\left(2v\left(n\alpha+a\beta\right)-c\left(nv+a\beta\right)\right)/\left(4nv\beta\right)$
		No	$a\left(v-cn\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-cn\right)^2/\left(4nv\right)$
	No	Yes	$a\left(v-c\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-c\right)^2/\left(4nv\right)$
		No	$a\left(v-cn\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-cn\right)^2/\left(4nv\right)$
$n > v/c$	Yes	Yes	$a\left(v\left(3n\left(4v-\alpha\right)+5a\beta\right)-c\left(9nv+5a\beta\right)\right)^2/\left(8nv\left(9nv+5a\beta\right)^2\right)$	$v\left(9n^2\alpha^2+2an\left(2v+5\alpha\right)\beta+5a^2\beta^2\right)/\left(4n\beta\left(9nv+5a\beta\right)\right)$ $-c\left(2v\left(n\alpha+a\beta\right)-c\left(nv+a\beta\right)\right)/\left(4nv\beta\right)$
		No	0	$\left(\alpha-c\right)^2/\left(4\beta\right)$
	No	Yes	$a\left(v-c\right)^2/\left(8nv\right)$	$\left(\alpha-c\right)^2/\left(4\beta\right)+a\left(v-c\right)^2/\left(4nv\right)$
		No	0	$\left(\alpha-c\right)^2/\left(4\beta\right)$

Fig. 1. Supply chain structure when the PI exists

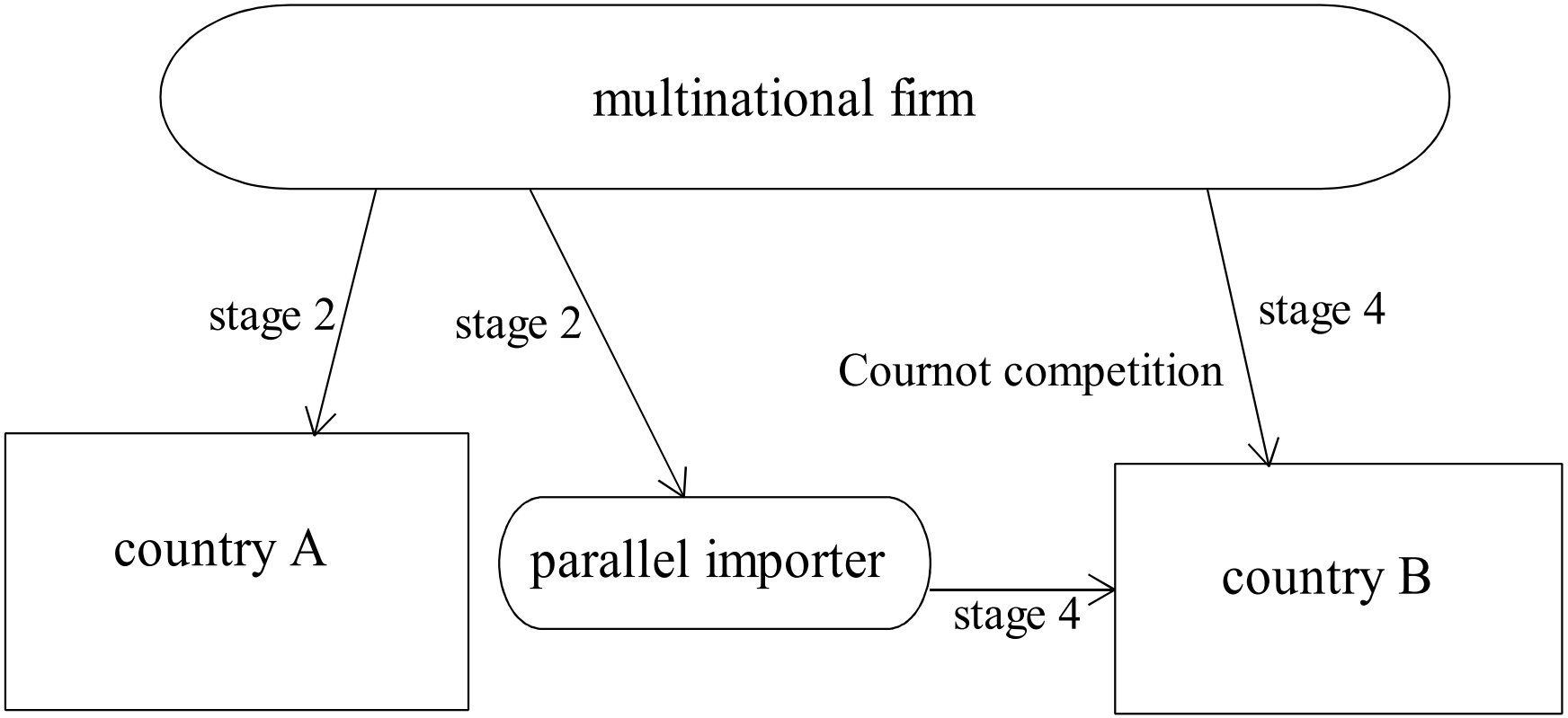


Fig. 2. Distribution of consumers in a segment

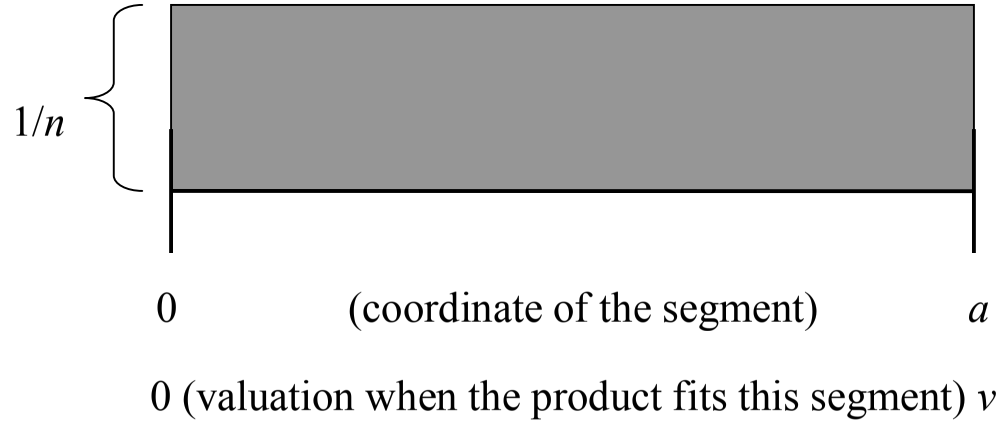


Fig. 3. Demand schedule changes according to the number of segments in the presence and in the absence of product information

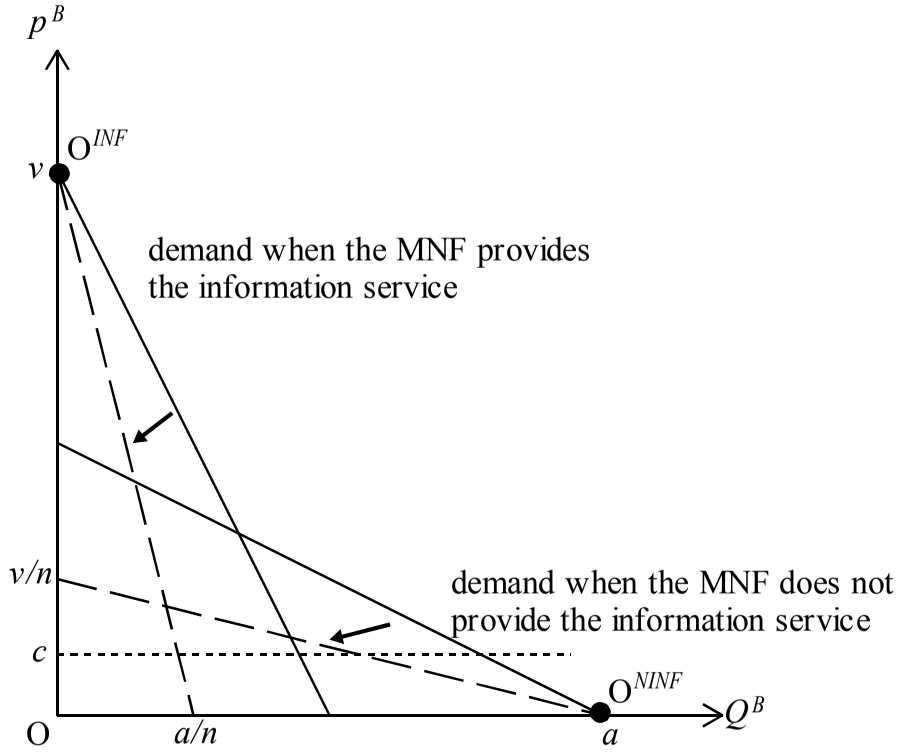
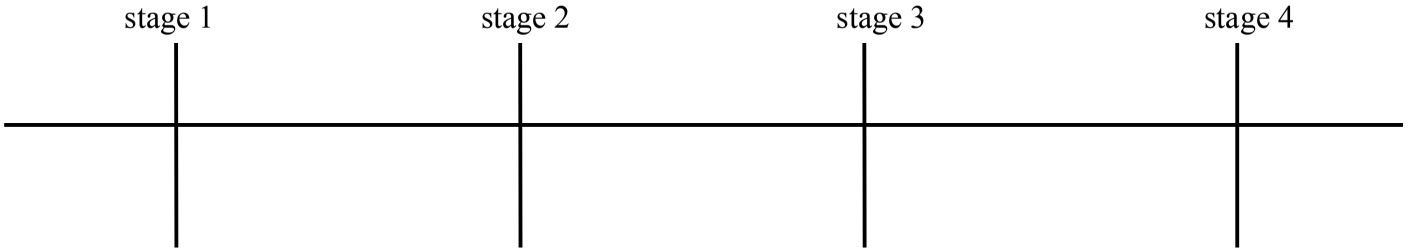


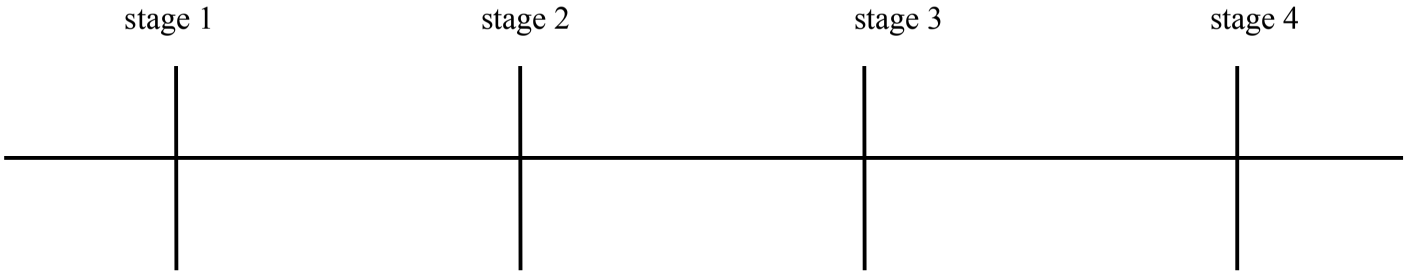
Fig. 4. Timeline of events

Panel A When the regulator in Country B prohibits parallel imports



Regulator in Country B prohibits parallel imports	MNF chooses selling quantity, Q^A, for consumers in country A	MNF determines whether it provides the information service or not in country B	MNF chooses selling quantity, q_{MNF}, for consumers in country B

Panel B When the regulator in Country B permits parallel imports



Regulator in Country B permits parallel imports	MNF chooses selling quantity, Q^A, for consumers and the PI in country A	MNF determines whether it provides the information service or not in country B	MNF and the PI are engaged in Cournot competition to sell the product for consumers in country B

Fig. 5. Demand schedules when consumers are minutely segmented