

Fragmentation, Welfare, and Imperfect Competition

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Abstract

In this paper, I explore the effect of fragmentation of production processes on social welfare in the imperfectly competitive market. In particular, I examine the welfare properties of fragmentation from the viewpoint of industrialized countries. Firms located at a country decide whether they produce at home or move their production overseas. I show that there exists Nash equilibrium in which all of the firms move production overseas although domestic production is socially desirable. This implies that reverse imports do not necessarily benefit the country. I also discuss the effectiveness of a subsidy for domestic production in improving the social welfare of the country.

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1 Introduction

In manufacturing industries, production processes that used to be integrated within nations have been disintegrated across countries. Firms in developed countries moved labor-intensive production stages to low-wage countries through foreign direct investment or outsourcing to subcontractors. As a result, the fragmentation of production processes leads to an increase in the so-called reverse imports: goods produced at overseas affiliates or subcontractors are exported back to developed countries.¹ A rise in reverse imports affects the labor markets in developed as well as developing nations. One of recent debates on globalization is concerned about the impact of fragmentation on income distribution within countries. The recent work on international trade examines this issue by using the general equilibrium models that are useful to investigate the distributional effect of fragmentation of production processes.²

In addition to its distributional effect, the impact of reverse imports on social welfare is important in the evaluation of the economic aspect of globalization. If a firm decides to move some of its production stages overseas, it must be profitable for the firm to do so. However, the firm's private decision on its production location would not necessarily benefit an economy as a whole. In particular, it is important to examine this issue for developed countries since it is often pointed out that globalization hurts workers in industrialized nations and thus governments should restrict international capital movement and international trade in goods. If firms in a developed country choose to disintegrate production processes across countries, what is its consequence in terms of the social welfare of the country? If fragmentation is not desirable for the country as a whole, is it justified for government to intervene in the firms' choice of production locations?

In this paper, I develop a simple model with imperfect competition to investigate these

¹For instance, over the past decade, there was a significant increase in the number of overseas affiliates of Japanese companies in the East Asian region. In addition, during this period, there was a noticeable increase in the reverse imports of manufactured goods. "Furthermore, looking at the share of exports to Japan in extra-regional exports in the Asian region, there is a noticeable increase in the rates of exports to Japan for all industries except iron and steel, which shows the expanding tendency of the so-called reverse imports (Ministry of Economy, Trade, and Industry (page 140, 2003))."

²See Feenstra (1998) and Jones (2000) for the recent development in the work on this topic.

questions. Firms locate their headquarters in a country and decide whether to produce at home or to move production overseas by FDI or outsourcing. Fragmentation provides savings in production costs for firms, but they must incur an additional fixed cost to coordinate the activities of foreign production. In addition to this tradeoff, firms have to incur transport costs to ship their products to the home market if they produce overseas. In this setting, the firms' optimal choice of production locations results in an undesirable outcome for the country as a whole. In fact, I show that two types of Nash equilibria exist. First, fragmentation is socially desirable but firms choose to integrate their production at home. Second, firms choose fragmentation but domestic production is desirable from the social viewpoint of the country. The latter result implies that reverse imports do not necessarily benefit the country. These results may also provide a rationale for government to intervene in the firms' choice of production locations. I discuss the effectiveness of a subsidy for domestic production in improving the social welfare of the country.

This paper is closely related to Jones and Kierzkowski (1990) and Jones (2000). They develop a simple model to show that a key to fragmentation of production processes is a reduction in communication costs. Fragmentation provides savings in production costs but it requires an additional cost to coordinate overseas production activities. The development of communication technology is a driving force for fragmentation since it significantly reduces costs to coordinate and/or monitor foreign production activities. In addition, Harris (1995) points out that communication costs are fixed costs rather than variable costs for firms. This paper incorporates the idea into a model in which firms strategically choose the location of production.

There is a recent work on strategic outsourcing and/or foreign direct investment.³ Chen, Ishikawa, and Yu (2003) focus on a domestic firm's choice of purchasing an intermediate input from a foreign firm that is the domestic firm's rival in the final good market. They show that the outsourcing has a collusive effect that could raise the prices of both intermediate and final goods. Ekholm, Forslid, and Markusen (2003) point out the importance of export-platform foreign direct

³ Another approach to outsourcing and/or foreign direct investment is based on the theory of firms. It emphasizes the role of transaction costs and incomplete contracts. For example, see McLaren (2000), Grossman and Helpman (2002), and Antras (2003) among others.

investment. They show that firms in the north make FDI in the south to export their outputs to third countries rather than export back to their home countries. This paper complements the existing work in that it examines the welfare properties of the fragmentation of production processes.⁴

The rest of this paper is organized as follows. In Section 2, I develop a monopoly model. This is a benchmark case that is useful to show the main idea of fragmentation. In Section 3, I extend the benchmark model to a duopoly setting in which firms strategically choose the location of production. I show that the firms' equilibrium choice of production locations does not necessarily lead to a desirable outcome for the country as a whole. In Section 4, I examine policy implications. In particular, I analyze whether a subsidy scheme for domestic production is effective or not in improving the social welfare of the country. In Section 5, I close this paper with concluding remarks.

2 A Benchmark Model

In this section, we examine the monopolist's optimal choice of its production location. The monopoly model is useful to introduce the basic idea of fragmentation of a production process. It is also a benchmark case with which we shall compare the duopoly setting. The comparison is useful to clarify the role of strategic interactions between firms in the choice of production locations.

Let us consider an economy with two countries, Home and Foreign. There is an industry in which a monopolist produces a product, X . The monopolist locates headquarters at Home, but it can choose the location of its production. Whether it produces X at Home or at Foreign depends on many factors, such as production costs, transport costs, and government policies. Here, we focus on one aspect: a difference in production costs. If labor costs at Foreign are lower than those at Home, the monopolist may want to move its production to Foreign by FDI

⁴Ishikawa and Komoriya (2004) examine the effects of the outsourcing on the labor markets in a model with cost heterogeneity of firms.

or outsourcing.⁵ However, it would incur additional costs to coordinate production activities at Foreign. Therefore, there is a tradeoff between low labor costs and high coordination costs. To model this trade-off, let us consider the following cost function.

$$\begin{aligned} C(x) &= cx && \text{if } X \text{ is produced at Home,} \\ &= c^*x + f && \text{if } X \text{ is produced at Foreign,} \end{aligned}$$

where c (c^*) ($c, c^* > 0$) represents marginal production costs at Home (Foreign) and f ($f > 0$) denotes constant fixed costs. We assume that $c > c^*$ holds. This implies that production costs at Home could be lower than those at Foreign due to a difference in variable costs. Foreign production requires additional fixed costs f that represent coordination costs.

Now, we turn to the demand side. Suppose that product X is consumed only at Home. Thus, if its production moves to Foreign, all of the outputs are exported back to Home. Preferences are quasi-linear and the demand for X is represented by a linear demand function,

$$p = a - bD, \quad a, b > 0$$

where p is the price of good X and D is its quantity of demand.

Given the demand and cost functions, we can derive the profit of the monopolist. If it produces X at Home, the profit is represented as follows.

$$\pi = px - cx$$

If the monopolist chooses to produce X at Foreign, it has to incur transport costs as well as coordination costs. We assume that the monopolist incurs transport costs t (> 0) to ship one

⁵It is an important issue to examine whether firms choose outsourcing or FDI. In this paper, I focus on the firms' choice of production locations, and thus, I abstain from investigating the firms' choice of organizational structures.

unit of X from Foreign to Home. The profit obtained from Foreign production is given as follows,

$$\pi = px - (c^* + t)x - f,$$

where t (> 0) denotes transports costs. We can solve the profit maximization problem backward. For each production location, we derive the optimal output and the market price for the given parameters. Then, a variable profit for the monopolist is obtained as a function of the marginal costs.⁶

$$\Pi(s) = \frac{(a - s)^2}{4b}$$

If X is produced at Home, the profit for the monopolist is $\pi = \Pi(c)$. If it chooses to produce X at Foreign, its profit is $\pi = \Pi(c^* + t) - f$. Clearly, $\Pi(c)$ is strictly smaller than $\Pi(c^* + t)$ if the transport cost, t , is strictly smaller than a cost difference, $c - c^*$. We assume that this condition, $t < c - c^*$, is met so that the monopolist could choose to produce at Foreign. Under this condition, there is a critical value of t , which satisfies the following condition.

$$\Pi(c) = \Pi(c^* + \bar{t}_\pi) - f$$

If t is greater than $\bar{t}_\pi$, then the monopolist produces X at Home. Thus, the production process of X is integrated at Home. If t is smaller than or equal to $\bar{t}_\pi$, then the monopolist moves its production to Foreign, and the fragmentation of the production process takes place. This result is stated formally in the following lemma.

Lemma 1 *Suppose that f satisfies a condition, $\Pi(c^* + t) - f > 0$. Then, there exists a critical value of t that meets a condition, $\Pi(c) = \Pi(c^* + \bar{t}_\pi) - f$. The monopolist produces X at Home if $t > \bar{t}_\pi$. It moves its production to Foreign if $t \leq \bar{t}_\pi$.*

Now we turn to the evaluation of the impact of a production regime change on the social

⁶The equilibrium output is derived as follows, $x(s) = (a - s)/2b$. Substituting it into the profit, we can obtain the equilibrium profit, $\Pi(s) = bx(s)^2$.

welfare of Home. Foreign production clearly benefits Home consumers due to a fall in the price of X . At the same time, Home must incur additional fixed costs f . Thus, whether fragmentation benefits Home or not depends on the relative size of these two effects. If the production process is integrated at Home, the social welfare of Home is represented as follows.

$$W = \int_0^x (a - bz)dz - cx$$

Using the equilibrium output, we can obtain the welfare as a function of marginal costs.

$$W(c) = \frac{3(a - c)^2}{8b}$$

If the production of X moves to Foreign, then the welfare of Home has the following functional form.

$$W(c^* + t) - f$$

Since $W(c)$ is monotonically decreasing with c , $W(c)$ is strictly smaller than $W(c^* + t)$. Thus, there is a critical value of t , which meets a condition.

$$W(c) = W(c^* + \bar{t}_w) - f$$

If t is smaller than $\bar{t}_w$, then social surplus obtained from Foreign production is higher than that from Home production. If t is greater than $\bar{t}_w$, overseas production is preferred to domestic production in terms of Home welfare.

Lemma 2 *Suppose that f satisfies a condition, $\Pi(c^* + t) - f > 0$. Then, there exists a critical value of t , which satisfies a condition $W(c) = W(c^* + \bar{t}_w) - f$. If $t > \bar{t}_w$, then domestic production is socially more desirable than overseas production. If $t \leq \bar{t}_w$, then foreign production gives the same or higher level of welfare as compared to home production.*

A comparison of Lemma 1 with Lemma 2 suggests that $\bar{t}_\pi$ is not equivalent to $\bar{t}_w$. Thus,

there is a possibility that a private decision by the monopolist may lead to a socially undesirable outcome. The following proposition shows that domestic production is chosen by the monopolist even if foreign production is socially desirable.

Proposition 1 *The critical value of transport costs that determines the monopolist's decision of production location $\bar{t}_\pi$ is smaller than the critical value that determines the socially desirable location of production $\bar{t}_w$. Thus, if $t \in (\bar{t}_\pi, \bar{t}_w)$, then the monopolist chooses to produce X at Home, although foreign production is socially desirable.*

Proof: Using consumer surplus CS , we can rewrite $W(s)$ as $W(s) = CS(s) + \Pi(s)$. The critical value $\bar{t}_w$ satisfies the following condition.

$$CS(c) - CS(c^* + \bar{t}_w) = \Pi(c^* + \bar{t}_w) - f - \Pi(c)$$

The left hand side is negative since the market price is increasing with the marginal costs. Thus, we have the following inequality,

$$\Pi(c^* + \bar{t}_w) - f - \Pi(c) < 0$$

On the other hand, the critical value $\bar{t}_\pi$ meets the condition $\Pi(c^* + \bar{t}_\pi) - f = \Pi(c)$. Substituting this condition into the above equation, we have the inequality.

$$\Pi(c^* + \bar{t}_w) < \Pi(c^* + \bar{t}_\pi)$$

Since the variable profit is decreasing with the marginal costs, we have the desired result. Q.E.D.

The intuition for this result is straightforward. The foreign production benefits Home consumers since cost savings in production lead to the lower market price. The monopolist does not take into account this effect when it decides the location of its production. Thus, there is a range of transport costs, at which fragmentation is socially desirable, but it is more profitable for the monopolist to integrate the production process domestically.

3 Strategic Fragmentation

Now let us extend the previous model to a setting with two Home firms. Firms produce homogeneous goods and have identical cost structures. In the first stage, they simultaneously determine the location of production. In the second stage, they choose their outputs in Cournot fashion. Using this extended model, we examine strategic interactions between firms in the choice of production locations.

Solving the firm's problem backward, we can show that the profit of each firm is represented as a function of marginal costs. Using the profit functions, we can show the payoff matrix as follows.

	I	F
I	$\Pi(c, c), \Pi(c, c)$	$\Pi(c, c^* + t), \Pi(c^* + t, c) - f$
F	$\Pi(c^* + t, c) - f, \Pi(c, c^* + t)$	$\Pi(c^* + t, c^* + t) - f, \Pi(c^* + t, c^* + t) - f$

I denotes integration and F denotes fragmentation. Given the rival chooses integration, the firm prefers F to I if the following inequality holds,

$$\Pi(c^* + t, c) - f > \Pi(c, c).$$

Since the profit is decreasing with its own marginal costs, fragmentation raises the variable profit, $\Pi(c^* + t, c) > \Pi(c, c)$. This increase in variable profits is greater as the smaller the transport cost is. In addition, the overall gain from fragmentation depends on the size of fixed costs to coordinate foreign production activities. If the fixed costs are extremely large, fragmentation would not be the best response to the rival's strategy. These observations suggest that the firm's best strategy crucially depends on transport costs and fixed costs. Suppose that $\Delta\Pi_{FI}$ denotes an increase in the variable profit by switching to F from I when the rival chooses I ,

$$\Delta\Pi_{FI}(t) = \Pi(c^* + t, c) - \Pi(c, c).$$

If $\Delta\Pi_{FI}(t) > f$ holds, then it is optimal for the firm to choose fragmentation given the rival's choice of integration. In a similar way, $\Delta\Pi_{FF}$ denotes an increase in variable profits by switching to F from I when the rival chooses fragmentation.

$$\Delta\Pi_{FF}(t) = \Pi(c^* + t, c^* + t) - \Pi(c, c^* + t)$$

If $\Delta\Pi_{FF}(t) > f$ is satisfied, then the firm prefers fragmentation to integration given the rival's choice of fragmentation.

Figure 1 shows the Nash equilibrium of the firms' locational choice. Since a reduction in transport costs makes fragmentation more profitable, $\Delta\Pi_{FI}(t)$ is shown by downward sloping curve EI . The same logic applies to the slope of $\Delta\Pi_{FF}(t)$, and it is shown by downward sloping line EH . Notice that $\Delta\Pi_{FI}(t)$ is greater than $\Delta\Pi_{FF}(t)$ for any transport costs except $c - c^*$. This suggests that it is more profitable to switch to F from I if the rival still chooses integration than if it already chooses overseas production.⁷ Suppose that the fixed cost is greater than OI . Then, it is never profitable for any firms to produce X overseas. Thus, both firms would choose integration at Nash equilibrium. If the fixed cost is smaller than OI , then firms' optimal strategies depend on transport costs as well as fixed costs.

Suppose that the fixed cost is given by OF . If the transport cost is high enough and thus t is in segment CE , then it is optimal for both firms to choose integration. As transport costs decline, it is more profitable for one firm to switch to fragmentation. There is a range of transport costs in which asymmetric Nash equilibrium appears. If t is in segment BC , then one firm optimally chooses fragmentation given the other firm choosing integration. Thus, at this range, (F, I) or (I, F) is Nash equilibrium. If the transport cost is small enough, and as a result, t is smaller than OB , then both firms optimally choose fragmentation at equilibrium.

Lemma 3 *Suppose that the transport cost t is smaller than a cost difference $c - c^*$. The Nash equilibrium choices of firms' production locations depend on transport costs t and fixed coordina-*

⁷See Appendix A for the proof.

tion costs f .

1. If (t, f) is above downward sloping curve EI in Figure 1, then both firms optimally choose to produce X at Home.
2. If (t, f) is within area EHI in Figure 1, then one firm chooses to move the production of X overseas and the other firm chooses to integrate the production of X at Home.
3. If (t, f) is below downward sloping curve EH in Figure 1, then both firms choose fragmentation and produce X overseas.

Proof: See Appendix A.

The Welfare Properties of Strategic Fragmentation

In this section, we shall evaluate the welfare properties of Nash equilibrium of firms' locational choice. In the monopoly case, the monopolist chooses domestic production even though fragmentation is socially desirable from the viewpoint of Home. The similar result is obtained in the duopoly model since firms do not take into account the positive effect of fragmentation on consumer surplus. In addition, a new result appears in the duopoly model. All of the firms choose fragmentation even though domestic production is still desirable from the social viewpoint of Home. This result is caused by strategic interactions between firms, and thus, it is not derived in the monopoly model.

It is possible to derive the social welfare of Home as a function of marginal costs. If firms choose to integrate the production process at Home, then the welfare of Home is given by

$$W(c, c) = CS(c, c) + 2\Pi(c, c),$$

where CS denotes the consumer surplus of Home. Similarly, if one firm chooses fragmentation

and the other still produces at Home, then the social welfare of Home is represented by

$$W(c^* + t, c) - f,$$

where $W(c^* + t, c) = CS(c^* + t, c) + \Pi(c^* + t, c) + \Pi(c, c^* + t)$. Notice that $W(c^* + t, c) = W(c, c^* + t)$ holds due to the symmetry of firms. If both firms choose fragmentation, then the social welfare of Home is given as follows,

$$W(c^* + t, c^* + t) - 2f.$$

A change in Home welfare caused by fragmentation crucially depends on transport costs and coordination costs. Let $\Delta W_{FI}(t)$ denote a change in the sum of consumer surplus and industry variable-profits. Subscripts FI mean that only one firm switch to fragmentation from integration given the rival choosing integration.

$$\Delta W_{FI}(t) = W(c^* + t, c) - W(c, c)$$

If $\Delta W_{FI}(t) > f$, then the fragmentation raises the social welfare of Home. In a similar way, if the firm switches to fragmentation given the rival's choice of fragmentation, a change in W is given by

$$\Delta W_{FF}(t) = W(c^* + t, c^* + t) - W(c^* + t, c).$$

The fragmentation benefits Home if $\Delta W_{FF}(t) > f$.

Figure 2 shows a change in Home welfare caused by fragmentation. $\Delta W_{FI}(t)$ is drawn as downward sloping curve EJ , and $\Delta W_{FF}(t)$ is shown by downward sloping curve EG . This graph suggests that fragmentation raises the sum of consumer surplus and industry variable-profits, W . Since fragmentation reduces marginal production costs, consumer surplus increases due to a fall in the market price. It is ambiguous whether industry variable-profits increase or not because of a reduction in the profit of the firm that does not change its location of production. The overall effect of fragmentation on the welfare of Home is proved to be positive. Observe that $\Delta W_{FF}(t)$

is uniformly smaller than $\Delta W_{FI}(t)$. This implies that net gains from fragmentation is higher if the production regime switches to (F, I) from (I, I) than if it changes to (F, F) from (F, I) .⁸

Figure 2 also shows that firms' optimal choice of production locations is not necessarily best from the viewpoint of the social welfare of Home. Observe that $\Delta W_{FI}(t)$ is located uniformly above $\Delta \Pi_{FI}(t)$. This suggests that gains from fragmentation for Home as a whole are larger than those for the firm switching to fragmentation from integration. As a result, firms could optimally choose to produce at Home even though fragmentation is socially desirable. Suppose that the fixed cost is given by OF . If the transport cost is in segment CD , then this outcome is obtained. The intuition for this result is similar to that obtained in the monopoly model. Firms do not take into account the positive effect of fragmentation on consumer surplus.⁹

A different story is obtained if all of the firms move production overseas. If the production regime switches to (F, F) from (F, I) , then overall gains from fragmentation for Home are smaller than those for the firm switching to fragmentation from domestic production. This is shown by the observation that $\Delta W_{FF}(t)$ is uniformly located below $\Delta \Pi_{FF}(t)$. As a consequence, all of the firms could optimally choose fragmentation even though the production regime is not desirable in terms of the social welfare of Home. If the fixed cost is given by OF and the transport cost is in segment AB , then this undesirable outcome is obtained. That is, the socially best production regime for Home is (F, I) , but all of the firms choose fragmentation at Nash equilibrium.

This result is closely related to strategic interactions between firms. In the Cournot setting, the firm switching to fragmentation always gains at the expense of the rival. The reduction in the rival's profit has a negative impact on the social welfare of Home. However, the firm switching

⁸A switch in the production regime from (F, I) to (F, F) provides the higher rise in consumer surplus than that from (I, I) to (F, I) because a reduction in the price is greater at the larger output level in the former than in the latter. On the other hand, the negative effect of fragmentation on the profit of the firm that does not change its production location is greater if the production regime shifts from (F, I) to (F, F) than if it does from (I, I) to (F, I) . Since the effects of industry variable-profits are larger than those of consumer surplus, $\Delta W_{FI}(t)$ is larger than $\Delta W_{FF}(t)$. See Appendix B for the details of these statements.

⁹This fragmentation has three different effects on the social welfare of Home: a positive effect on consumer surplus, a positive effect on the profit of the firm switching to fragmentation, and a negative effect on the profit of the firm choosing integration. The sum of the positive effect on consumer surplus and the negative effect on the profit of the firm choosing integration is positive. This net positive effect makes ΔW_{FI} greater than $\Delta \Pi_{FI}$, and it is not taken into account by the firm in its decision of switching to fragmentation.

to fragmentation from integration does not take into account this negative effect on the rival's profit. This external effect does not exist at the monopoly model since there is no strategic interaction between firms. Therefore, this result is obtained only in the duopoly model. The strategic effect on the rival's profit is a cause for the outcome in which the socially undesirable production regime is chosen by firms at Nash equilibrium.¹⁰

Proposition 2 *There exists Nash equilibrium, in which all of the firms choose fragmentation but the equilibrium choice of the production regime is not desirable in terms of the social welfare of Home.*

Proof: See Appendix B.

This result implies that reverse imports do not necessarily benefit Home. Suppose that the fixed cost is given by OF and the transport cost is in segment BC in Figure 2. Then, at equilibrium, one firm chooses fragmentation and the other produces at Home. The equilibrium is socially desirable in the viewpoint of Home. If the transport cost falls to some point in segment AB , then all of the firms would move production overseas at new equilibrium. As a result, there is an increase in reverse imports to Home. This change in the volume of imports does not benefit Home since the production regime (F, I) is still more desirable for Home than (F, F) at that range of transport costs.

4 Policy Implications

The result obtained in the previous section suggests that the government of Home should use subsidy-tax policies to induce the firms to choose the socially ideal location of production. There are some policy options. It is beyond the scope of this paper to examine all of them. Thus, let us examine the simplest policy scheme: lump-sum subsidies and taxes.

¹⁰A change in the production regime from (F, I) to (F, F) has three effects on the welfare of Home. In contrast to the regime switch from (I, I) to (F, I) , the positive effect on consumer surplus is smaller in absolute values than the negative effect on the profit of the firm already choosing fragmentation. This net negative effect on the welfare makes ΔW_{FF} smaller than $\Delta \Pi_{FF}$, and it is not taken into account by the firm switching to fragmentation.

Suppose that the government of Home provides a lump-sum subsidy for the firm if it chooses to produce X at Home. The size of the subsidy is predetermined or exogenous and it is given by m . Then, the firm has to incur opportunity costs of losing the subsidy as well as the fixed coordination costs if it moves its production overseas. Given the rival's choice of the production location, the firm gains from fragmentation if

$$\Pi(c^* + t, s') - \Pi(c, s') > f + m$$

where $s' = c, c^* + t$. Figure 3 shows the effects of the lump-sum subsidy on the firms' choice of production locations. The size of the subsidy is shown by FF' , which is an additional cost for the firm to choose fragmentation. As a result of the subsidy, the segment of transport costs in which all of the firms choose fragmentation shrinks to OB' . Since it is financed by a lump-sum tax, the subsidy does not affect the size of fixed costs which must be incurred by the society of Home. Thus, there is no change in the critical values of transport costs such as A and D .

These results imply that the subsidy reduces the possibility of the outcome in which all of the firms choose fragmentation but the production regime is not desirable in terms of the social welfare of Home. The segment of transport costs in which this undesirable outcome is obtained is shown by AB before the subsidy for domestic production is introduced. After the subsidy scheme is implemented at Home, the segment shrinks to AB' . The subsidy scheme might be effective to prevent the firms from choosing socially undesirable fragmentation.

Nonetheless, the subsidy for domestic production is not necessarily welfare improving. If the transport cost is in segment $C'D$, fragmentation by one firm is socially desirable, but all of the firms choose to produce at Home. In fact, the possibility of this outcome being obtained is raised by the implementation of the production subsidy. For instance, suppose that transport cost is in segment CC' . If the subsidy is not implemented, one firm would choose fragmentation and the consequent regime of production is socially desirable. The subsidy distorts the choice of the firm, and as a result, all of the firms produce at Home. Clearly, this production regime is socially

undesirable.

5 Concluding Remarks

In this paper, I examine the welfare properties of fragmentation of a production process in the imperfectly competitive market. The firm's optimal choice of production locations does not necessarily result in the best outcome for the economy as a whole. In the monopoly setting, the firm does not take into account the positive effect of fragmentation on consumer surplus, and as a result, the firm chooses to integrate its production process at Home despite the desirability of overseas production in terms of the social welfare of Home. In the duopoly setting, the firm gains from fragmentation at the expense of the rival. The negative impact of fragmentation on the domestic rivals's profit reduces the social welfare of Home, but its effect is not taken into account by the firm in choosing to move production overseas. As a result, there is Nash equilibrium in which all of the firms choose fragmentation but the equilibrium outcome is not desirable from the social viewpoint of Home. This result also implies that an increase in reverse imports due to the fragmentation does not necessarily raise the welfare of Home.

These results would provide a rationale for government to intervene in the firm's private choice of production locations. In the duopoly setting, the government of Home can use the lump-sum subsidy for domestic production to achieve the socially desirable equilibrium outcome. On the other hand, the subsidy may induce all of the firms to produce at Home despite the social desirability of fragmentation by one firm. This can be caused by the policy maker's lack of information about the firms' cost structures. In this sense, policymakers should be cautious about intervening in the firm's choice of production locations.

In this paper, I focus on strategic interactions between firms that locate their headquarters in the same country. In addition, firms compete only in their home market, and thus, all of the outputs produced overseas are exported back to the home market. Empirical evidences suggest that firms in developed nations move their production to low-wage countries and export the

outputs produced there to other developed countries as well as their home countries. For the investigation of this aspect, we need to develop a model in which firms locating headquarters in different countries choose whether to produce at their home nations or to move production to low-wage countries. In this situation, governments may want to intervene strategically in the firms' choice of production locations. It is a future research agenda to analyze strategic government policy for firms' locational choice.

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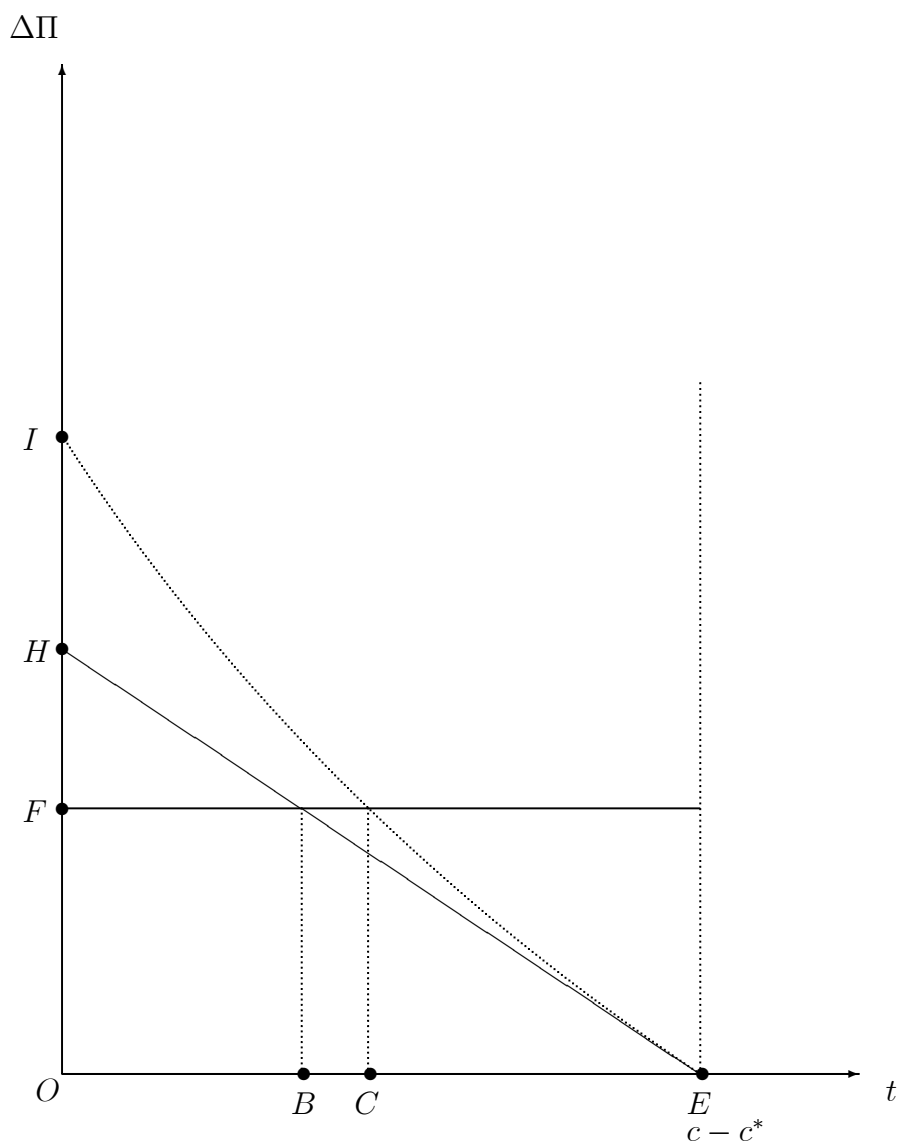


Figure 1: The effects of transport and coordination costs on the firms' locational choice

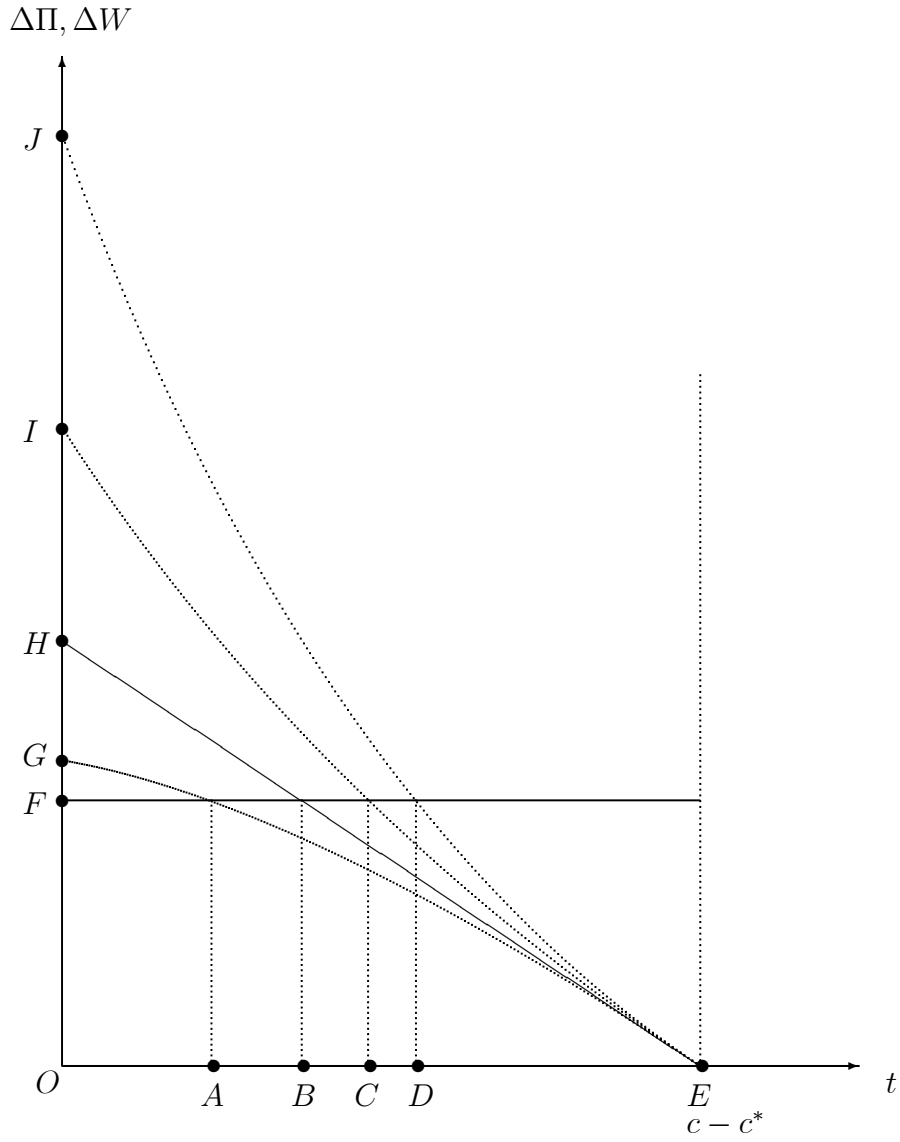


Figure 2: The effects of the firms' locational choice on the welfare of Home

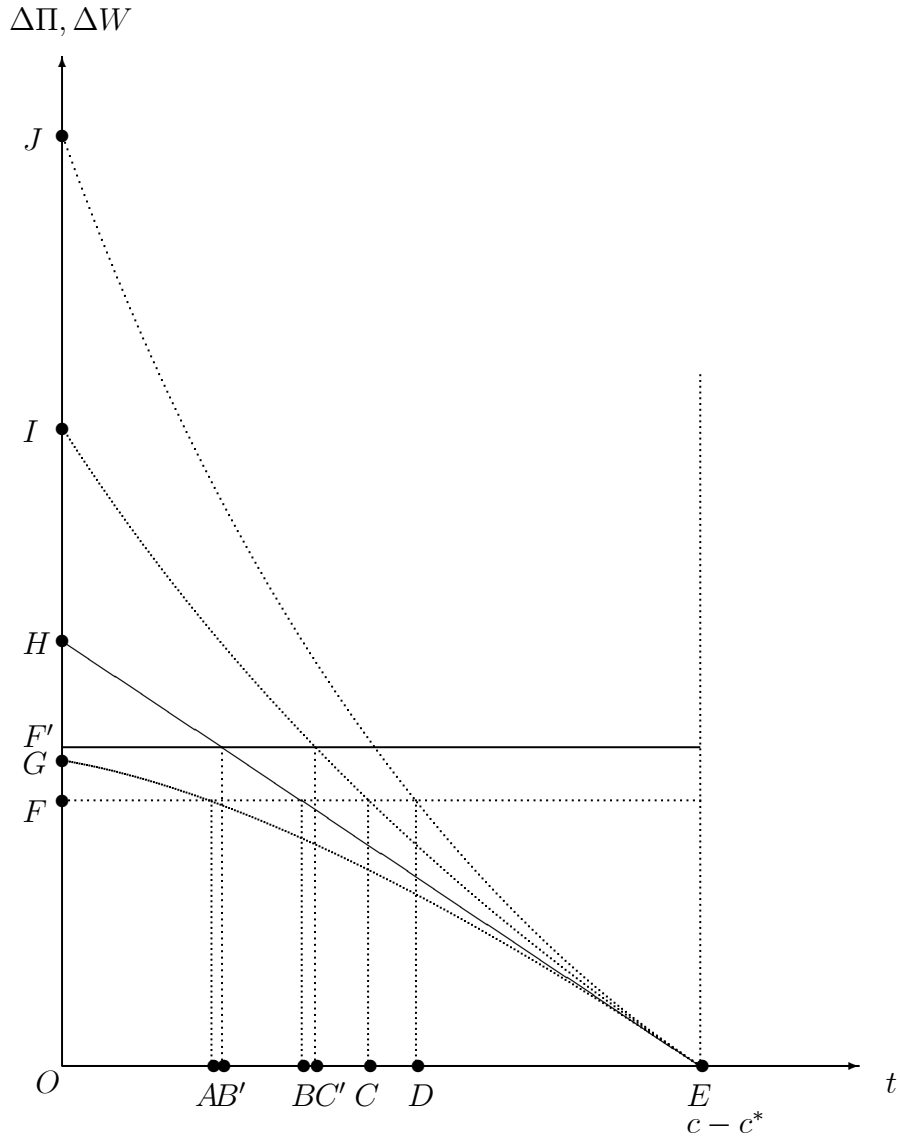


Figure 3: The effects of the lump-sum subsidies on the firms' locational choice

Appendix A: Proof of Lemma 3.

In this appendix, we shall show that $\Delta\Pi_{FI}(t) > \Delta\Pi_{FF}(t)$ if $t < c - c^*$. In the duopoly setting, the equilibrium outputs are derived as follows,

$$x(s, s') = \frac{1}{3b}\{2(a - s) - (a - s')\}$$

where $(s, s') \in \{(c, c), (c, c^* + t), (c^* + t, c), (c^* + t, c^* + t)\}$. Using the equilibrium outputs, the equilibrium variable profits are obtained as well.

$$\Pi(s, s') = bx(s, s')^2$$

Similarly, consumer surplus is calculated as a function of marginal costs,

$$CS(s, s') = \frac{1}{2b}[a - p(s, s')]^2,$$

where $p(s, s') = (a + s + s')/3$ is the equilibrium market price. The sum of consumer surplus and industry variable-profits is obtained as W ,

$$W(s, s') = CS(s, s') + \Pi(s, s') + \Pi(s', s).$$

In order to show that $\Delta\Pi_{FI}(t) \geq \Delta\Pi_{FF}(t)$, it is useful to calculate their partial derivatives with respect to t .

$$\begin{aligned}\Delta\Pi_{FI}(t)' &= -\frac{4}{3}x(c^* + t, c) < 0, \\ \Delta\Pi_{FF}(t)' &= -\frac{4}{3}x(c, c) < 0.\end{aligned}$$

It is easy to show that $|\Delta\Pi_{FI}(t)'| \geq |\Delta\Pi_{FF}(t)'|$ and $|\Delta\Pi_{FI}(c - c^*)'| = |\Delta\Pi_{FF}(c - c^*)'|$. Notice

that $|\Delta\Pi_{FI}(c - c^*)| = |\Delta\Pi_{FF}(c - c^*)|$ holds. These results imply that $\Delta\Pi_{FI}(t) \geq \Delta\Pi_{FF}(t)$ if $t \leq c - c^*$. Thus, downward sloping curve EI ($\Delta\Pi_{FI}(t)$) is uniformly located above downward sloping line EH ($\Delta\Pi_{FF}(t)$) in Figure 1 and 2.

Appendix B: Proof of Proposition 2.

In this appendix, we shall show that $\Delta W_{FI}(t) > \Delta\Pi_{FI}(t) > \Delta\Pi_{FF}(t) > \Delta W_{FF}(t)$ if $t < c - c^*$. Before we proceed to examine the effect of fragmentation on the social welfare, we need to calculate the partial derivatives of ΔCS ,

$$\begin{aligned}\Delta CS_{FI}(t)' &= -\frac{1}{3}[x(c^* + t, c) + x(c, c^* + t)] < 0, \\ \Delta CS_{FF}(t)' &= -\frac{4}{3}x(c^* + t, c^* + t) - \Delta CS_{FI}(t)' < 0.\end{aligned}$$

We can easily confirm that $|\Delta CS_{FF}(t)'| - |\Delta CS_{FI}(t)'| = [x(c^* + t, c^* + t) - x(c, c)]/3 > 0$. This suggests that fragmentation provides the larger benefits for consumers if the production regime changes to (F, F) from (F, I) than if it switches to (F, I) from (I, I) .

In a similar way, we can derive a change in the profit of the other firm. Let $\Delta\tilde{\Pi}_{FI}(t)$ denote a change in the variable profit of the firm choosing integration if its rival switches to F from I .

$$\Delta\tilde{\Pi}_{FI}(t) = \Pi(c, c^* + t) - \Pi(c, c)$$

In a similar way, $\Delta\tilde{\Pi}_{FF}(t)$ is a change in the variable profit of the firm that chooses fragmentation when its rival switches to F from I .

$$\Delta\tilde{\Pi}_{FF}(t) = \Pi(c^* + t, c^* + t) - \Pi(c^* + t, c)$$

Taking the partial derivative of $\Delta\tilde{\Pi}$ with respect to t , we can obtain

$$\begin{aligned}\Delta\tilde{\Pi}_{FI}(t)' &= \frac{2}{3}x(c, c^* + t) > 0, \\ \Delta\tilde{\Pi}_{FF}(t)' &= \frac{2}{3}[2x(c^* + t, c) - x(c^* + t, c^* + t)] > 0.\end{aligned}$$

A comparison between $\Delta\tilde{\Pi}_{FI}(t)'$ and $\Delta\tilde{\Pi}_{FF}(t)'$ leads to $\Delta\tilde{\Pi}_{FI}(t)' < \Delta\tilde{\Pi}_{FF}(t)'$. This implies that a loss for the firm caused by the rival's choice of F is greater if the firm chooses fragmentation than if it chooses integration.

Now it is ready to examine a change in the social welfare in response to a shift in the production regime. ΔW can be decomposed into three elements, $\Delta W = \Delta CS + \Delta\Pi + \Delta\tilde{\Pi}$. Taking the partial derivative of ΔW with respect to t , we have

$$\begin{aligned}\Delta W_{FI}(t)' &= \Delta CS_{FI}(t)' + \Delta\Pi_{FI}(t)' + \Delta\tilde{\Pi}_{FI}(t)', \\ &= -\frac{1}{3}[x(c^* + t, c) - x(c, c^* + t)] + \Delta\Pi_{FI}(t)' < 0.\end{aligned}$$

The second equation leads to $|\Delta W_{FI}(t)'| > |\Delta\Pi_{FI}(t)'|$ and $|\Delta W_{FI}(c - c^*)'| = |\Delta\Pi_{FI}(c - c^*)'|$. This result implies that downward sloping curve EJ ($\Delta W_{FI}(t)$) is uniformly located above downward sloping curve EI ($\Delta\Pi_{FI}(t)$) in Figure 2. In a similar way, we can derive the partial derivative of ΔW_{FF} with respect to t .

$$\begin{aligned}\Delta W_{FF}(t)' &= \Delta CS_{FF}(t)' + \Delta\Pi_{FF}(t)' + \Delta\tilde{\Pi}_{FF}(t)', \\ &= \frac{1}{3}[x(c^* + t, c^* + t) - x(c, c)] + \Delta\Pi_{FF}(t)'.\end{aligned}$$

A simple calculation leads to $\Delta W_{FF}(t)' = -[x(c, c^* + t) + x(c, c)]/3 < 0$. It is also easy to check that $|\Delta W_{FF}(t)'| < |\Delta\Pi_{FF}(t)'|$ and $|\Delta W_{FF}(c - c^*)'| = |\Delta\Pi_{FF}(c - c^*)'|$. These results imply that downward sloping line EH ($\Delta\Pi_{FF}(t)$) is uniformly located above downward sloping curve EG ($\Delta W_{FF}(t)$) in Figure 2.

Combining these results with those obtained in Appendix A, we can easily show that $\Delta W_{FI}(t) >$

$$\Delta\Pi_{FI}(t) > \Delta\Pi_{FF}(t) > \Delta W_{FF}(t) \text{ if } t < c - c^*.$$