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Abstract

The type of marginal cost faced by a firm is important when considering the firm's export behavior. However, in the literature, it is frequently assumed that firms have constant marginal costs. By contrast, this paper considers the case in which a firm's marginal cost is increasing, and the firm pays a fixed cost when it exports. We show that an asymmetric trade pattern, whereby one country exports but the other does not, appears in a symmetric two-country two-firm setting. We also show that trade liberalization produces a non-monotonic change in welfare because of reduced transport costs.

Key words: Increasing marginal cost; Fixed export cost; Transport cost; Trade pattern

JEL classification: F12; L13; D43

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1 Introduction

In a framework of oligopolistic intra-industry trade, that is, the Brander and Krugman (1983)-type two-way trade model, it is frequently assumed that firms have constant marginal costs. This assumption of "constant marginal cost" is significant in simplifying the analysis, and hence the results, of firms' behavior and the welfare consequences. However, by assuming constant marginal costs, a significant problem tends to be overlooked, namely the "realizing trade pattern". This is because, if oligopolistic firms can choose whether to export or not, the firms' cost structure affects the interaction between markets, which can markedly alter the realizing trade pattern.

In this paper, we consider a two-way oligopolistic trade model in which a fixed cost is necessary for a firm to export. We incorporate Melitz (2003)-type firm options regarding "whether to export or not" into an oligopolistic competition scenario. Then, we consider what size transport and fixed export costs result in unilateral entry to the foreign market in response to the export decision or a bidirectional entry to the foreign market. In this environment, a firm's marginal cost has a key role. We assume that firms have increasing marginal costs. Based on this cost structure, we demonstrate that the following unprecedented trade pattern appears in the equilibrium state. [a] When the transport cost is large and the fixed export cost is small, *asymmetric equilibria in which only one country exports between two symmetric countries*, i.e., "One-way trade," can occur. [b] When the transport cost is small and the fixed export cost is large, *multiple equilibria involving "No trade" and "Two-way trade" between the two symmetric countries* can occur.

We built an oligopoly model of the Brander and Krugman (1983) type, consisting of two symmetric countries and two firms. Each firm has two options: export to the

foreign market and/or supply the local domestic market. If a firm exports, it pays not only transport costs but also a fixed export cost. The firm only supplies the domestic market if it does not export. Each firm has a quadratic cost function, and first chooses whether to export, and subsequently decides on quantities.[1] In this situation, two kinds of multiple equilibria appear when the transport cost and the fixed export cost are at intermediate levels. [a] When the transport cost is large and the fixed export cost is small, an asymmetric equilibrium in which only one country exports (i.e., "One-way trade") appears. There are positive and negative effects when firms export. The positive effect is "obtaining foreign market share" and the negative effect is "an increase in the marginal cost of domestic supply". When the rival firm chooses not to export, the positive effect is strong because the fixed export cost is small. Thus, each firm has an incentive to choose to export. When the rival firm chooses to export, the import barriers become higher and the positive effect becomes weaker. Thus, each firm no longer has an incentive to choose to export. When the rival firm does not export, the positive effect is dominant because each firm's local market is non-competitive and a new market can be enjoyed by choosing to export. Hence, each firm exports.

[b] When transport cost is small and the fixed export cost is large, multiple equilibria involving "No trade" and "Two-way trade" appear. When the rival firm exports, the low transport cost means that the positive effect is dominant, so each firm chooses to export. When the rival firm does not export, the large fixed export cost allows each firm to enjoy a local monopoly. In this case, the negative effect is relatively strong, and hence, each firm chooses not to export.[2]

[1] In the Discussion section, we consider both differentiated quantity and price competition.

[2] If the firms' marginal production costs are constant, multiple equilibria cannot appear because the

In addition, we show that trade liberalization with a reduction in the transport cost can significantly reduce consumer welfare. If the fixed export cost is relatively small, "One-way trade" can appear. In this situation, let us consider that trade liberalization proceeds. Then, the trade pattern can switch from "No trade" to "One-way trade." That is, because the equilibrium regime can switch from a "No one exports" regime to a regime in which "only the home country becomes an exporting country," the consumer surplus in the home country can drop sharply when the transport cost falls below a certain level.

We also show that trade liberalization can produce non-monotonic fluctuations in welfare. In general, in the Brander and Krugman (1983)-type model, welfare is U-shaped with respect to the transport cost. Hence, the area in which trade liberalization occurs suffers from reduced welfare. In contrast, changes in the trade pattern create gaps in welfare, and so trade liberalization may reduce welfare multiple times. Even if welfare rises following trade liberalization, practitioners should pay special attention to further trade liberalization.

Furthermore, we discuss how the mode of competition affects the trade pattern. In differentiated quantity competition, our main result does not alter. However, in differentiated price competition, because the rivalry among firms increases compared with quantity competition, the equilibrium trade pattern becomes a multiple equilibria of "No trade" and "Two-way trade."

The three main contributions of our paper to the literature are as follows: First, we determine the trade pattern between two symmetric countries based on firms' strategic exporting behavior. As a result, we show that all possible trade patterns can appear

strategic interactions between firms does not occur. Hence, trade patterns are "both countries export" or "both countries do not export."

according to the size of the transport and fixed export costs. This analysis presents new insights to the trade literature. Second, our study demonstrates that trade liberalization may reduce consumer welfare significantly. Therefore, competition authorities that value consumer welfare [e.g., the Federal Trade Commission (FTC) in the USA] should ensure that the governments of their countries pay attention to the effects of trade liberalization. Third, we show that each country should become a non-exporting country rather than an exporting country if the fixed export cost is relatively large. This result offers a new perspective to practitioners, who tend to emphasize export promotion and exports of firms.[3] Thus, our result offers a unique policy implication.

This paper is related to the works of Melitz and others adopting Melitz-style models to investigate firm exporting behavior and international trade (e.g., Melitz, 2003; Demidova and Rodríguez-Clare, 2013; Melitz and Ottaviano, 2008; and Long et al., 2011). To address firm heterogeneity, Melitz (2003) incorporated a productivity distribution into a standard monopolistic competition model, and showed that efficient firms both export and sell domestically, whereas less-efficient firms only operate in the domestic market. This model is extended to asymmetric two-country models and is related to our paper. Demidova and Rodríguez-Clare (2013) conducted a welfare analysis using a Melitz-type model.[4] They demonstrated that trade liberalization for the home country raises the country's welfare. Melitz and Ottaviano (2008) constructed a model with an endogenous markup rate.

These studies are central and significant to the literature focusing on a monopolisti-

[3]In fact, Van Biesebroeck et al. (2015) point out that export promotion programs are often observed.

[4]Arkolakis et al. (2012) showed that the condition of gains from trade in the Melitz model depends on two factors. One is the shape of the productivity distribution, and the other is the expenditure share for the own country's products in the open economy.

cally competitive trade model with firm heterogeneity. However, as they are all based on monopolistic competition they do not analyze strategic interaction among firms. Therefore, the analyses do not consider all possible trade patterns that occur according to the size of the transport and fixed costs.

To consider the relationship between firm process innovation (cost-reducing R&D activity) and trade liberalization, Long et al. (2011) incorporated Melitz-type firm exporting behavior into an oligopolistic competition model.[5] However, the main purpose of Long et al. (2011) was to examine the effects of trade liberalization on R&D investment and hence, the *firms' strategic choice regarding whether to export* and *the decision of trade pattern* are omitted in their model.

This paper is also related to the studies in which firms endogenously determine whether to become a multiproduct producer (e.g., Basak and Mukherjee, 2018; Grossmann, 2007; and Kawasaki et al., 2023). In our model, firms consider whether to become an exporter. This situation is similar to single-product firms becoming multiproduct firms due to paying a fixed cost and by developing new products. Basak and Mukherjee (2018) consider new product development, that is, product R&D, in a unionized duopoly model. Kawasaki et al. (2023) examine downstream firms' new product development and upstream firms' cost-reducing R&D. Moreover, Grossmann (2007) builds a model in which firms decide the number of their products. Although these studies offer interesting results, their models are limited to the domestic market alone, and therefore, do not cover international trade.

The remainder of this paper is organized as follows. Section 2 presents the baseline

[5]Impullitti et al. (2022) considered heterogeneous oligopolistic competition and R&D in a general equilibrium framework. Furthermore, Edmond et al. (2015) presented a general equilibrium model in which intermediate-good producers compete in Cournot fashion.

model and Section 3 examines the trade patterns that arise. Section 4 presents the welfare considerations. Section 5 discusses the case of differentiated goods and considers the scenario in which firms have constant marginal costs. Section 6 concludes.

2 Model

We consider a segmented market of the Brander and Krugman (1983) type. There are two symmetric countries, the home country (labeled H) and the foreign country (labeled F), and each country has a product market and a firm, which we refer to as firms H and F, respectively. Each firm has two options, that is, it must decide whether to export or not export, and it pays a fixed export cost $k \geq 0$ if it exports. When firm i exports, its output includes both "domestic supply" (labeled D) and "exports" (labeled E). To export one unit of product to the foreign market, firms must pay a per unit transport cost $t \geq 0$. We assume that the firms have a quadratic cost function:[6] $(\gamma/2)\, q^2$, where $\gamma > 0$ is the production efficiency of firms and q is a quantity. According to the decisions made by the firms, four trade patterns appear. In the baseline model, firms engage in a homogenous quantity competition in both the Home and Foreign markets. In the discussion in Section 5, we consider differentiated quantity and price competition.

The inverse demand of country i when all firms export is $p_i = a - q_{ii} - q_{ji}$, $i \neq j$,

[6]The production technology for manufacturing often involves decreasing returns to scale. Basu and Fernald (1997) found that a typical industry has decreasing returns to scale based on aggregate data of 34 manufacturing industries in the US. In addition, Xu et al (1994), among others, found that decreasing returns to scale can be observed in the transportation sector. Furthermore, a quadratic cost function is frequently adopted in theoretical studies of oligopoly. See, for example, Dastidar (1995), Delbono and Lambertini (2016), Goerke (2022), Mizuno and Takauchi (2020, 2024), Mukherjee (2014, 2024), Takauchi and Mizuno (2022), and von Weizsäcker (1980).

$i, j = H, F$, where p_i is the product price, q_{ii} is the domestic supply of firm i, and q_{ji} is the export of firm j (or the imports of country i from country j). The inverse demand of country i when firm j does not export is $p_i = a - q_{ii}$. The consumer surplus in country i is given by $CS_i = Q_i^2/2$, where Q_i is aggregate output of country i. For example, if all firms choose E, the consumer surplus in country i becomes $CS_i = (q_{ii} + q_{ji})^2/2$ for $i \neq j$, $i, j = H, F$.

The profits of the firms depend on the trade pattern realized. When all firms choose E, two-way trade occurs. Then, firm i's profit without k (the fixed export cost) is given by: $\Pi_i \equiv (a - q_{ii} - q_{ji})q_{ii} + (a - q_{jj} - q_{ij} - t)q_{ij} - \frac{\gamma}{2}(q_{ii} + q_{ij})^2$ for $i \neq j, i, j = H, F$.

When only firm i $(\neq j)$ chooses D, its profit is: $\Pi_i \equiv (a - q_{ii} - q_{ji})q_{ii} - \frac{\gamma}{2}(q_{ii})^2$ for $i \neq j, i, j = H, F$. When only firm i $(\neq j)$ chooses E, its profit without k is: $\Pi_i \equiv (a - q_{ii})q_{ii} + (a - q_{jj} - q_{ij} - t)q_{ij} - \frac{\gamma}{2}(q_{ii} + q_{ij})^2$ for $i \neq j, i, j = H, F$.

When all firms choose D, there is no trade. Then, firm i's profit is: $\Pi_i \equiv (a - q_{ii})q_{ii} - \frac{\gamma}{2}(q_{ii})^2$ for $i = H, F$.

For simplicity, hereafter, we normalize γ at unity, i.e., $\gamma = 1$. This normalization does not alter our main results. In the Online Appendix, we illustrate the equilibrium of our model with parameter γ. (Refer to the Online Appendix for further details.)

We consider the following two-stage game. In the first stage, each firm chooses either E or D. If a firm chooses E, it pays k. In the second stage, each firm enters a homogeneous quantity competition. The solution concept is the sub-game perfect Nash equilibrium. The game is solved by backward induction.

3 Trade Patterns

In the second stage of the game, each firm i ($i = H, F$) competes in Cournot fashion. By solving the first-order conditions (FOCs) for the profit maximization of firms in each regime, we obtain the following outputs:

$$\begin{aligned} q_{ii}^{EE*} &= \frac{a+2t}{5}; \quad q_{ij}^{EE*} = \frac{a-3t}{5}; \quad q_{ii}^{DD*} = \frac{a}{3}, \\ q_{HH}^{DE*} &= \frac{2a+t}{7} = q_{FF}^{DE*} = q_{HH}^{ED*} = q_{FF}^{ED*}; \quad q_{FH}^{DE*} = \frac{a-3t}{7} = q_{HF}^{ED*}, \end{aligned} \tag{1}$$

where "$*$" is an equilibrium value.

To ensure a positive quantity, we set Assumption 1.

Assumption 1. $t/a < 1/3$.

Equation (1) yields the firms' equilibrium profit without k:

$$\begin{aligned} \Pi_i^{EE*} &= \frac{8a^2 - 8at + 27t^2}{50}; \quad \Pi_i^{DD*} = \frac{a^2}{6}, \\ \Pi_H^{DE*} = \Pi_F^{ED*} &= \frac{3(2a+t)^2}{98}; \quad \Pi_F^{DE*} = \Pi_H^{ED*} = \frac{19a^2 - 16at + 24t^2}{98}. \end{aligned} \tag{2}$$

From equation (2), we obtain Lemma 1.

Lemma 1. *(i) Suppose that rival (firm j) chooses E. If $\varphi_D \equiv \frac{2(23a-104t)(a-3t)}{1225} > (\leq)\, k/a^2$, firm i chooses E (D). (ii) Suppose that rival chooses D. If $\varphi_E \equiv \frac{4(a-3t)^2}{147} > (\leq)\, k/a^2$, firm i chooses E (D).*

Proof. $\varphi_D \equiv \Pi_H^{EE*} - \Pi_H^{DE*} = \Pi_F^{EE*} - \Pi_F^{ED*} = \frac{2(23a-104t)(a-3t)}{1225}$ and $\varphi_E \equiv \Pi_H^{ED*} - \Pi_H^{DD*} = \Pi_F^{DE*} - \Pi_F^{DD*} = \frac{4(a-3t)^2}{147}$. Q.E.D.

From Lemma 1, we establish Proposition 1.

Proposition 1. *I. Suppose that $t/a \leq 19/162$. (i) If $k/a^2 < \varphi_E$, then EE occurs. (ii) If $\varphi_E \leq k/a^2 \leq \varphi_D$, then $DD\&EE$ can arise. (iii) If $k/a^2 > \varphi_D$, then DD occurs.*

II. Suppose that $19/162 < t/a < 23/104$. *(i) If* $k/a^2 < \varphi_D$, *then EE emerges. (ii) If* $\varphi_D \leq k/a^2 \leq \varphi_E$, *then DE&ED can occur. (iii) If* $k/a^2 > \varphi_D$, *then DD occurs.*

III. Suppose that $23/104 \leq t/a < 1/3$. *(i) If* $k/a^2 \leq \varphi_E$, *then DE&ED can occur. (ii) If* $k/a^2 > \varphi_E$, *then DD occurs.*

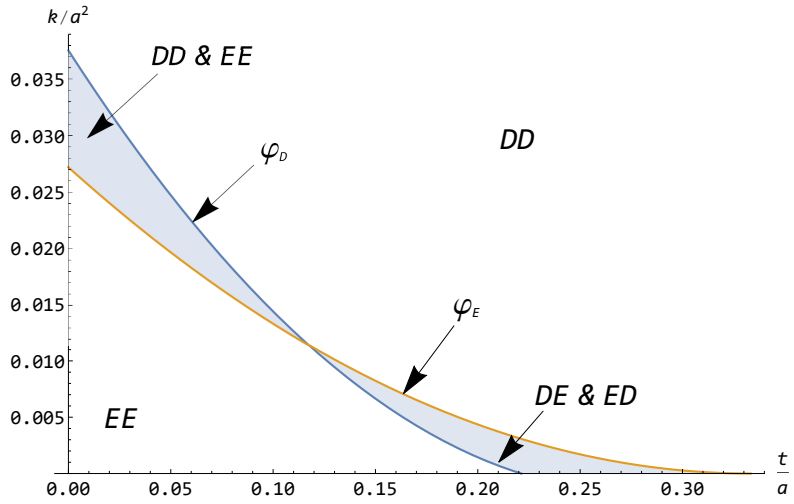

Figure 1: Four areas

The equilibrium trade pattern depends on the sizes of both the transport cost t and the fixed export cost k. (See Figure 1.) Independent of the rival's strategy, firm i exports if k is small and does not export if k is large. Whether the rival exports or not is dependent of the thresholds φ_D and φ_E to which firms are indifferent between choosing E and choosing D.

To consider the mechanism of Proposition 1, let us explain why (i) $\varphi_D > \varphi_E$ for $t = 0$ and (ii) $\partial\varphi_D/\partial t < \partial\varphi_E/\partial t < 0$. We first consider the case where $\varphi_E (\equiv \Pi_H^{ED*} - \Pi_i^{DD*} = \Pi_F^{DE*} - \Pi_i^{DD*}) = k/a^2$. In this case, the rival chooses D. There are positive and negative effects when firms export. The positive effect is "obtaining foreign market share". The negative effect is "an increase in the marginal cost of domestic supply". If $\varphi_E = k/a^2$, the positive and negative effects are equal.

Suppose that the rival switches its strategy from D to E. It is then easier for each firm to obtain the foreign market share required to start exporting. This is because the rival's marginal cost increases, so the competition in the destination market becomes weaker. This raises the benefit of exporting. Further, the effects of "an increase in the marginal cost of domestic supply" become weak. This is because the rival is already exporting before firm i begins to export, so the domestic supply is small and the profit reduction caused by an increase in the firm's marginal cost eases. This illustrates the benefit of firm i exporting. From these two factors, when "$\varphi_E = k/a^2$ for $t = 0$", firm i has a greater incentive to export in the case where the rival chooses E compared with the case where the rival chooses D. Hence, firm i chooses E. This implies that when the rival chooses E, the value of k at which firm i is indifferent between E and D (i.e., $k/a^2 = \varphi_D$) is greater than $k/a^2 = \varphi_E$.

We now show that (ii) "$\partial\varphi_D/\partial t < \partial\varphi_E/\partial t < 0$". Note that exports decrease as t increases. We first consider the slope of φ_D. When the rival chooses E, a rise in t weakens the effects of "obtaining the foreign market". Furthermore, the local firm's domestic supply increases because of the reduction in the exports of the foreign rival, so the effect of the increased marginal cost in the domestic supply by starting to export becomes stronger. These effects combine to reduce the benefit of exporting. Hence, if t rises in the case where the rival chooses E, a significant decrease in k is required to make firm i indifferent between choosing E and choosing D.

We next consider the slope of φ_E. If the rival chooses D, its exports are zero and the expansion in domestic supply caused by a rise in t partly disappears. Hence, the reduction in export benefit that appears when the rival chooses E becomes weaker. When t rises in this situation, it is not necessary for a significant reduction in k to make firm i indifferent

between choosing E and choosing D.

From the above arguments, "$\varphi_D > \varphi_E$ for $t = 0$". Because "$\partial\varphi_D/\partial t < \partial\varphi_E/\partial t < 0$", $\varphi_D = \varphi_E$ holds at a certain level of t. If t exceeds this level, $\varphi_D < \varphi_E$ holds.

As a result, within some range where the value of t is small, "strategic complementary equilibrium" (i.e., [b] "No trade" and "Two-way trade") appears if k is of intermediate magnitude. By contrast, within some range where the value of t is large, "strategic substitutes equilibrium" (i.e., [a] "One-way trade") appears if k is of intermediate magnitude.[7]

We showed that, in a symmetric two-country model, depending on the transport and fixed export costs, "all possible trade patterns" appear. This is our contribution. Overall, it is significant that "One-way trade" (asymmetry) occurs from a symmetric two-country scenario (symmetry). In general, studies based on Brander and Krugman's (1983) model frequently assume that firms have constant marginal costs. However, under this assumption of constant marginal costs, asymmetric results cannot occur from a symmetric two-country setting. Hence, when we consider the trade pattern, we must pay special attention to the production technology of firms. Our analysis indicates this point. Thus, we believe that our results make a significant contribution to the literature.

[7]It is well-known that some firms will continue exporting but others will stop exporting and behave inside the country. In reality, for example, Onkelinx et al. (2016) report that many Belgian small and medium-sized enterprises (SMEs) stopped exporting and continued activities domestically. "More than half (2,786 or 53%) of the 5,283 SMEs that were exporting in 1998 had stopped exporting by 2008. ...The remaining 1,866 firms are still active in the domestic market." (Onkelinx et al., 2016, p. 54.) In Estonia, a similar situation is found by Vissak and Masso (2015).

4 Welfare Considerations

As illustrated in Figure 1, the welfare in each country can vary drastically because the size of transport cost t alters the trade pattern. Therefore, we now consider the effects of a change in the transport cost on the welfare in each country.

4.1 Consumer Surplus

Competition authorities often focus on consumer surplus compared with total surplus (e.g., Albæk, 2013; Viscusi et al., 2018); hence, we first consider how trade liberalization (i.e., a reduction in the transport cost t) affects the consumer surplus.

From equation (1), the consumer surplus in each equilibrium regime is:

$$CS_i^{EE*} = \frac{(2a-t)^2}{50};\ CS_i^{DD*} = \frac{a^2}{18};\ CS_H^{DE*} = \frac{(3a-2t)^2}{98};\ CS_H^{ED*} = \frac{(2a+t)^2}{98}, \tag{3}$$

where $CS_H^{DE*} = CS_F^{ED*}$ and $CS_H^{ED*} = CS_F^{DE*}$.

Equation (3) and Proposition 1 yield Proposition 2.

Proposition 2. *Suppose that $k/a^2 < 25/2187$. Then, trade liberalization involving a reduction in the transport cost, t, may suddenly lower the consumer surplus of the exporting country.*

Proof. First, $DE\&ED$ can appear if $k/a^2 < 25/2187$. Second, $\forall t/a < 1/3$, $CS_H^{DE*} > CS_i^{EE*} > CS_i^{DD*} > CS_H^{ED*}$. Hence, $\forall k/a^2 < 25/2187$, consumer surplus can drop if t decreases. Q.E.D.

Proposition 2 can be explained by ranking consumer surplus. (Figure 2 illustrates the relationship between consumer surplus and the transport cost.) In the regime in which only the foreign firm exports, the marginal cost of the home firm is small because it does

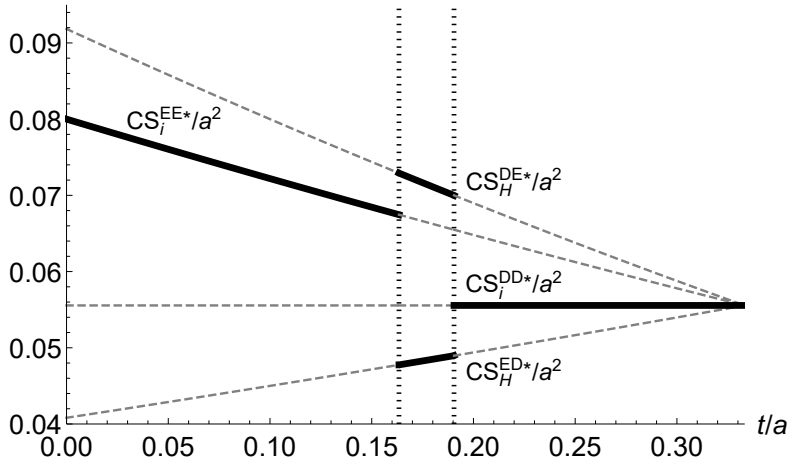

Figure 2: Effect of trade liberalization on consumer surplus ($k = 0.005$)

not export. Hence, its domestic supply increases. In addition, imports exist and hence, aggregate outputs are the largest among all other regimes. Thus, the consumer surplus is also at its largest. In the regime in which everyone exports, each firm's marginal cost is large. Furthermore, because strategic substitutes exist in markets, the domestic firm's domestic supply decreases because of the rival's exports entering its market. Hence, the aggregate output in this regime is smaller than that in the regime in which only the foreign firm exports. In the regime in which no one exports, because there are no imports, the aggregate output in this regime is smaller than that in the regime in which everyone exports. Finally, in the regime in which only the domestic firm exports, because the domestic firm supplies two markets, its marginal cost increases. Hence, its domestic supply decreases. In this case, there are no imports; hence, the aggregate output equals the domestic supply. As a result, the consumer surplus is at its smallest among all the regimes.

Proposition 2 and Figure 2 have important implications. As illustrated in Figure 2, trade liberalization with a reduction of transport costs can suddenly lower the consumer

surplus in the exporting country. The reason is that the trade pattern switches from "No trade" to "One-way trade" (where the home country exports, and the foreign country does not) through the reduction in the transport cost. This switching in the trade pattern makes the home country's total output equal to firm H's domestic supply only (given the home country does not receive any imports).

Some studies in the literature have pointed out that trade liberalization can reduce consumer welfare (e.g., Kabiraj and Marjit, 2003; Marjit and Mukherjee, 2015; Takauchi and Mizuno, 2022).[8] Marjit and Mukherjee (2015) and Takauchi and Mizuno (2022) indicated that a reduction of trade costs (including tariffs and transport costs) may decrease consumer surplus in various vertical market structures. Furthermore, Kabiraj and Marjit (2003) showed that in a situation of technology licensing, an increase in the tariff rate in the country receiving the technology licensing causes a technology licensing from the superior foreign firm, which leads to a sudden rise in consumer surplus.[9] Hence, a decrease in the tariff rate sharply reduces consumer surplus.

In contrast, our study reveals that *trade liberalization can lead to a sudden decline in consumer surplus through an alteration in the trade pattern.* This substantially differs from the conclusions of the literature and therefore, our study provides new insights into trade liberalization.

Furthermore, the negative effects of trade liberalization on the consumer surplus may

[8]Moreover, although they focus on different situations, studies have examined international trade and consumer welfare. Mukherjee and Sinha (2019) showed that an export cartel between exporting firms can increase consumer surplus in the importing country under a third-market model. Mizuno and Takauchi (2018) demonstrated that if the initial level of the tariff is high, a tariff reduction by the final-good importing country in a free trade area decreases consumer surplus in that country.

[9]Similarly, Takauchi and Mizuno (2020) demonstrated that relatively high transport costs maximize consumer surplus in a two-country, two-way trade model with product innovation.

not be considered desirable by the government even if it can improve the domestic total surplus. This is because competition authorities, such as the FTC in the US.,[10] believe a sharp decline in the consumer surplus should be avoided because the consumer surplus is the standard used to measure welfare. Thus, the competition authorities will have strong incentives to pressure their governments to avoid a non-negligible reduction in the consumer surplus. Therefore, a meaningful policy implication of our study is that the government may need to pay particular attention to the effects of the trade liberalization.

4.2 Total Surplus

We show that trade liberalization may decrease total surplus. Total surplus in each regime is as follows:

$$TS_i^{EE*} = \frac{2(3a^2 - 3at + 7t^2)}{25} - k; \quad TS_i^{DD*} = \frac{2a^2}{9},$$
$$TS_H^{ED*} = TS_F^{DE*} = \frac{23a^2 - 12at + 25t^2}{98} - k; \quad TS_H^{DE*} = TS_F^{ED*} = \frac{3a^2 + t^2}{14}.$$

By comparing these total surpluses, we obtain Proposition 3.

Proposition 3. *(i) If trade liberalization changes the trade regime, it always reduces total surplus. (ii-a) Without changing the trade regime, trade liberalization always reduces the total surplus of the non-exporting country. (ii-b) Without changing the trade regime, the total surplus of the exporting country decreases if* $3/14 < t/a < 23/104$ *and* $k/a^2 < \varphi_D$ *in the EE regime, and if* $6/25 < t/a < 1/3$ *and* $k/a^2 < \varphi_E$ *in the ED regime.*

Proof. See the Appendix.

To confirm that trade liberalization reduces total surplus, we illustrate total surplus

[10] In the US., the consumer welfare standard is adopted in practice (e.g., Viscusi et al., 2018, p. 97).

as a function of transport costs in the figures below. In Figure 3, trade liberalization with a changing trade regime reduces total surplus. In addition, the total surplus of the non-exporting country in the DE or ED regimes decreases with t. Thus, we confirm results (i) and (ii-a) in Figure 4.

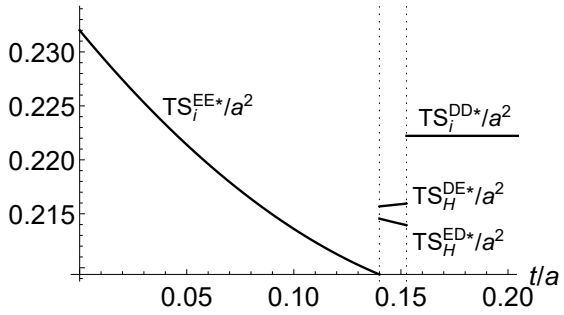

Figure 3: Effect of trade liberalization on total surplus ($k/a^2 = 0.008$)

Figure 4 illustrates the total surpluses of the exporting country under the EE and $ED\&DE$ regimes at $k/a^2 = 0$. Note that from Proposition 1, either the EE or $ED\&DE$ regimes occur at $k/a^2 = 0$. In Figure 4, the shaded areas represent the case in which trade liberalization has a negative impact on total surplus. Figure 4 illustrates a significant policy implication. In our model, unlike that of Brander and Krugman (1983), there are two areas in which trade liberalization reduces welfare. Hence, if a policymaker considers the increase in national welfare generated by trade liberalization and further proceeds with the trade liberalization, the national welfare may fall. This implies that *a trap related to trade liberalization* can appear.

The intuition behind Proposition 3 is as follows: As trade liberalization (a decrease in t) progresses, the exporting firm's supply shifts from the domestic market to foreign markets. As a result, the domestic firm's profit increases and the domestic consumer surplus decreases. Which of these effects is larger determines whether total surplus increases. If t

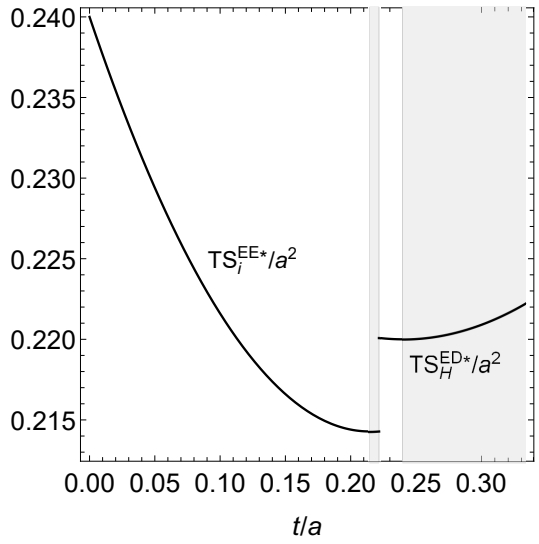

Figure 4: Welfare decreasing trade liberalization ($k/a^2 = 0$)

is large, the supply to the foreign market is small and the supply to the domestic market is large. In this case, a decrease in t significantly changes the supply to the domestic market such that the dominant effect of trade liberalization is the reduction in consumer surplus. Thus, in each regime, trade liberalization reduces the aggregate surplus in the region in which t is large: see (ii-b) in Proposition 3.

When the foreign firm trades and the domestic firm does not, trade liberalization increases the domestic consumer surplus but reduces the domestic firm's profit. In our model, this profit-decreasing effect dominates; hence, the total surplus of the non-exporting country decreases with trade liberalization: (ii-a) in Proposition 3.

Next, the same intuition applies when a decrease in t changes the trade regime. When a slight decrease in t changes the trade regime, the profit of the firm that begins to export changes little. However, the total surplus of the country in which firms begin to export falls because the supply to that country is significantly reduced. Furthermore, because trade liberalization intensifies competition among firms, the profits of the firms

that do not change their export decisions also decline. Although consumer surplus in the country increases, the total surplus of the country falls because this profit-lowering effect dominates: (i) in Proposition 3.

Finally, we consider a characteristic implication of the total surplus in the "One-way trade" situation.

Comparing TS_H^{ED*} with TS_H^{DE*}, we establish Proposition 4.

Proposition 4. *In the "One-way trade" situation, the welfare level of an importing country is larger than that of an exporting country if and only if the fixed export cost is relatively large. Formally,* $TS_H^{ED*} \leq TS_H^{DE*}$ *if and only if* $25a^2/2187 > k \geq (a-3t)^2/49$.

Proof. See the Appendix.

The result of Proposition 4 is illustrated in Figure 4. The logic behind Proposition 4 is intuitive. When the transport cost t is large, "One-way trade" holds (see Figure 1). A larger transport cost means that the increase in profit caused by choosing to export is smaller. In contrast, if firm i chooses D, country i can import from the foreign rival. The imports from the foreign rival raise the aggregate outputs, so the product price falls. Then, the consumer surplus increases. If the fixed export cost is large, the dominant effect is the increase in the consumer surplus and thus the total surplus in the importing country is larger than that in the exporting country.

Proposition 4 indicates that in a situation of intra-industry trade, when firms can decide whether to export, the country can enhance its welfare if it becomes a net importer. This offers a new perspective to practitioners and policy makers who tend to emphasize that firms should choose to export. Thus, our welfare analysis offers a new insight into the context of international trade.

5 Discussions

5.1 Trade Patterns in Differentiated Products

Here, we consider how the equilibrium trade pattern is affected by differentiated quantity and price competition.

Differentiated quantity competition First, we consider differentiated quantity competition in both the Home and Foreign markets. In the EE regime, the inverse demand functions of country i ($i = H, F$) are $p_{ii} = a - q_{ii} - bq_{ji}$ and $p_{ij} = a - q_{ij} - bq_{jj}$ for $i \neq j$, $i, j = H, F$. Note that $b \in [0, 1)$ is a measure of the degree of product differentiation between the Home and Foreign products. By adopting a similar method to that of the previous section, we obtain the following the equilibrium firms' profits without k.[11]

$$\begin{aligned} \pi_i^{EE*} &= \frac{8a(2-b)^2(a-t) + 3(8+b^2)t^2}{2(2-b)^2(4+b)^2}; \quad \pi_H^{DE*} = \pi_F^{ED*} = \frac{[2a(4-b)+3bt]^2}{6(8-b^2)^2}, \\ \pi_H^{ED*} &= \pi_F^{DE*} = \frac{a^2(b^4 - 8b^2 - 32b + 96) - 48a(2-b)t + 72t^2}{6(8-b^2)^2}, \end{aligned} \tag{4}$$

where $\pi_i^{DD*} = a^2/6 = \Pi_i^{DD*}$ in the DD regime. (See equation (2).)

From equation (4), the difference in profits without k is given by:

$$\left.\begin{aligned} \Delta_E &\equiv \pi_H^{EE*} - \pi_H^{DE*} = \pi_F^{EE*} - \pi_F^{ED*} > 0, \\ \Delta_D &\equiv \pi_H^{ED*} - \pi_H^{DD*} = \pi_F^{DE*} - \pi_F^{DD*} > 0. \end{aligned}\right\} \tag{5}$$

From equation (5), we establish Proposition 5.

Proposition 5. *I. Suppose that $\tau < \tau_\delta(b)$. Then, $\Delta_D < \Delta_E$. (i) If $k < \Delta_D$, EE occurs. (ii) If $\Delta_D \leq k \leq \Delta_E$, EE&DD can emerge. (iii) If $\Delta_E < k$, DD occurs.*

II. Suppose that $\tau > \tau_\delta(b)$. Then, $\Delta_E < \Delta_D$. (i) If $k < \Delta_E$, EE occurs. (ii) If $\Delta_E \leq k \leq$

[11] To ensure positive quantities, in this part we assume that $\tau \equiv t/a < \tau_{\max} \equiv (2-b)/3$.

Δ_D, *DE&ED can occur. (iii) If* $\Delta_D < k$, *DD emerges. Here,* $\tau_\delta(b) \equiv \frac{(2-b)(64-40b-8b^2+3b^3)}{3(8+b^2)(8-b-b^2)}$.

Proof. See the Appendix.

Because the two threshold curves Δ_E and Δ_D intersect, the result of Proposition 5 is essentially the same as that of Proposition 1.

Differentiated price competition Next, we consider differentiated price competition.

In the EE regime, the demand functions are:

$$q_{ii} = \frac{(1-b)a - p_{ii} + bp_{ji}}{1-b^2}; \quad q_{ij} = \frac{(1-b)a - p_{ij} + bp_{jj}}{1-b^2} \quad \text{for } i \neq j,\ i,j = H,F.$$

Here, note that $b \in [0,1)$ again.

In the ED regime, the demand functions are:

$$q_{HH} = a - p_{HH}; \quad q_{HF} = \frac{(1-b)a - p_{HF} + bp_{FF}}{1-b^2}; \quad q_{FF} = \frac{(1-b)a - p_{FF} + bp_{HF}}{1-b^2}.$$

In the DE regime, the demand functions are:

$$q_{HH} = \frac{(1-b)a - p_{HH} + bp_{FH}}{1-b^2}; \quad q_{FH} = \frac{(1-b)a - p_{FH} + bp_{HH}}{1-b^2}; \quad q_{FF} = a - p_{FF}.$$

In the DD regime, the demand function is $q_{ii} = a - p_{ii}$ for $i = H,F$.

By adopting a similar method to that of the previous section,[12] we obtain the following equilibrium firm profits without k.

$$\bar{\pi}_i^{EE*} = \frac{4a(1-b)(2-b^2)(b+2)^2(a-t) + (2b^5+2b^4-11b^3-9b^2+24b+24)t^2}{2(1-b)(b+2)^2(b^2-b-4)^2},$$
$$\bar{\pi}_H^{DE*} = \bar{\pi}_F^{ED*} = \frac{(3-2b^2)\left[a(b+2)(3b-4) - 3bt\right]^2}{2(3b^4-20b^2+24)^2},$$

[12] The equilibrium outputs and prices are reported in the Online Appendix.

$$\bar{\pi}_F^{DE*} = \bar{\pi}_H^{ED*} = \frac{(3b^8 - 48b^6 - 24b^5 + 222b^4 + 104b^3 - 432b^2 - 96b + 288)\, a^2}{2(3b^4 - 20b^2 + 24)^2} + \frac{2a(b^2-3)(2b^2+3b-6)(3b^2-4)t}{(3b^4-20b^2+24)^2} - \frac{3(b^2-3)^2(3b^2-4)t^2}{(3b^4-20b^2+24)^2},$$

where $\bar{\pi}_i^{DD*} = a^2/6 = \Pi_i^{DD*}$.

The above profits without the fixed export cost k yield the following:

$$\left.\begin{aligned} B_D &\equiv \bar{\pi}_H^{EE*} - \bar{\pi}_H^{DE*} = \bar{\pi}_F^{EE*} - \bar{\pi}_F^{ED*} > 0, \\ B_E &\equiv \bar{\pi}_H^{ED*} - \bar{\pi}_H^{DD*} = \bar{\pi}_F^{DE*} - \bar{\pi}_F^{DD*} > 0. \end{aligned}\right\} \tag{6}$$

Further, from equation (6), we obtain: $B_D > B_E$.[13]

The equation (6) and the relation "$B_D > B_E$" yield Proposition 6.

Proposition 6. *(i) If $k < B_E$, EE occurs. (ii) If $B_E \leq k \leq B_D$, EE&DD can arise. (iii) If $B_D < k$, DD emerges.*

The market competition becomes keener because the competition mode changes from quantity to price. The two threshold curves B_D and B_E do not intersect because of this tougher competition between firms (i.e., $B_D > B_E$). Consequently, only the multiple equilibria comprising "No trade" and "Two-way trade" emerge.

5.2 Constant Marginal Cost

To compare the case of a quadratic cost function, we consider the scenario in which firms have the cost function cq, where $c \geq 0; a > c$, and q is a quantity. Note that c is a constant marginal cost. All other conditions are the same as in the previous section. If each firm has a constant marginal cost c, because the threshold is equivalent, there is only

[13]The derivation of $B_D > B_E$ is reported in the Online Appendix.

one threshold curve. That is,

$$\hat{\Pi}_H^{DE*} - (\hat{\Pi}_i^{EE*} - k) = -\frac{(a-c-2t)^2}{9} + k = \hat{\Pi}_H^{DD*} - (\hat{\Pi}_i^{ED*} - k),$$

where $\hat{\Pi}_H^{DE*} = \hat{\Pi}_F^{ED*}$ and $\hat{\Pi}_H^{ED*} = \hat{\Pi}_F^{DE*}$. Here, " $\hat{}$ " denotes the case in which each firm's cost function is cq. There is only one threshold curve in the plane of the transportation cost and the fixed export cost. Therefore, because no multiple equilibria exist, the equilibrium is EE or DD. See Figure 5.

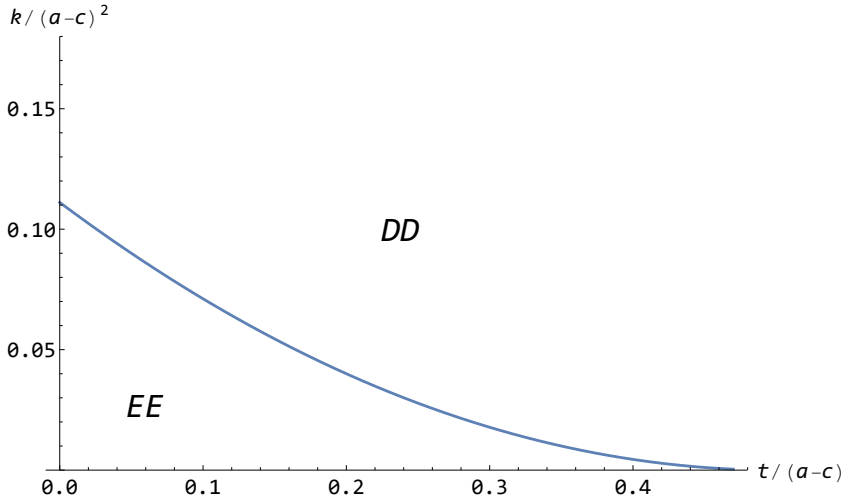

Figure 5: Trade patterns of constant marginal cost ($a - c = 1$)

6 Conclusion

This paper constructed a symmetric two-country two-firm homogenous Cournot trade model to examine the effect of the technology employed by firms, that is, the role of an increasing marginal cost faced by the firms, on realizable trade patterns. In our setting, when firms choose to export, they must pay not only the transport cost, but also a fixed export cost.

Our main findings are summarized as follows: (i) The firms' exporting choices and

trade patterns largely depend on the marginal costs of the firms. When the sizes of both transport and fixed export costs are at an intermediate level, two kinds of multiple equilibria can appear. These two multiple equilibria involve characteristic trade patterns. One brings endogenous asymmetry, that is, only one country becomes an exporter, creating "One-way trade." The other is based on strategic complements, and so causes both "No trade" and "Two-way trade." These multiple equilibria do not appear when the firms have constant marginal costs. (See section 5.2.) (ii) Trade liberalization, that is, a reduction in transport costs, changes consumer surplus and total surplus nonmonotonically and discontinuously through changes in the trade patterns. For example, trade liberalization switches the trade pattern from "No trade" to "One-way trade." If one country becomes an exporter, it does not import from overseas (because the other country does not export), that country's aggregate output is equal only to the local firm's domestic supply. Hence, the product price rises and the consumer surplus of that country experiences a sudden fall.

Moreover, we consider the cases in which the firms engage in differentiated quantity and price competition. Although the differentiated quantity competition does not alter the equilibrium trade pattern, the differentiated price competition can do so because competition is stronger compared with the quantity competition.

Furthermore, we derive a policy implication concerning trade liberalization. We find that trade liberalization may lower consumer surplus and total surplus as a result of the changes in trade patterns. Although practitioners tend to believe trade liberalization always increases welfare, we caution that this may not always be the case.

Appendix

Proof of Proposition 3. We distinguish two scenarios in which trade liberalization reduces total surplus: (i) trade liberalization with a changing trade regime and (ii) trade liberalization without a changing trade regime.

We consider case (i). From Proposition 1, the trade regime change occurs at $k/a^2 = \varphi_D$ or $k/a^2 = \varphi_E$. From Proposition 1, for $t/a \leq 19/162$, we compare TS_i^{DD*} with TS_i^{EE*} at $k/a^2 = \varphi_D$ or $k/a^2 = \varphi_E$:

$$\left(TS_i^{DD*} - TS_i^{EE*}\right)_{k=\varphi_D a^2} = \frac{2(a-3t)(109a+93t)}{11025} > 0; \left(TS_i^{DD*} - TS_i^{EE*}\right)_{k=\varphi_E a^2} = \frac{2(a-3t)(52a+579t)}{11025} > 0.$$

Hence, for $t/a \leq 19/162$, trade liberalization reduces the total surplus of both countries.

Next, we consider case (i) with $t/a > 19/162$. By evaluating $TS_i^{DD*} - TS_H^{ED*}$ at $k/a^2 = \varphi_E$, we obtain the following equation: $(TS_i^{DD*} - TS_H^{ED*})_{k=\varphi_E a^2} = \frac{(a-3t)(13a+3t)}{882} > 0$. In addition, $TS_i^{DD*} - TS_H^{DE*}$ and $TS_H^{ED*} - TS_i^{EE*}$ are as follows:

$$TS_i^{DD*} - TS_H^{DE*} = \frac{(a-3t)(a+3t)}{126} > 0; \quad TS_H^{ED*} - TS_i^{EE*} = \frac{(249t-13a)(a-3t)}{2450} > 0.$$

Substituting $k/a^2 = \varphi_D$ into $TS_H^{DE*} - TS_i^{EE*}$, we obtain: $(TS_H^{DE*} - TS_i^{EE*})_{k=\varphi_D a^2} = \frac{(29a-17t)(a-3t)}{2450} > 0$. Therefore, trade liberalization with a changing trade regime always reduces the total surplus.

Now, we consider case (ii): trade liberalization without a changing trade regime. By differentiating the total surplus in each trade regime with respect to t, we obtain the following:

$$\frac{\partial TS_i^{EE*}}{\partial t} = -\frac{2(3a-14t)}{25a^2}; \quad \frac{\partial TS_H^{ED*}}{\partial t} = -\frac{6a-25t}{49}; \quad \frac{\partial TS_H^{DE*}}{\partial t} = \frac{t}{7} > 0; \quad \frac{\partial TS_i^{DD*}}{\partial t} = 0.$$

Hence, if the trade regime is ED or DE, trade liberalization always reduces the total surplus of the non-exporting country. In addition, without an exporting country, trade liberalization has no effect on total surplus.

Because $\partial TS_i^{EE*}/\partial t > 0$ if $t/a > 3/14$, trade liberalization reduces the total surplus if $3/14 < t/a < 23/104$ and $k/a^2 < \varphi_D$. Next, because $\partial TS_H^{ED*}/\partial t > 0$ if $t/a > 6/25$, trade liberalization reduces the total surplus if $6/25 < t/a < 1/3$ and $k/a^2 < \varphi_E$.

Summarizing the above results, we obtain Proposition 3. Q.E.D.

Proof of Proposition 4. First, we obtain $TS_H^{ED*} - TS_H^{DE*} = (a-3t)^2/49 - k$. Hence, $k \geq (a-3t)^2/49 \Rightarrow TS_H^{ED*} \leq TS_H^{DE*}$. Second, we check that $(a-3t)^2/49$ does not exceed the level of k that brings about "One-way trade." Solving $\varphi_E - \varphi_D = 0$ with respect to t, we have $t = 19a/162$. Thus, $\varphi_E\,|_{t=19a/162} = \varphi_D\,|_{t=19a/162} = 25a^2/2187$ holds. Simple algebra yields:

$$\frac{25a^2}{2187} - \frac{(a-3t)^2}{49} = \frac{-962a^2 + 13122at - 19683t^2}{107163} > 0 \quad \forall t \in \left[\frac{19a}{162}, \frac{a}{3}\right).$$

This implies Proposition 4. Q.E.D.

Proof of Proposition 5. From equation (5), simple algebra yields:

$$\Delta_E - \Delta_D = \frac{2b(ab-2a+3t)(3ab^4-14ab^3-24ab^2+144ab-128a-3b^4t-3b^3t-24bt+192t)}{3(b-2)^2(b+4)^2(b^2-8)^2}.$$

This yields the following.

$$\Delta_E \begin{cases} \geq \Delta_D & \text{if} \quad \tau \leq \tau_\delta(b) \equiv \dfrac{(2-b)(64-40b-8b^2+3b^3)}{3(8+b^2)(8-b-b^2)}, \\ < \Delta_D & \text{if} \quad \tau > \tau_\delta(b), \end{cases}$$

where $\tau_\delta(b) < \tau_{\max}$ holds. From the above formula and the definitions of Δ_E and Δ_D, we obtain Proposition 5. Q.E.D.

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