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Tariff Policy and Transport Costs under Reciprocal Dumping

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Abstract

This paper analyzes tariff competition by investigating the strategic interactions among firms that are highly mobile across national boundaries. Although high transport costs yield a geographic dispersion of the industry, sufficiently low transport costs result in a core-periphery location where nobody bears tariff burdens. In any case, the world economy would be in a much better position under an international coordination scheme. An economy is only required to enforce a *weak* international trade agreement for improving global welfare.

JEL classification: F12; F21; R38

Keywords: Tariff competition; Transport costs; Reciprocal dumping; Trade agreement; Factor mobility

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†Graduate School of Economics, Osaka University, 1–7, Machikaneyama, Toyonaka, Osaka 560-0043, Japan. E-mail address: jgp006oj@mail2.econ.osaka-u.ac.jp

1 Introduction

The significance of strategic relationships among governments has long been documented in the literature on foreign direct investments (FDIs). This is because international mobility of capital creates fiscal externalities; a country's taxation, public expenditures and trade policies may cause a flow of capital to another country, which influence the economic welfare of the residents in that country. In response to these international externalities, a coordinated international fiscal policy must be identified and evaluated with extreme prudence in order to improve welfare. In this context, the example of governments independently competing for a fixed amount of mobile capital stock through a tariff policy may be considered. According to the "tariff-jumping" motivation[1], governments may have an incentive to over-protect domestic firms in order to attract capital, despite a tariff barrier that essentially restricts trade and distorts the allocation of resources. Increased capital mobility engages governments in global trade negotiations.

This paper focuses on the relationship between an optimal trade policy and trade costs. "New economic geography" literature continually explains the matter in which changing trade costs may endogenously lead to industrial agglomeration and geographical differentiation. Trade policy influences the *total* trade costs, which are divided into transport costs and tariffs in this paper. Although the former are exogenously given, the latter are strategically determined by governments; therefore, transport costs are of consequence in both industrial locations as well as for formulating trade strategies. This implies that the level of transport costs significantly impact the welfare implications of the non-cooperative trade policies.

This paper investigates an optimal tariff policy in a strategic setting that considers the location choices of imperfectly competitive firms. We consider the tariff competitions among the governments and establish a relationship between the strategic interactions in the trade policy and the degree of market integration (as measured by exogenous transport costs). Tariff rates on import goods are established for maximizing a representative consumer's indirect utility. Tariff competition involves international externalities associated with capital mobility.

Thus far, only a few attempts have been made to address the issues regarding tariff competition in a new economic geography framework. A few important exceptions are Haufler and Wooton (1999), Ludema (2002), and Mai, Peng, and Tabuchi (2008; hereafter MPT). Haufler

[1] For example, Bhagwati (1987), Motta (1992), Belderbos and Sleuwaegen (1998), Dehejia and Weichenrieder (2001), and Blonigen, Tomlin and Wilson (2004).

and Wooton (1999) considered a framework wherein two countries of different sizes compete for a foreign-owned monopolist location. They highlighted that a tariff policy reinforces the importance of selecting a large region for establishing a plant. Unfortunately, their study lacks a detailed welfare analysis. Since monopoly firms are owned by foreigners, their contributions do not provide any insight into the distortions in the capital market. Therefore, the assumption of a single firm is disregarded and both spatial dispersion and industrial agglomeration are comprehensively studied.

Ludema (2002) focused on the relationship between transport costs and trade agreements under increasing returns and imperfect competition in a repeated game framework. In a one-shot game, each government's dominant strategy is modeled to impose a tariff that is high enough to attract multinational enterprises. However, one-shot tariff competition does not necessarily result in such tariff war, even taking into account the influence of tariffs on the location decisions of firms. In the MPT model as well as ours, each country avoids a tariff war. The models exhibit asymmetry in the equilibrium tariff strategies and location configurations. More importantly, when asymmetric Nash equilibrium arises, it is difficult to enforce cooperative agreements in the absence of supranational political institutions despite the governments being sufficiently patient.

This paper extends and complements the MPT argument regarding the strategic tariff policy, wherein CES preferences and monopolistic competition have been introduced. We introduce strategic interactions among firms that are Cournot competitors and encounter segmented markets. In our model, the relationship between an optimal tariff policy and transport costs are analogous to MPT's model, wherein firms can freely enter and exit a monopolistic competitive market. High transport costs induce governments to set low trade barriers and lead to dispersion of production. Conversely, tariff competition with sufficiently low transport costs leads to a core-periphery structure wherein the core government imposes a sufficiently high tariff and the periphery government eliminates its trade barrier. As a result, nobody bears the tariff burden (i.e., de facto free trade becomes the equilibrium).

Our primary objective is to compare the welfare implications. Even if the equilibrium actions based on a theoretical model appear to be compatible with the evidence, we must nevertheless exercise caution while making political decisions. The economic welfare implications presented in this paper are rather different from those offered by MPT. Although tariff competition over large distances may reduce welfare, an internationally binding agreement is not necessary for free trade. In addition, de facto free trade between the core and the periphery governments will not be globally efficient. In this paper, we propose a practical international rule for improving world welfare.

The remainder of this paper is organized as follows: Section 2 presents the basic model. Section 3 characterizes the tariff competition for duopoly firms. Section 4 indicates the results for a more generalized case (i.e., oligopoly economy). Finally, Section 5 presents the concluding remarks.

2 The Model

2.1 Production

Our model is a reciprocal dumping model à la Brander (1981) that considers footloose capital. In this model, the economy is assumed to comprise two countries, that is, $i \in \{1, 2\}$, two factors of production (capital and labor) and two sectors: manufacturing ($\mathbb{M}$) and agriculture ($\mathbb{A}$).

Further, capital is freely mobile between these two countries. The total endowments of capital, K, are evenly owned by identical consumers who inelastically supply one unit of labor each.

The two countries have identical preferences, technologies, and populations. L denotes the labor population in each country. Although labor is internationally immobile, it possesses intersectoral mobility.

In the agricultural sector, a homogeneous good ($\mathbb{A}$-good) is produced by employing only labor according to the constant returns technology. $\mathbb{A}$-good is traded with zero transaction costs under perfect competition and is taken as a numéraire (the marginal cost is normalized to one).

The manufacturing sector employs both the factors of production in order to produce a homogeneous good ($\mathbb{M}$-good) under imperfect competition and increasing returns to scale. Each firm requires one unit of capital for operations and a_M units of labor per unit of output. Now, n_i denotes the number of firms located in country i; therefore, the total number of firms is given by $n = n_1 + n_2 = K$. For the sake of simplicity, it is assumed that $K = 2$.[2] In other words, firms behave like Cournot duopolists.

[2]This assumption will be relaxed in Section 4, wherein the qualitative nature of the analysis remains unchanged.

Shipping a unit of $\mathbb{M}$-good from country i to country j requires positive specific tariffs[3][4] $\theta_j \geq 0$ and positive transport costs $\tau > 0$. Therefore, the total access costs that need to be paid by firms for exporting goods to country j are $\tau+\theta_j$ units of the numéraire. Governments impose specific import tariffs to maximize their objective functions and redistribute its tariff revenue to the consumers. The equilibrium condition in the tariff policy of government i is given by

$$Ls_i = \theta_i n_j q_{ji}, \tag{1}$$

where s_i denotes the per unit lump-sum transfer and q_{ji} denotes the quantity of imports from country j.

Now it is assumed that the markets are spatially segmented. Therefore, the profit of an identical firm located in region i is given by

$$\pi_i = (p_i - w_i a_M)q_{ii} + (p_j - w_i a_M - \tau - \theta_j)q_{ij} - r_i, \tag{2}$$

where r_i and w_i represent the rewards to capital and labor, respectively, p_i denotes the price of $\mathbb{M}$-good, and q_{ii} denotes country i's consumption of the $\mathbb{M}$-good produced in country i.

Because of the costless trade of the numéraire, the equilibrium wages of the workers in both the countries are regarded as unity; that is, $w_1 = w_2 = 1$.

2.2 Preferences

We assume a quasi-linear utility with a quadratic subutility of a representative consumer in country i, which is expressed as follows:

$$U_i = x_i + \alpha D_i - \frac{\gamma}{2}D_i^2, \tag{3}$$

where x_i and D_i represent the consumption of $\mathbb{A}$-good and $\mathbb{M}$-good respectively. α and γ are constant parameters.

The budget constraint is given by

$$x_i + p_i D_i = Y_i + s_i + \omega, \tag{4}$$

[3]For the sake of simplicity, indeterminate locations have not been considered in this paper; therefore, negative tariffs have been omitted. In addition, MPT assumed positive tariffs and emphasized that, in reality, negative tariffs are rare. Even if negative tariffs are considered, the equilibrium location configuration remains unchanged in the case of a duopoly.

[4]It is assumed that the features of the model are independent of how transport costs are modeled — that is, whether they are per unit or ad valorem costs. See Behrens (2006).

where Y_i denotes the income of an individual and ω denotes the initial endowment, which is assumed to be large enough to ensure a positive demand of the numéraire.

The utility function (3) yields the following inverse demand function for $\mathbb{M}$-good:

$$p_i = \alpha - \gamma \frac{(n_i q_{ii} + n_j q_{ji})}{L}. \tag{5}$$

The utility maximization problem yields the following standard indirect utility function:

$$V_i = \frac{(\alpha - p_i)^2}{2\gamma} + Y_i + s_i + \omega. \tag{6}$$

The first term represents country i's consumer surplus in the $\mathbb{M}$-good market.

2.3 Structure of the Tariff Game

The tariff game comprises the following three stages, each of which is analyzed. In the first stage, both the national governments simultaneously and irreversibly[5] select their specific tariff rates, where country i's strategy is $\theta_i \in \mathbf{R}_+$. In the second stage, firms select the location for establishing their plant after observing both the tariffs. In the third stage, firms initiate production in the international market.

3 Equilibrium

3.1 Trade Patterns

Here, the duopolistic market of sector $\mathbb{M}$ is discussed in detail.

Firms cannot always yield positive revenues from exports. As indicated below, the price of $\mathbb{M}$-good is endogenously determined as a function of tariffs. The threshold values of tariffs at which a firm located in country j is not active in country i are defined as $\overline{\theta}_i = \overline{\theta}_i(\theta_j)$. If

[5]The reason why governments can credibly make their short-run policy choices even before firms make their "long-run" choices (the mobility of capital is assumed to be costless here) may appear to be slightly confusing. In Haufler and Wooton (1999), tariffs are selected only after the location decision has been made. However, the order of play adopted here follows MPT to enable a comparison of results.

$\theta_i \geq \bar{\theta}_i(\theta_j)$, then $q_{ji} = 0$. The sets that represent trade patterns are defined as follows:

$$\begin{aligned}
B =& \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid \theta_1 < \bar{\theta}_1(\theta_2) \text{ and } \theta_2 < \bar{\theta}_2(\theta_1)\},\\
U^{ij} =& \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid \theta_i \geq \bar{\theta}_i(\theta_j) \text{ and } \theta_j < \bar{\theta}_j(\theta_i)\} \text{ for } i \neq j,\\
A =& \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid \theta_1 \geq \bar{\theta}_1(\theta_2) \text{ and } \theta_2 \geq \bar{\theta}_2(\theta_1)\}.
\end{aligned}$$

The trade pattern sets B, U^{ij} and A represent pairs of tariffs that characterize bilateral trade, unilateral trade (only firms in country i can export to country j), and autarky, respectively.

3.2 Third-Stage Game: Cournot Competition

Given the tariff rates and the location of the industries, each firm maximizes its operating profit in the last stage.

The equilibrium price of $\mathbb{M}$-good may be expressed as follows:

$$p_i = \begin{cases} \dfrac{\alpha + n_i a_M}{n_i + 1} & \text{if } \theta_i \geq \bar{\theta}_i(\theta_j), \\ \\ \dfrac{\alpha + 2a_M + n_j(\tau + \theta_i)}{3} & \text{if } \theta_i < \bar{\theta}_i(\theta_j). \end{cases} \tag{7}$$

Therefore, the no trade threshold is derived as follows:

$$\bar{\theta}_i = \frac{a}{n_i + 1} - \tau, \tag{8}$$

where $a \equiv \alpha - a_M$ is assumed to be constant and positive.[6] As we will observe below, n_i is determined as a function of the tariffs. Equation (7) implies that when all other things remain constant, an increase in the number of firms located in the country result in lowering the prices of the goods there.

The equilibrium reward to fixed costs is derived as follows:

- If $(\theta_1, \theta_2) \in A$,

$$r_i = \left(\frac{a}{n_i + 1}\right)^2 \frac{L}{\gamma}. \tag{9}$$

- If $(\theta_1, \theta_2) \in U^{ij}$,

$$r_i = \left(\frac{a}{n_i + 1}\right)^2 \frac{L}{\gamma} + \left[\frac{a - (n_j + 1)(\tau + \theta_j)}{3}\right]^2 \frac{L}{\gamma}, \tag{10}$$

$$r_j = \left[\frac{a + n_i(\tau + \theta_j)}{3}\right]^2 \frac{L}{\gamma}. \tag{11}$$

[6]This assumption ensures that the individual demand for $\mathbb{M}$-good is positive for any positive access costs.

- If $(\theta_1, \theta_2) \in B$,

$$r_i = \left[\frac{a + n_j(\tau + \theta_i)}{3}\right]^2 \frac{L}{\gamma} + \left[\frac{a - (n_j + 1)(\tau + \theta_j)}{3}\right]^2 \frac{L}{\gamma}. \tag{12}$$

3.3 Second-Stage Game: Equilibrium Distribution of Firms

In the second stage, firms can freely move to any location where they can earn a higher profit. The strategic interactions regarding the location preferences of duopolists have been considered. In other words, each firm cannot disregard the decision made by the other.

Lemma 1. *The location game possesses at least one Nash equilibrium for any given pair of positive tariffs.*

Proof. We consider an issue wherein two firms determine the locations for establishing their businesses. Table 1 indicates the payoff matrix of this location game.

[Table 1. HERE]

The term $r_i(n_1)$ denotes the rent of return when a firm operates in country i, and is dependent on the number of firms located in country 1. Here, it may be recalled that each firm possesses the same technology. Subsequently, we are only required to evaluate the signs of the following: $r_1(2) - r_2(1)$ and $r_1(1) - r_2(0)$. The signs of $r_1(2) - r_2(1)$ and $r_1(1) - r_2(0)$ indicate the ideal locations for a company to establish its factory if the rival establishes its factory in country 1 and country 2, respectively. Since $r_1(n_1)$ and $r_2(n_1)$ take the real values for any $(\theta_1, \theta_2) \in \mathbf{R}_+^2$ at all trade patterns, it is always possible to ascertain these signs. Therefore, Lemma 1 holds. □

Table 2 summarizes the results of the location game.[7] Both $r_1(2) = r_2(1)$ and $r_1(1) = r_2(0)$ are simultaneously satisfied only if $\theta_1 = \theta_2 = -\tau < 0$. This implies that $(\theta_1, \theta_2) \in \mathbf{R}_+^2$ s.t. $r_1(2) > r_2(1)$ and $r_1(1) < r_2(0)$ are empty sets. Therefore, both $n_1 = 2$ and $n_1 = 0$ are not simultaneously supported in equilibrium.

[Table 2. HERE]

[7] When $r_1(2) = r_2(1)$ and $r_1(1) > r_2(0)$, then both $n_1 = 2$ and $n_1 = 1$ are Nash equilibrium locations in this game. For the sake of simplicity, it is assumed that $n_1 = 1$ if $r_1(2) = r_2(1)$ and $r_1(1) > r_2(0)$. Likewise, when $r_1(2) < r_2(1)$ and $r_1(1) = r_2(0)$, the symmetric location is assumed to be $n_1 = 1$, even though $n_1 = 0$ is also a Nash equilibrium location.

The sets representing location configurations are defined as follows.

$$C^1 = \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid n_1 = 2\},$$
$$I = \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid n_1 = 1\},$$
$$C^2 = \{(\theta_1, \theta_2) \in \mathbf{R}_+^2 \mid n_1 = 0\}.$$

3.4 First-Stage Game: Tariff Competition for Welfare

Before analyzing welfare, we must consider the per capita income, Y_i. Y_i consists of wages and capital income. Wages are normalized to 1. The global reward to capital is given by $n_1 r_1 + n_2 r_2$, which is equally distributed among all the consumers. Therefore, the per capita income is given by

$$Y_i = 1 + \frac{(n_1 r_1 + n_2 r_2)}{2L}. \tag{13}$$

The first-stage game considers tariff competition. The welfare maximization problem may be divided into the following two component parts. First, the "local" maxima within each of the subsets may be identified from the first-order conditions (see Appendix 1). However, these are not necessarily global solutions. Second, the welfare levels are compared and investigated for identifying whether or not either of the governments has any incentive to deviate.

National welfare can be altered by a tariff increase through the following three channels. First, in contrast to the monopolistic competition model, strategic interactions among firms play an important role in welfare analysis. Protecting the domestic firm in one country increases domestic sales and lowers foreign sales in the market because domestic and foreign outputs are strategic substitutes under Cournot competition. Such a production shift benefits the domestic firm, and consequently enhances domestic welfare by saving on transport costs. At the same time, domestic protection reduces the total supply in the domestic market, thereby increasing the domestic price.[8] As Brander and Krugman (1983) emphasized, each government encounters a trade-off between saving uneconomical transport costs as a result of trade and fostering competition. The level of transport costs and the location configuration of the firms determine which one of the two effects, the production-shifting effect or the anti-competitive effect, is more dominant.

[8]Now firms can only partially transfer the marginal costs to foreign consumers ($\partial p_i / \partial \theta_i \in [0, 2/3]$ if $\theta_i < \overline{\theta}_i$). In other words, there exists "reciprocal dumping" which can be regarded as terms-of-trade gains (or losses). We would like to emphasize that dumping will work even if firms co-locate.

Second, a tariff change generates a rent-shifting effect that creates international externalities. Since the equities of firms are equally owned by domestic and foreign consumers, domestic consumers receive only half of the profits (or losses) from a change in rents. For example, if a reduction in the operating profits earned by firms in the domestic market is exactly offset by an increase in the domestic consumers' surplus and tariff revenues, then the domestic welfare must increase. Furthermore, both the production-shifting gains and the anti-competitive losses influence foreign welfare.

The first-order conditions within each subset are indicated in Appendix 1 and represent the reactions of each of the countries to their rival's tariff without any changes in the trade patterns and the locations of the firms. Keeping trade flow and capital allocation unchanged, the optimal trade policy is to reduce the tariff to zero.[9]

Third, trade barriers operate through a tariff-jumping relocation of firms. Raising tariff barriers above a certain level would attract additional capital into the region because suppliers want to be protected by a high tariff rate and export goods at a low tariff rate. Spatial concentration enhances the competitive pressure on the firms, and therefore a lower price of $\mathbb{M}$-good benefits consumers who incur no trade costs. Despite this, an increase in the number of firms located in a country will certainly lead to a reduction in this country's tariff revenue. We must not disregard the fact that location configuration influences the impacts of both production-shifting and anti-competitive effects.

3.4.1 Benchmark Case: International Tariff Coordination

We assume that there is a world-level benevolent planner who simultaneously establishes the tariff levels in both countries, thereby maximizing the sum of indirect utilities, which is given by

$$\max_{\theta_1,\theta_2} L(V_1 + V_2).$$

Subsequently, the following proposition describes the optimal tariff policy as a function of the transport costs, τ.

Proposition 1. *It is assumed that the economy is duopolistic. On the basis of this assumption, tariff coordination is obtained as follows:*

(i) *For $\tau \geq a/4$, $(\theta_1, \theta_2) \in A \cap I$;*

[9] This is largely owing to the assumption of symmetry in country size.

(ii) *For* $a/5 < \tau < a/4$, $(\theta_1, \theta_2) \in B \cap I$ *and* $\theta_1 = \theta_2 = 5\tau - a > 0$*;*

(iii) *For* $\tau \leq a/5$, $(\theta_1, \theta_2) = (0, 0) \in B \cap I$.

Proof. See Appendix 2. □

When wasteful transport charges are sufficiently higher than demand, international trade becomes rather expensive. Therefore, it is more effective to impose high tariffs that restrict the import of products and promote domestic production. However, firms need to gradually adopt an open trade policy when the transport costs become so low that the wastage of resources is lesser than the loss from the anti-competitive effect.

For any levels of transport costs, the benchmark policy requires dispersed locations. The following is a straightforward corollary of Proposition 1.[10]

Corollary 1. *If countries are symmetric with respect to their populations, agglomeration of the manufacturing sector is inefficient.*

How are agglomeration diseconomies obtained? The strategic interactions among oligopolistic competitors play an important role in this analysis. When two firms are located in the same country, there is no cost difference in the segmented markets. However, when the firms are located in different countries, each firm enjoys an advantage of circumventing the payment of trade costs in its own home market. Consequently, domestic production substitutes for import in both the country, thereby saving on transport costs.

3.4.2 Non-cooperative Equilibiria

We now investigate the case where governments select a tariff rate within their jurisdictions for maximizing the welfare of its citizens.

For $\tau \geq a/4$, the sets C^1 and C^2 are empty. All strategies induce a dispersed location. This yields a unique free-trade[11] equilibrium in this game; that is, $\theta_1 = \theta_2 = 0$. Furthermore, reducing the tariff rate is a dominant strategy. However, owing to the high transport costs in the case of free trade, the closed economy yields more desirable trade patterns for both the countries. The tariff protection reduces transport costs.

[10] In the case of $K \geq 2$, we can also derive Corollary 1 (see Section 4).

[11] This depends on the assumption of both symmetric countries and duopolistic markets. However, if we relax even one of these assumptions, then the analytical description cannot be pursued over a broad range of parameter values.

Proposition 2. *When transport costs are higher than demand, free trade is a unique subgame perfect Nash equilibrium of the tariff competition for duopoly firms in identical countries. This equilibrium, wherein firms are geographically dispersed, is less efficient than that obtained under tariff coordination.*

Proof. See Appendix 3. □

The reason for the difference in the result is that the benevolent planner internalizes the rent-shifting effect, which is counterbalanced by summing the welfare of the countries.

Subsequently, the case where $\tau < a/4$ is considered. Figure 1 illustrates equilibrium trade as well as location patterns as the functions of the countries' tariff offers.

[Figure 1. HERE]

When transport costs are lower than demand, the game exhibits different results. There exists no equilibrium on set I in this range.

Lemma 2. *If transport costs are low enough to cause agglomeration, then a geographically dispersed location is not achievable in equilibrium.*

Proof. See Appendix 4. □

Propositions 1 and 2 and Lemma 2 indicate that *non-cooperative tariff competition is unambiguously harmful for global welfare.* Although the economy requires international policy coordination, according to Lemma 2, mutual agreements among governments, which both facilitate and regulate trade, are difficult to accomplish as the economy integrates.

We are now in a position to characterize the equilibrium of the game for $\tau < a/4$.

Proposition 3. *An equilibrium in pure strategies does not exist for intermediate transport costs. When transport costs are sufficiently lower than demand, there exists a subgame perfect Nash equilibrium such that one country sets its tariff at zero and the other imposes a sufficiently high tariff with industrial agglomeration. This tariff competition deteriorates global welfare whenever the transport costs are strictly positive.*

Proof. See Appendix 5. □

Even among symmetric countries, we arrived at the asymmetric distribution of capital in equilibrium. Tariff competition with low transport costs leads to a core-periphery economy wherein the periphery country imposes a zero tariff for importing goods. When transport costs are sufficiently low[12], it is rather economical for the periphery country to import goods. The government has a weak incentive to attract firms by increasing the level of tariff protection, which exacerbates the anti-competitive effect and reduces capital income. This is in sharp contrast to Ludema (2002), wherein all the countries provide their domestic plants with the shield of tariff protection regardless of the behavior of other governments in the static Nash equilibrium.

In this case, no country collects tariff revenue in equilibrium for low transport costs. This indicates the existence of a de facto free trade. This result may support Waugh (2007), who argued that, as compared to rich countries, poor countries must bear higher costs in order to export goods.

However, in our model, the governments cannot select a pure strategy for intermediate transport costs. When the transport costs are not too low, the core-periphery structure is not an equilibrium structure because the periphery country raises its tariff rate in order to recapture the firm.

3.5 Discussion

In terms of the relationship between equilibrium location configurations and the level of transport costs, our quasi-linear utility model with variable demand elasticity is partially consistent with MPT, which assumed a constant markup pricing rule for firms. Both MPT's and our results indicate that although high transport costs yield a symmetric dispersed location, sufficiently low transport costs lead to a core-periphery structure virtually without any tariff burden.

However, the implications for welfare are contrary to those for transport costs. MPT suggested that sufficiently high transport costs result in an equilibrium wherein both governments establish excessive protection, which necessitates a mutually binding agreement for free trade. However, our model implies that the non-cooperative equilibrium is inefficient for very low tariffs but not for very *high* tariffs, because of a lack of "taste for variety." In addition, de facto free trade with sufficiently low transport costs is optimal in MPT; this is contrary to Proposition 3. Even without market-distorting tariffs, we find that distortions in the location of firms continue

[12]The core-periphery equilibrium exists for $\tau < (9 - \sqrt{78})a/12 \approx 0.014a$. This does not appear to be a broad range. In MPT, the threshold iceberg transport costs that an agglomerated configuration can achieve in equilibrium is given by $1 \leq t < 1.28$.

to exist because of the Nash policies. The political implication derived from the monopolistic competition setting may therefore be a model-specific result.

This difference in results is largely due to the differences in the assumed preferences. Since this paper excludes the taste for variety, it was required to consider significant savings in transport costs and increased domestic production of homogeneous goods.

Here, we discuss the manner in which our model may be extended to a setting of self-enforcing agreements. In Section 3.4.1, we analyze the cooperative outcome that maximizes the joint surplus of the two countries, and subsequently pose the following question: If international transfer payments are not available, how should agreements be designed so as to enable their effective implementation? For $\tau \geq a/4$, the outcome of international cooperation Pareto dominates the Nash equilibrium. Therefore, cooperative self-enforcing agreements are well characterized by certain repeated games.[13] In other words, when the rate at which governments discount the future is below a critical level, the tariff coordination policy can be effectively implemented without international transfers. However, for $\tau < a/4$, the outcome of international cooperation does not Pareto dominate the Nash equilibrium. In the absence of side payments, international tariff coordination leads to industrial delocation and welfare loss for households in the core country. Both countries always have an incentive to deviate from the trade agreement and impose a tariff that is high enough to attract FDI. Therefore, it is difficult to provide a useful and practical method to establish a self-enforcing agreement by considering circumstances such as the repeated game for sufficiently low transport costs.

We note that a simple agreement that specifies tariff ceilings will enable the establishment of more efficient tariff levels. Our study, for example, requires only two conditions, which may be expressed as follows: a lower limit on tariffs, i.e., $\theta_i \geq 5\tau - a$, for $\tau \geq a/5$, and an upper limit, i.e., $\theta_i < \Phi_2 \equiv \left(1 - \sqrt{1 - 4\tau/a}\right)a/2 - \tau$, for $\tau \leq 5a/24$. Under these constraints, non-cooperative tariff competition can effectively implement the tariff coordination results for any level of transport costs. When governments need to save high transport costs, the lower limit on the tariff is the relevant constraint. In contrast, when transport costs are low, it is desirable to restrict the use of tariffs as an industry-grabbing policy. The upper limit on tariffs prompts governments to lower their tariffs to a level below the limit in order to reduce the distortion in prices.

This argument emphasizes the importance of a commitment by each government to prevent

[13] See, for example, Friedman (1971), Bagwell and Staiger (1990) and Ludema (2002).

the deprivation of firms by imposing a prohibitive tariff. In fact, the World Trade Organization (WTO) determines a bound rate, which is the maximum tariff that the members can charge. The tariff ceilings may be of consequence in practice albeit they are much higher than their corresponding applied rates.

4 Extension: Oligopoly

This section discusses an extension of our model, that is, an oligopolistic economy, where $K = n \geq 2$. Consider the following two types of locational equilibria: interior equilibria where $r_1 = r_2$ and $n_1/n \in (0, 1)$, and corner solutions where $n_i = n$ and $r_i > r_j$.[14]

In this case, the marginal effect of the tariff on the firms' location choices can be comprehensively studied. However, the analytical solution becomes uninformative because the form of the indirect utility function is highly non-linear and includes a flat range. Instead, we rely on numerical simulation.

In order to enable a comparison with MPT, it is assumed that $\tau < a$. This yields a relationship between optimal tariffs and transport costs that is similar to the relationship demonstrated in MPT. In other words, a sufficiently high transport cost gives $\theta_1 = \theta_2 > 0$ and $n_1 = n_2 = K/2$ at the equilibrium. In addition, a sufficiently low transport cost provides a core-periphery location; that is, $\theta_i > \theta_j = 0$ and $n_i = n$. The symmetric equilibrium may be derived so long as the following inequality holds: $\tau \geq a[-1 + \sqrt{1 + (n-1)/(n+1)}]/(n-1)$ (see Appendix 6 for details).

Once again, the welfare implication in our study is different from that in MPT. When transport costs are high, the equilibrium welfare in the oligopoly case can be further improved by *increasing* the tariff rates imposed by both the governments as indicated in the case of a duopoly. Besides, when transport costs are sufficiently low, the free trade equilibrium rather than the core-periphery equilibrium derived by the non-cooperative game is more beneficial for global welfare; this result contradicts MPT's finding. Our main results are remotely related to the specifications of a duopoly.

[14]This condition determines a finite number of firms, n_1 and n_2 (and n_1/n), which may not necessarily be an integer. However, in this section, we will assume that the proportion of the firms located in country 1, n_1/n, is continuously differentiable on $(0, 1)$ with respect to tariffs.

5 Conclusion

In this paper, we have developed a strategic tariff competition model with factor mobility. Proposition 2 suggests that the tariff competition between symmetric countries generate symmetric access costs and an inefficient equilibrium when transport costs are higher than demand. Consequently, mutual trade protection may improve welfare levels. On the other hand, tariff competition results in asymmetric access costs and spatial agglomeration of firms in the process of economic integration. In such a case, nobody bears tariff burdens; however, industrial distributions without free entry are inefficient in such equilibria. Although these findings are contrary to the findings of previous studies, both the models have indicated similar relationships between tariff policy and trade freeness. Therefore, as is evident, this model must be interpreted prudently.

We found that establishing constraints for tariff rates and not negotiating these rigid tariff constraints may enhance global welfare. An international trade agreement that establishes a lower limit on tariffs for high transport costs and an upper limit on tariffs for small transport costs improves welfare. An agreement that prevents governments from engaging in a tariff war for attracting capital results in an accommodative trade policy. Horn, Maggi, and Staiger (2010) argued that the presence of both uncertainty and contracting costs may explain a weakness of the trade agreement made under the General Agreement on Tariffs and Trade (GATT)/WTO. Another explanation for the gap between the bound duty rate and the applied tariff rate as it exists in reality was also offered in this study. The strategy space available to players will be an important component in a game.

Appendix

Appendix 1: First-order Conditions of Each Set

The following indicates the first-order conditions and all these conditions also satisfy the associated second-order conditions:

- If $(\theta_1, \theta_2) \in B \cap I$, $\theta_1 = \theta_2 = 0$.
- If $(\theta_1, \theta_2) \in U^{ij} \cap I$, $\theta_j = 0$.
- If $(\theta_1, \theta_2) \in C^i$, $\theta_j = 0$.

When country i does not import $\mathbb{M}$-good, θ_i is indeterminate.

Appendix 2

Global welfare per capita may be calculated as follows:

$$(V_1+V_2)\big|_{(\theta_1,\theta_2)\in B\cap I} = \frac{1}{18\gamma}[16a^2+22\tau^2-\theta_1^2-\theta_2^2+10\tau(\theta_1+\theta_2)-2a(8\tau+\theta_1+\theta_2)] + 2(1+\omega)$$

$$(V_1+V_2)\big|_{(\theta_1,\theta_2)\in U^{ij}\cap I} = \frac{1}{72\gamma}[59a^2+44\tau^2+40\tau\theta_j-4\theta_j^2-8a(4\tau+\theta_j)]+2(1+\omega)$$

$$(V_1+V_2)\big|_{(\theta_1,\theta_2)\in C^i} = \frac{2}{9\gamma}[4a^2+2\tau^2+\tau\theta_j-\theta_j^2-a(4\tau+\theta_j)]+2(1+\omega)$$

Subsequently, the following are the first-order conditions:

- If $(\theta_1,\theta_2)\in B\cap I$, $\theta_1=\theta_2=5\tau-a$. According to the non-negativity requirement on θ_i, $\theta_1=\theta_2=0$ are global welfare maximizers for $\tau\le a/5$.
- If $(\theta_1,\theta_2)\in U^{ij}\cap I$, $\theta_j=5\tau-a$. For $5a/24<\tau<a/4$ and $\theta_i\ge a/2-\tau$, $(\theta_i,5\tau-a)\in U^{ij}\cap I$.
- If $(\theta_1,\theta_2)\in C^i$, $\theta_j=(\tau-a)/2<0$.

All the conditions also satisfy the second-order condition.

Substituting the optimal tariffs from above into global welfare yields the maximum welfare levels within each of the subsets. We obtain Proposition 1 by comparing these maximum welfare levels. Figure 2 summarizes these calculations.

[Figure 2. HERE]

Appendix 3

For $\tau\in[a/4,a/2)$, we have

$$V_1\big|_{(0,0)\in B\cap I} - V_1\big|_{(\bar{\theta}_1,0)\in U^{12}\cap I} = \frac{(a-2\tau)^2}{12\gamma}>0$$

and

$$V_1\big|_{(0,\bar{\theta}_2)\in U^{21}\cap I} - V_1\big|_{(\bar{\theta}_1,\bar{\theta}_2)\in A} = \frac{(a-2\tau)^2}{12\gamma}>0.$$

A protected country always profits by opening up its import market. This discussion is completely pertinent for country 2 as well. Therefore, $(\theta_1,\theta_2)=(0,0)\in B\cap I$ is a unique Nash equilibrium. Proposition 1 indicates that free trade is inefficient. This proves Proposition 2.

Appendix 4

We demonstrate that there exists no Nash equilibrium for $\tau < a/4$ such that (i) $(\theta_1, \theta_2) \in B \cap I$, $(\theta_1, \theta_2) \in A$, and $(\theta_1, \theta_2) \in U^{ij} \cap I$. The following proof relates to country 1 but is completely pertinent to country 2.

For $\tau < a/4$ and given $\theta_j = 0$, country i decides to deprive firms with $\theta_i \geq \bar{\theta}_i$.

$$V_1\Big|_{(0,0)\in B\cap I} - V_1\Big|_{(\bar{\theta}_1,0)\in U^{12}\cap C^1} = -\frac{\tau}{18\gamma}(4a - 9\tau) < 0.$$

Therefore, free trade is no longer a global Nash equilibrium.

Likewise, for $\tau < a/4$ and given that $\theta_j \geq a/2 - \tau$, country i continues to reduce its tariff until its consumers can import $\mathbb{M}$-good.

$$V_1\Big|_{(a/4-\tau,\bar{\theta}_2)\in U^{21}\cap I} - V_1\Big|_{(\bar{\theta}_1,\bar{\theta}_2)\in A} = \frac{a(3a - 8\tau)}{48\gamma} > 0$$

In other words, autarky is also unachievable in equilibrium.

In addition, we can demonstrate that in the set $U^{ji} \cap I$, exporting country j has an incentive to open up its market.

$$V_1\Big|_{(\bar{\theta}_1,a/4-\tau)\in U^{12}\cap I} - V_1\Big|_{(a/4-\tau,a/4-\tau)\in B\cap I} = \frac{a(-3a + 8\tau)}{48\gamma}$$

Therefore, for $\tau < a/4$, the protected country will reduce its tariff in the absence of the core. There is no Nash equilibrium in $U^{ij} \cap I$ for $\tau < a/4$.

Appendix 5

Lemma 2 indicates that all Nash equilibria in pure strategies must belong to either C^1 or C^2 for $\tau < a/4$ if they exist. We indicate that a periphery country has an incentive to increase its tariff and refuse to import rather than agree to be a periphery for at least $\tau \in (3a/16, a/4)$. Since the two countries are assumed to be of the same size, this model is symmetric. Therefore, we examine whether or not country 1 will be a core in equilibrium.

First, we consider $\theta_1 \geq \bar{\theta}_1(\theta_2)$ for any θ_2.

$$V_2\Big|_{(\theta_1,0)\in U^{12}\cap C^1} - V_2\Big|_{(\theta_1,a/4-\tau)\in U^{12}\cap I} = \frac{a^2 - 72a\tau + 48\tau^2}{144\gamma}$$

This equation takes a negative value if $\tau > (9 - \sqrt{78})a/12 \approx 0.014a$. Therefore, in the range $\tau \in (3a/16, a/4)$, a periphery country will deprive the protected core country of capital.

Second, we identify a range wherein a periphery country can become a core by increasing its tariff. When $\theta_1 = \Phi_2$ and $\theta_2 = 0$, then $r_1(2) = r_2(1)$ where $\Phi_2 = \left(1 - \sqrt{1 - 4\tau/a}\right) a/2 - \tau$. Φ_2 is a horizontal intercept of $r_1(2) = r_2(1)$ line. Here, $(a/4 - \tau) - \Phi_2 > 0$ since $\tau < 3a/16$. In other words, when $\tau > 3a/16$, periphery country 2 never obtains the entire capital by increasing its tariff for a given $\theta_1 \in [\Phi_2, a/2 - \tau)$ such that $(\theta_1, 0) \in C^1$.

$$\partial \left(V_2\big|_{(\theta_1,0)\in C^1} - V_2\big|_{(\theta_1,\bar{\theta}_2)\in U^{21}\cap I} \right) / \partial\theta_1 = \frac{a - 5\tau - 5\theta_1}{9\gamma} < 0$$

The difference decreases in θ_1 for $\tau > 3a/16$ and $\theta_1 \geq \Phi_2$. Therefore, if $V_2\big|_{C^1} - V_2\big|_{U^{21}\cap I} < 0$ in the border between $U^{21} \cap I$ and A, which is the point at which the difference is smallest, then $V_2\big|_{C^1} < V_2\big|_{U^{21}\cap I}$ holds for all $\theta_1 \geq \Phi_2$. The following equation is presented for $\tau > 3a/16$:

$$\begin{aligned}
&\lim_{\epsilon\to 0} \left(V_2\big|_{(\Phi_2+\epsilon,0)\in C^1} - V_2\big|_{(\Phi_2+\epsilon,\bar{\theta}_2)\in U^{21}\cap I} \right) \\
&= -\frac{1}{36\gamma} \left(14a\tau - 12\tau^2 - 3a^2\sqrt{1 - 4\tau/a} \right) < 0
\end{aligned}$$

Overall, periphery always endeavors to recover its capital share and unilaterally protect a domestic firm.

For the second result, we found Nash equilibria that belonged to the sets C^1 or C^2 for $\tau < (9 - \sqrt{78})a/12$. In this range, we understand that $V_2\big|_{(\bar{\theta}_1,0)\in U^{12}\cap C^1} > V_2\big|_{(\bar{\theta}_1,a/4-\tau)\in U^{12}\cap I} > V_2\big|_{(\bar{\theta}_1,\bar{\theta}_2)\in A}$ and $V_1\big|_{(0,0)\in B\cap I} < V_1\big|_{(\bar{\theta}_1,0)\in U^{12}\cap C^1}$. Therefore, $\theta_1 > a/2 - \tau$ and $\theta_2 = 0$ are subgame perfect Nash equilibria. Subsequently, C^1 is obtained.

Although another equilibrium could exist, all equilibria resulted in the core-periphery location with "limit tax" owing to Lemma 2.

Corollary 1 indicates that the equilibria are trivially inefficient.

Appendix 6: Simulations

Solving the systems of the first-order conditions in $B \cap I$ (i.e., $n_1/n \in (0,1)$ and $\theta_i < \bar{\theta}_i$ for $i \in \{1,2\}$) yields the following solution:

$$\theta_1 = \theta_2 = \theta^{*B\cap I} > 0$$

Symmetric property implies that when $\theta_1 = \theta_2 = \theta^{*B\cap I}$, $n_1 = n_2$.

Here we examine whether or not $\theta_1 = \theta_2 = \theta^{*B\cap I}$ is a global equilibrium or not. In other words, we investigate whether or not a country has an incentive to change its tariff and move out of $B \cap I$. If $V_1\big|_{(\theta^{*B\cap I},\theta^{*B\cap I})\in B\cap I} < V_1\big|_{(0,\theta^{*B\cap I})\in C^2}$, then $\theta_1 = \theta_2 = \theta^{*B\cap I}$ is not a Nash equilibrium.

If $(0, \theta^{*B\cap I}) \notin C^2$, then $\theta_1 = \theta_2 = \theta^{*B\cap I}$ is a unique Nash equilibrium.

If $(0, \theta^{*B\cap I})$ belongs to the set C^2, then $V_1\big|_{(\theta^{*B\cap I}, \theta^{*B\cap I})\in B\cap I} < V_1\big|_{(0,\theta^{*B\cap I})\in C^2}$ for any feasible parameter settings with numerical calculations. We can also see that $V_2\big|_{(0,\theta_2)} > V_2\big|_{(0,\theta_2'')}$ for any θ_2 and θ_2'' such that $(0, \theta_2) \in C^2$ and $(0, \theta_2'') \in B \cap I$ with numerical calculations. Therefore, Nash equilibria must belong to C^j with $\theta_i = 0$.

Since we derive a symmetric Nash equilibrium when $C^2 = \emptyset$ in $\mathbf{R}_+^2$,

$$\tau \geq \frac{a}{n-1}\left[-1 + \sqrt{1 + \frac{n-1}{(n+1)}}\right]$$

is a necessary condition for a symmetric Nash equilibrium.

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	Country 1	Country 2
Country 1	$r_1(2)$, $r_1(2)$	$r_1(1)$, $r_2(1)$
Country 2	$r_2(1)$, $r_1(1)$	$r_2(0)$, $r_2(0)$

Table 1: Payoff matrix.

$r_1(2) - r_2(1)$	$r_1(1) - r_2(0)$	Equilibrium Location
$+$	$+$	$n_1 = 2$
$-$	$+$	$n_1 = 1$
$-$	$-$	$n_1 = 0$
0	$+$	$n_1 \geq 1$
$-$	0	$n_1 \leq 1$

Table 2: Equilibrium location.

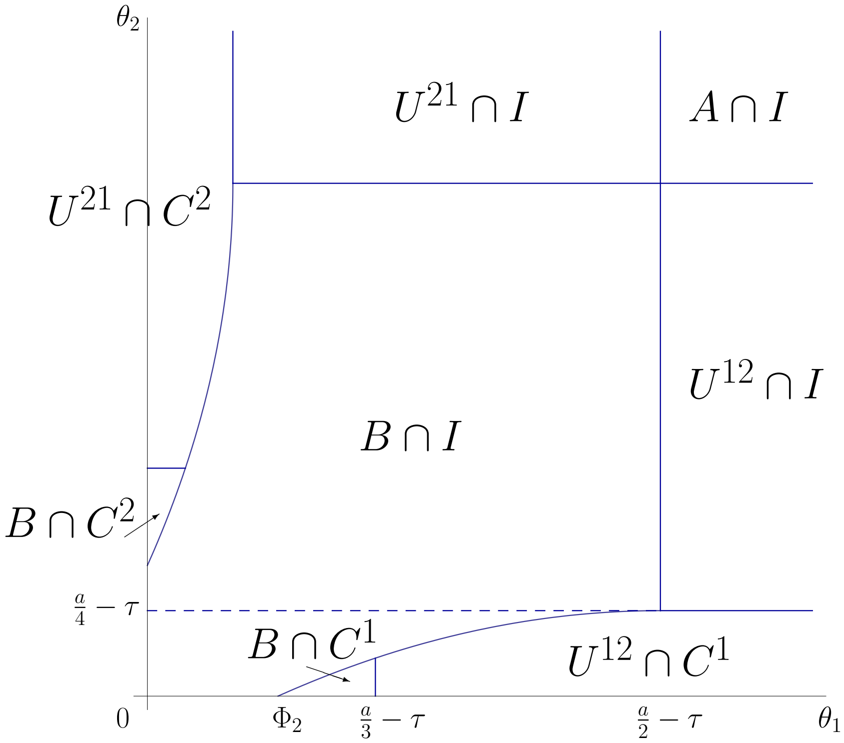

Figure 1: Trade and location configurations for $\tau < a/4$.

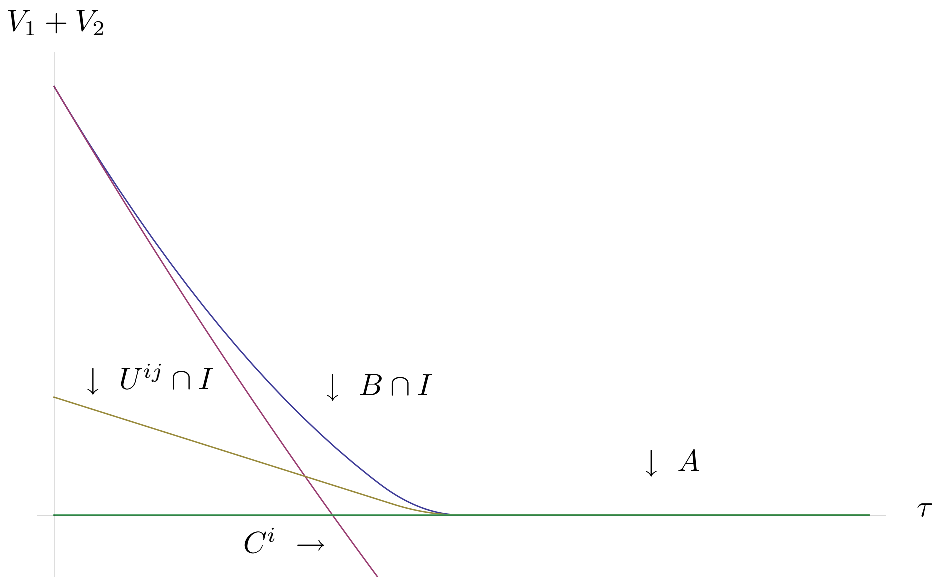

Figure 2: Transport costs and maximized global welfare within each set.