Economic geography with tariff competition

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Abstract: A simple two-country model of economic geography is constructed in order to examine the effect of tariff competition on the spatial distribution of manufacturing activities as well as on welfare. We show that when the transport cost is small, tariff competition with firm migration leads to a core-periphery economy, where one of the two countries imposes no tariff in Nash equilibrium. We also show that when the transport cost is sufficiently large, both countries impose a positive tariff, which decreases the welfare of both countries.

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1 Introduction

Ever since Krugman (1980), trade costs, which include tariffs and transport costs, have been important features of new trade theory and new economic geography (e.g. Fujita, Krugman and Venables, 1999; Baldwin, Forslid, Martin, Ottaviano and Robert-Nicoud, 2003). It has long been believed that trade costs have fallen significantly over time. Baier and Bergstrand (2001) estimate that income growth explains 67%, tariff-rate reductions 25%, transport-cost declines 8% of the average growth of world trade among OECD countries between the late 1950s and the late 1980s. Nevertheless, there still exist large border costs even between Canada and the United States having the Free Trade Agreement (FTA) as shown by McCallum (1995) and his successors.

According to Anderson and van Wincoop (2004), “trade costs are broadly defined to include all costs incurred in getting a good to a final user other than the production cost of the good itself. Among others this includes transport costs (both freight costs and time costs), policy barriers (tariffs and non-tariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (wholesale and retail).” They further proceed to report that an approximate estimate of the tax equivalent of representative trade costs for “industrialized countries” amounts to 170%; transport costs, local retail and wholesale distribution costs, and border-related barriers account for roughly 21%, 55%, and 44% of this estimate, respectively (2.7 = 1.21 × 1.55 × 1.44).

There is a sharp distinction between transport costs and tariffs. The transport costs are considered to be exogenous and to disappear, whereas tariffs are determined endogenously by national tariff policies and are redistributed to consumers in importing countries. While the transport costs are major concern, the tariffs are neglected in new economic geography. We therefore explicitly consider that trade costs consist of the
transport costs and the tariffs.\footnote{Frankel, Stein and Wei (1995) also treat them explicitly in order to analyze the number of blocs. However, their tariffs are exogenously given, while ours are endogenous, which significantly complicates the entire analysis.} We extend Krugman’s (1980) model of firm migration, wherein each country engages in tariff competition in order to attain a high national welfare level. In particular, it differs from Krugman (1980) in that the tariffs are strategically determined, whereas the transport costs are exogenously given.

The specific structure of the model yields some interesting results. On the one hand, we show that when the transport cost is large enough, each country imposes a positive tariff. Such a tariff is shown to harm each other because it distorts market efficiency. Therefore, if both countries can reach mutually binding agreement of free trade, then it is a Pareto improvement for both countries. On the other hand, when the transport cost is small enough, we show that one of the two countries does not impose a tariff and firms migrate from a zero-tariff country to a positive-tariff country, leading to a core-periphery structure. In sum, we can say that de facto “free trade” agreements are likely to be concluded between neighbor countries like EU, whereas they are unlikely between distant countries like Japan.

The organization of the paper is as follows. In the next section, we present the model and characterize equilibria with agglomeration and non-agglomeration of firms for the given tariffs. In Section 3, we analyze the tariff competition in the case of both a large and small transport costs. In order to substantiate the analytical results, we perform numerical simulations, using the values of Anderson and van Wincoop (2004) in section 4. Section 5 concludes.

2 The model

The global economy comprises two countries, indexed by $r$ and $s$, and involves two sectors, called the manufacturing sector (M-sector) and the agricultural sector (A-sector). Each country is endowed with an identical number of homogenous workers
(= consumers) by mass $L_r = L_s = L/2$. Each worker supplies one unit of labor inelastically and is perfectly mobile between sectors but spatially immobile between countries.

Individual preferences are identical and described by the following utility function:

$$ U = \left[ \int_0^n q(i)^{\frac{1}{\sigma}} \, di \right]^{\frac{\sigma}{\sigma - 1}} q_A^\alpha $$

(1)

where $q(i)$ represents the consumption of a differentiated manufacturing good ($M$-good) of variety $i \in [0, n]$, $n$ is the mass of varieties, $q_A$ is the consumption of the homogenous agricultural good ($A$-good), $\sigma > 1$ measures both the elasticity of demand of any variety and the elasticity of substitution between any pair of varieties, $\mu$ is the expenditure share of $M$-goods, and $\alpha$ is the expenditure share of $A$-good, where $0 < \mu < 1$, $0 < \alpha < 1$ and $\mu + \alpha = 1$. Each individual maximizes her utility subject to the income constraint:

$$ \int_0^n p(i)q(i)di + q_A = y $$

(2)

where $p(i)$ is the price of the $M$-good $i$, $y$ is the income of an individual, and the price of the $A$-good is chosen as a numéraire.

Ex-post symmetry between varieties imposes that $q_{rs}(i) = q_{sr}$ for all variety $i$ produced in country $r$ and sold in country $s$. Thus, the first-order condition to maximize the individual utility yields the demand of each variety in country $s$ for a good produced in region $r$ as

$$ q_{rs} = \frac{p_{rs}^{-\sigma}}{P_s^{1-\sigma}} \mu y_s $$

(3)

where $p_{rs}$ is the price of any variety produced in country $r$ and sold in country $s$, $y_s$ is the individual income in country $s$,

$$ P_s = \left( n_r p_{rs}^{1-\sigma} + n_s p_{ss}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} $$

(4)

is the price index of $M$-goods in country $s$, and $n_r$ is the mass of firms in country $r$. Product differentiation ensures a one-to-one relation between firms and varieties. Thus, the number of firms and varieties in country $r$ is given by $n_r$. 

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On the production side, firms in the A-sector produce a homogenous good using labor under perfect competition and constant returns to scale. Without loss of generality, units are chosen such that one unit of output requires one unit of labor. Assuming costless transportation of the A-good, the equilibrium wage of workers is equalized between the countries as \( w_r = w_s = 1 \).\(^2\)

While both the firms in the A-sector and all the workers are immobile, the firms in the M-sector are mobile between countries. The production technology for any variety of M-goods needs the same marginal and fixed labor requirements, labeled \( c \) and \( F \) respectively, under increasing returns to scale in a monopolistically competitive market. We assume “iceberg” transport costs both between the countries and within each country: a firm in country \( r \) has to produce \( t_d q_{rs} \) units to satisfy the final demand \( q_{rs} \) in country \( s(\neq r) \), and \( t_d q_{rr} \) units to satisfy the final demand \( q_{rr} \) in country \( r \), where \( t_d(\geq 1) \) is the local retail and wholesale distribution costs (i.e. domestic transport costs) which are identical between countries, and \( t(\geq 1) \) denotes the international transport cost. We also assume that country \( s \) imposes the ad valorem tariff \( \tau_s \) on one unit of M-good imported from country \( r \), while no tariff is imposed on A-good. The transport costs “melt” during the process of trade, whereas the tariffs do not and are redistributed equally to workers in importing countries. Given the demand (3), each firm (i.e., each owner of capital) in country \( r \) maximizes its profits

\[
\pi_r = p_{rr} q_{rr} L_r + \frac{1}{1 + \tau_s} p_{rs} q_{rs} L_s - w_r \left[ c (t_d q_{rr} L_r + t_d q_{rs} L_s) + F \right]
\]  

(5)

The second term in (5) is discounted by \( 1 + \tau_s \) owing to the ad valorem tariff in country \( s \). This is because the share \( \tau_s/(1 + \tau_s) \) of export sales is levied by the government in importing country \( s \), and the share \( 1/(1 + \tau_s) \) of export sales is earned by a firm in exporting country \( r \).

The first-order conditions for maximization (5) with respect to \( p_{rr} \) and \( p_{rs} \) yield the

\(^2\)We assume \( \mu < 1/2 \) such that factor price equalization holds for any tariff. See Appendix A in Behrens, Lamorgese, Ottaviano and Tabuchi (2004) for more details.
equilibrium prices as
\[ p^*_r = \frac{\sigma c}{\sigma - 1} w_r t_d = 1 \]
\[ p^*_s = \frac{\sigma c}{\sigma - 1} (1 + \tau_s) w_r t_d = (1 + \tau_s) t \]  
where we normalize \( c = (\sigma - 1)/\sigma t_d \) and utilize the factor price equalization \( w_r = 1 \). Substituting (6) into (4), the price index of manufacturing goods in country \( r \) is rewritten as
\[ P_r \equiv \left[ (\lambda_r + \phi (1 + \tau_r)^{1-\sigma} \lambda_s) n \right]^{\frac{1}{1-\sigma}} \]  
where \( \lambda_r = n_r/n \) is the share of \( M \)-firms in country \( r \) with \( \lambda_r + \lambda_s = 1 \), \( \phi \equiv t^{1-\sigma} \) is the freeness of trade, where \( 0 \leq \phi \leq 1 \).

In what follows, we assume that both countries select their tariffs simultaneously, and then after having observed the decisions made, \( M \)-firms decide to enter the market, choose their locations and prices of \( M \)-goods. Therefore, the tariffs are determined by the Nash game of two countries, while the prices and spatial distribution are determined by monopolistic competition of a continuum of firms. Following the procedure of backward induction, we first solve the second stage of firm’s decision, given the tariffs of both countries in the next two subsections.

### 2.1 Non-agglomeration of firms

Assuming free entry and exit of \( M \)-firms in the market of each country, the profits must be driven down to zero in equilibrium. Plugging (6) into (5), we have the zero profit condition in country \( r \) as
\[ \pi^*_r = \frac{\mu L}{2\sigma n} \left[ \frac{y_r}{\lambda_r + \phi (1 + \tau_r)^{1-\sigma} \lambda_s} + \frac{\phi y_s}{\phi (1 + \tau_s) \lambda_r + (1 + \tau_s) n \lambda_s} \right] - F = 0 \]  
Solving \( \pi^*_r = \pi^*_s = 0 \) and \( \lambda_r + \lambda_s = 1 \) yields the unique equilibrium distribution of firms \( (\hat{\lambda}_r, \hat{\lambda}_s) \) and the unique equilibrium number of firms \( \hat{n} \).

Unlike the transport costs, the tariffs do not disappear during the trading processes. The equilibrium tariff revenue per worker in country \( r \) is given and computed as
\[ T_r^* = \frac{\tau_r p^*_r q^*_r L_r n_s}{1 + \tau_r} = \frac{\mu \phi y_r \tau_r \lambda_s}{(1 + \tau_r)^{1-\sigma} \lambda_r + \phi (1 + \tau_r) \lambda_s} \]  

where \( \tau_s / (1 + \tau_s) \) is the tariff share, \( p_{sr}^* q_{sr} L_r n_s / L_r \) is the total import of \( M \)-goods divided by the number of individuals in country \( r \), and the prices (6) and the demand (3) are substituted.

Each worker in country \( r \) has two sources of income: wage income \( w_r \) and the tariff revenue \( T_r^* \):

\[
y_r = w_r + T_r^* \tag{10}
\]

Thus, substituting \( \lambda_r = \hat{\lambda}_r \), \( \lambda_s = \hat{\lambda}_s \), and \( n = \hat{n} \) into (10) for countries \( r \) and \( s \), we have a system of two linear equations with respect to \( y_r \) and \( y_s \). Solving them and plugging the solution into \( \lambda_r^\text{int} \) and \( \lambda_s^\text{int} \) yields a unique interior solution of the spatial distribution of \( M \)-firms

\[
\lambda_r^\text{int} = \left[ (1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi (2 + \alpha \tau_r) (1 + \tau_s)^\sigma + \phi^2 (1 + \alpha \tau_r) \right] A_1 (\tau_r, \tau_s)^{-1} \tag{11}
\]

where

\[
A_1 (\tau_r, \tau_s) \equiv 2 (1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi (1 + \tau_r)^\sigma (2 + \alpha \tau_s) + (1 + \tau_s)^\sigma (2 + \alpha \tau_r) + \phi^2 (2 + \alpha \tau_r + \alpha \tau_s)
\]

Hence, the equilibrium distribution of \( M \)-firms is given by

\[
\lambda_r^* = \begin{cases} 
0 & \text{if } \lambda_r^\text{int} \leq 0 \\
\lambda_r^\text{int} & \text{if } 0 < \lambda_r^\text{int} < 1 \\
1 & \text{if } \lambda_r^\text{int} \geq 1
\end{cases} \tag{12}
\]

When the solution is interior \( \lambda_r^* = \lambda_r^\text{int} \), the equilibrium configuration is non-agglomerated, where the number of firms is

\[
n^* = \mu L \left[ (1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi^2 \right] A_1 (\tau_r, \tau_s) / 2 \sigma F A_2 (\tau_r, \tau_s)
\]

the individual income is

\[
y_r^* = \frac{A_3 (\tau_r, \tau_s)}{[(1 + \tau_r)^\sigma - \phi] [(1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi^2 (1 + \alpha \tau_r) (1 + \alpha \tau_s)]} \tag{13}
\]

and the price index is

\[
P_r^* = \left[ \mu L \left[ (1 + \tau_s)^\sigma - \phi^2 \right] A_4 (\tau_r, \tau_s) / 2 \sigma F A_2 (\tau_r, \tau_s) \right] \frac{1}{\mu L}
\]

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Here,
\begin{align*}
A_2(\tau_r, \tau_s) &\equiv [(1 + \tau_r)^\sigma - \phi] [(1 + \tau_s)^\sigma - \phi] [(1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi^2 (1 + \alpha \tau_r) (1 + \alpha \tau_s)] \\
A_3(\tau_r, \tau_s) &\equiv (1 + \tau_r)^{2\sigma} (1 + \tau_s)^\sigma - \phi (1 + \tau_r)^\sigma (1 + \tau_s)^\sigma [1 - (1 - \alpha) \tau_r] \\
&\quad - \phi^2 (1 + \tau_r)^\sigma (1 + 2 \tau_r - \alpha \tau_r + \alpha \tau_s + \alpha \tau_r \tau_s) + \phi^3 (1 + \tau_r) (1 + \alpha \tau_s) \\
A_4(\tau_r, \tau_s) &\equiv (1 + \tau_r)^\sigma (1 + \tau_s)^\sigma - \phi (1 + \tau_s)^\sigma [1 - (1 - \alpha) \tau_s] - \phi^2 (1 + 2 \tau_r - \alpha \tau_r + \alpha \tau_s + \alpha \tau_r \tau_s) \\
&\quad + \phi^3 (1 + \tau_r)^{1-\sigma} (1 + \alpha \tau_s)
\end{align*}

The indirect utility in non-agglomerated equilibrium is therefore computed as
\begin{equation}
V^*_r = \frac{y^*_r}{(P^*_r)^\mu} \tag{15}
\end{equation}
where $y^*_r$ and $P^*_r$ are given by (13) and (14). Hence, the indirect utility (15) is expressed as a function of the two strategic variables $\tau_r$ and $\tau_s$ together with the parameters $\sigma$, $\phi$, $F$, $L$, and $\alpha(= 1 - \mu)$. The strategic variables $(\tau_r, \tau_s)$ are determined in the next section.

### 2.2 Agglomeration of firms

We have analyzed the non-agglomerated configuration $\lambda^*_r \in (0, 1)$ in the previous section. However, $\lambda^\text{int}_r$ in (12) is not necessarily in the interval of $(0, 1)$. For example, if the transport cost $t$ is small, $\tau_r$ is small, and $\tau_s$ is large, then $\lambda^\text{int}_r < 0$ holds from (11), which implies a corner solution $(\lambda^c_r, \lambda^c_s) = (0, 1)$. In this case, solving the zero profit condition (8) for country $s$ with $(\lambda^c_r, \lambda^c_s) = (0, 1)$, we have the agglomerated equilibrium, where the number of firms is computed as

$$
\hat{n}^c = \frac{L (1 - \alpha) (2 + \alpha \tau_r)}{2 \sigma F (1 + \alpha \tau_r)}
$$

Solving (10) with $\lambda^c_r = 0$ and $n^c = \hat{n}^c$ yields the incomes

$$
y^c_r = \frac{1 + \tau_r}{1 + \alpha \tau_r}, \quad y^c_s = 1
$$

and the utilities

$$
V^c_r = \frac{\mu L \phi (2 + \alpha \tau_r)}{2 \sigma F (1 + \alpha \tau_r)} \frac{1 + \tau_r}{(1 + \tau_r)^\alpha (1 + \alpha \tau_r)}
$$
$$
V^c_s = \frac{\mu L (2 + \alpha \tau_r)}{2 \sigma F (1 + \alpha \tau_r)} \frac{2^{\mu - 1}}{(1 + \alpha \tau_r)^{\mu - 1}} \tag{16}
$$
Observe that these utilities do not involve $\tau_s$ because no firm in country $r$ ($\lambda_r^c = 0$) means no import in country $s$. This implies *de facto* “free trade”.

## 3 Tariff competition

Thus far, the tariffs are considered to be exogenously given in the location and price competition by $M$-firms. We now proceed to investigate the first-stage tariff competition, where each country noncooperatively chooses its tariff in order to maximize its national welfare, anticipating the consequences of the location and price competition by $M$-firms.

Setting a high tariff has three effects on the welfare. The first is tariff jumping effect. A high tariff induces in-migration of firms because firms want to avoid incurring the burden of a high tariff. Attracting firms implies a decrease in the prices of the goods for in-migration firms due to reduction in the transport cost $t$, which enhances the welfare. The second is tariff income effect. A high tariff implies a high tariff revenue and a high income, which raises the welfare. The third is market distortion effect, which is opposite to these two effects. A high tariff distorts the market by raising the prices of imported goods, which decreases the welfare. The country’s welfare is thus depending on which effects are dominant. It can be analytically verified in the following subsections that the first two effects dominate the third in the case of a large transport cost, but that the reverse is true in the case of a small transport cost.

### 3.1 When the transport cost is large

Differentiating the interior distribution $\lambda^*_r = \lambda^\text{int}_r$ with respect to $\tau_r$, it is shown that

$$\frac{\partial \lambda^\text{int}_r}{\partial \tau_r} > 0 \quad (17)$$

when $\tau_r$ is close to $\tau_s$ (otherwise $\lambda^*_r = 0, 1$). This implies that a tariff reduction leads to a loss of firms because firms move to a higher-tariff country in order to avoid paying a higher tariff when exporting $M$-goods. Such tariff-jumping by firms that are a source of
foreign direct investments is supported empirically by Blonigen (2002) and theoretically by Konishi, Saggi and Weber (1999).

This is true in our framework. When the transport cost between the countries is large, we can establish the following (the proof is contained in Appendix A).

**Proposition 1** When the transport cost is sufficiently large, there exists a unique Nash equilibrium such that both countries impose the same positive tariff:

\[
\tau_r^* = \tau_s^* = \frac{1}{\sigma - 1}
\]  

(18)

In the presence of a large transport cost between countries, each country attempts to attract firms by raising tariffs because firms want to increase market access and avoid paying the high tariff when exporting $\mathcal{M}$-goods (tariff jumping effect), which also increases the tariff revenue (tariff income effect). These two effects are more important for each noncooperative country than the market distortion effect, which results from the imposition of a high tariff. It should be noted that although (18) is a standard result Krugman, 1991a; Gros, 1987), we show below that this is not true for small transport costs.

A positive tariff adversely affects the other country. In fact, given the same tariff between two countries $\tau_r = \tau_s = \tau$, it is readily shown that the welfare level necessarily decreases with the tariff:

\[
\frac{\partial V^*_r}{\partial \tau} \bigg|_{\tau_r = \tau_s = \tau} < 0
\]

where $V^*_r$ is given by (15). We thus obtain the following.

**Proposition 2** In the presence of a large transport cost, tariff competition harms each other.

Proposition 2 implies that when the transport cost between countries is relatively large, tariff competition distorts the $\mathcal{M}$-goods market, which leads to a so-called prisoners’ dilemma. Therefore, if mutually binding agreement of free trade is possible, the two countries would benefit more from such an arrangement. In reality, however, such a free trade agreement is rarely concluded between distant countries.
3.2 When the transport cost is small

In the previous subsection, we have seen that a tariff reduction triggers out-migration of firms, which would decrease the consumer utility. This serves as an incentive for each government to set a positive tariff, although it ends up with the prisoners’ dilemma.

However, this is not true for small transport cost $t$. Because the market access becomes easy for both countries, and because the tariff revenues decrease, attracting firms by raising tariffs is no longer unimportant. In fact, it can be verified that setting zero tariff is a dominant strategy when the transport cost is small enough (the proof and the expression of $\phi$ are given in Appendix B).

**Proposition 3** When the transport cost is small ($\phi > \hat{\phi}$), there exist Nash equilibria such that one country imposes a sufficiently high tariff and another zero tariff: $\tau^*_s \gg \tau^*_r = 0$.

Proposition 3 suggests that when each country maximizes its welfare by tariff competition under small transport cost, one of the two countries does not impose a tariff for importing goods in Nash equilibrium. Then, all the firms would move out from the zero-tariff country because of the inequality (17). Consequently, no tariff revenue is generated in both countries: no firm in country $r$ implies no imports from country $r$ and no tariff revenue in country $s$ despite imposing a positive tariff; and zero tariff in country $r$ implies no tariff revenue in country $r$ despite importing $M$-goods. We may therefore conclude that tariff competition leads to de facto free trade in spite of the fact that the economy exhibits a core-periphery structure; this is in sharp contrast to Proposition 1.

We have seen in the previous subsection that reducing the tariff leads to loss of firms because they prefer to locate in a higher-tariff country in order to avoid the

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3If we allow for negative tariffs (i.e. import subsidies), which are seldom observed in the real world, the Nash equilibrium tariffs may become negative for a small transport cost. This is because negative tariffs correct market distortions by decreasing the $M$-good prices, which are higher than the marginal costs in monopolistic competition (see Ottaviano, Tabuchi and Thisse, 2002, section 5).
tariff barriers in exporting M-goods. Moreover, reducing the tariff decreases the tariff revenue for each worker. However, a tariff reduction depreciates the prices of imported goods and, hence, the consumer price index, which in turn increases the consumer utility. In fact, $V^c_r$ in (16) is decreasing in $\tau_r$, implying that the peripheral country has no incentive to impose a tariff in the case of an agglomerated configuration. Due to the mixed effects of tariff reduction on the welfare, the net effect is generally not clear. However, if the transport cost is small enough, it can be shown that the losses are outweighed by the gains from free trade due to the lower prices of imported goods. Consequently, each country has an incentive to remove the tariff. Stated differently, an international binding agreement for free trade is not required when the transport cost is so small that an agglomerated equilibrium is realized. Thus, the small transport cost presents the opportunity of attaining a socially efficient outcome with no market-distorting tariffs. The policy implication would be that it is more desirable to allow than to prohibit firm migration when the transport cost is small.

When $\tau^*_s \gg \tau^*_r = 0$, the individual utilities in (16) are simplified as

$$
V^c_r = \left( \frac{\mu L \phi}{\sigma F} \right)^{\frac{\mu}{\sigma-1}} \quad V^c_s = \left( \frac{\mu L}{\sigma F} \right)^{\frac{\mu}{\sigma-1}}
$$

From $\phi < 1$, we have $V^c_r < V^c_s$: workers in peripheral country $r$ attains a lower welfare because they have to incur the entire transport cost. Tariff competition induces core-country to set the positive tariff and brings externality about the economy. Nevertheless, they benefit from no tariff. That is, country $r$ chooses zero tariff by allowing country $s$ to attract all firms; this is more beneficial than engaging in fierce tariff competition.

In particular, when the transport cost between the countries is negligible, we have the following.

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4Conversely, imposing a prohibitively high tariff in country $r$ would attract all firms. However, these firms would have to incur the non-negligible import tariff in the other country $\tau^*_s \gg 0$, which would decrease the welfare, and hence such a high tariff would not be chosen.
Corollary 1 In the absence of the transport cost, there exists a continuum of Nash equilibria such that at least one country does not impose a tariff:

\[ \tau_r^* = 0 < \tau_s^* \text{ with } \lambda_r^* = 0 \text{ or} \]
\[ \tau_r^* = \tau_s^* = 0 \text{ with arbitrary } \lambda_r^*. \]

Finally, summing up the propositions with large and small transport costs between countries, we may conclude that neighboring countries are likely to conclude de facto “free trade” agreements, such as NAFTA and EU, but that other OECD countries like Japan and Australia are too remote to conclude de facto “free trade” agreements with NAFTA and EU countries.

4 Simulations

So far, we have examined the cases of large and small transport costs between countries. In the case of intermediate transport costs, we are unable to get analytical results because the indirect utilities are not quasi-concave, and highly nonlinear with respect to the tariffs. We therefore resort to a numerical analysis by using Newton methods in Mathematica. Given the parameter values, we can calculate Nash equilibrium tariffs numerically.

The parameter values are set as follows. The expenditure share of \( M \)-goods, \( \mu = 0.24 \), is derived from the average manufacturing share of the value added in 30 OECD countries in 2000. The international transport cost, \( t = 1.21 \), the domestic transport cost (local distribution cost), \( t_d = 1.55 \), and the tariff (border-related trade barriers), \( \tau_r^* = \tau_s^* = 0.44 \), are taken from Anderson and van Wincoop (2004) presented in the introduction. The only parameter we do not know is the elasticity of substitution, \( \sigma \). However, \( \sigma \) can be determined as \( \sigma = 2.7 \) by numerically solving \( \partial V_r^*/\partial \tau_r = 0 \) for \( \sigma \) given the above parameter values.

We therefore set \( \mu = 0.24 \) and \( \sigma = 2.7 \), and compute the best response tariffs for different values of the transport cost \( t \), ranging from 1 to infinity as explained in
Appendix C. Let $t_1$ be the solution of $V_r^*|_{\tau_r=\tau_s=1/(\sigma-1)} = V_r^c|_{\tau_r=0, \tau_s=1/(\sigma-1)} = \left(\frac{\mu \phi}{\sigma \rho} \right)^{\frac{\sigma}{\sigma-1}}$, and $t_2$ be the solution of $\max_{\tau_r} V_r^*|_{\tau_s \to \infty} = V_r^c|_{\tau_r=0, \tau_s=1/(\sigma-1)}$. Then, the results are summarized as follows:

(i) If $t > t_2$, there is a dispersed configuration with a Nash equilibrium $\tau_r^* = \tau_s^* > 0$ (which corresponds to Proposition 1).

(ii) If $t_1 < t < t_2$, there is a dispersed configuration with a Nash equilibrium $\tau_r^* = \tau_s^* > 0$ and an agglomerated configuration with Nash equilibria $\tau_s^* \gg \tau_r^* = 0$ and $\tau_r^* \gg \tau_s^* = 0$.

(iii) If $1 \leq t < t_1$, there is an agglomerated configuration with Nash equilibria $\tau_s^* \gg \tau_r^* = 0$ and $\tau_r^* \gg \tau_s^* = 0$ (which corresponds to Proposition 3).

Accordingly, we may confirm that the Nash equilibrium tariffs are positive for large transport costs and zero for small transport costs. Because the actual value $t = 1.21$ in Anderson and van Wincoop (2004) is between the thresholds $t_1 = 1.16$ and $t_2 = 1.28$, we are in a position of case (ii) on average. However, the transport cost $t$ would be large between distant countries like the United States and Japan, whereas the transport cost would be small between neighboring countries like Belgium and Luxemburg. Choosing a positive tariff by each country is a Nash equilibrium between them in the former case, while zero tariff in the latter. As the transport cost goes down to below $t_1$ due to technical progress in the transport sector, the above results predict transition to case (iii). This implies that the core-periphery structure with de facto “free trade” may be realized without any international coordination not in the far future.

5 Concluding remarks

Since regions under study belong to the same country in new economic geography, transport costs constitute a significant fraction of the trade costs; hence, the trade costs are considered exogenous. On the other hand, in new trade theory, tariff barriers account for a non-negligible proportion of the trade costs; therefore, the trade costs are
considered endogenous. We developed a unified model of the new economic geography and new trade theory, where the transport costs melt according to the conventional assumption, but the tariffs do not melt and are redistributed equally to consumers.

On analyzing Nash equilibrium of the tariff competition, we showed that when the transport cost is small, one of the two countries does not impose a tariff, in which the core is associated with a positive tariff and the periphery is associated with zero tariff. Therefore, trade is virtually free. We also showed that in the case of a high transport cost, tariff competition harms each country, which suggests the necessity of mutually binding agreement of free trade from a welfare point of view.

It is worth studying several extensions of this model along these lines. First, in order to examine the North-South trade, one may consider the tariffs of both the $A$-good and the $M$-goods, which means each country has two strategic variables. Second, it may be interesting to investigate positive and negative feedbacks due to mobility of workers as well as of firms, which is assumed in Krugman’s (1991b) new economic geography. We would expect a dramatic increase in the geographical concentration of industrial activities via self-reinforcing agglomeration processes. Finally, it may also be interesting to consider using the tariff revenues to finance public goods instead of redistributing these revenues equally among workers, and to reexamine the effect on social welfare.

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Appendix A. Proof of Proposition 1

When $\lambda^*_r \in (0, 1)$, the indirect utility can be rewritten as

$$V_r^* = (y_r^*)^{1 + \frac{\mu}{\sigma}} A_5 (\tau_r, \tau_s) ^{\frac{\mu}{\sigma}}$$

where

$$A_5 (\tau_r, \tau_s) \equiv \frac{\mu L [ (1 + \tau_s)^\sigma - \phi^2 (1 + \tau_r)^{-\sigma} ]}{2 \sigma F [(1 + \tau_s)^\sigma - \phi]}$$

Then,

$$\frac{\partial V_r^*}{\partial \tau_r} = (y_r^*)^{\frac{\mu}{\sigma} - 1} A_5 (\tau_r, \tau_s) ^{\frac{\mu}{\sigma} - 1} \left( \frac{\partial y_r^*}{\partial \tau_r} + \frac{y_r^*}{A_5 (\tau_r, \tau_s)} \frac{\partial A_5 (\tau_r, \tau_s)}{\partial \tau_r} \right)$$

(19)

When $t$ is sufficiently large, we get

$$\lim_{t \to \infty} \frac{\partial y_r^*}{\partial \tau_r} = \mu \phi (1 + \tau_r)^{-\sigma - 1} (1 + \tau_r - \sigma \tau_r)$$

$$\lim_{t \to \infty} y_r^* = 1$$

$$\lim_{t \to \infty} \frac{\partial A_5 (\tau_r, \tau_s)}{\partial \tau_r} = \frac{\mu L \phi^2}{2 F} (1 + \tau_r)^{-\sigma - 1} (1 + \tau_s)^{-\sigma}$$

$$\lim_{t \to \infty} A_5 (\tau_r, \tau_s) = \frac{\mu L}{2 \sigma F}$$

Since $t \to \infty$ implies $\phi \to 0$, the second term of (19) disappears more quickly than does the first one. Hence,

$$\lim_{t \to \infty} \frac{\partial V_r^*}{\partial \tau_r} \approx (y_r^*)^{\frac{\mu}{\sigma} - 1} A_5 (\tau_r, \tau_s) ^{\frac{\mu}{\sigma} - 1} \frac{\partial y_r^*}{\partial \tau_r}$$

$$= \mu \phi (1 + \tau_r)^{-\sigma - 1} (1 + \tau_r - \sigma \tau_r) \left( \frac{\mu L}{2 \sigma F} \right) ^{\frac{\mu}{\sigma} - 1}$$

which implies

$$\frac{\partial V_r^*}{\partial \tau_r} \geq 0 \quad \text{when} \quad \tau_r \leq \frac{1}{\sigma - 1}$$

This means that (18) is a unique Nash equilibrium. $\blacksquare$

Appendix B. Proof of Proposition 3

(a) Interior solution. When $\lambda^*_r \in (0, 1)$, we want to show that (19) is negative for all $\tau_r$ so that any interior solution of $\lambda^*_r \in (0, 1)$ is not an equilibrium outcome in tariff competition for small $t$ and sufficiently large $\tau_s$. 

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First, we show that the second term in (19) approaches zero. Since \( \lim_{\tau_s \to \infty} y^*_r > 0 \) and \( \lim_{\tau_s \to \infty} A_5(\tau_r, \tau_s) > 0 \), we have
\[
\lim_{\tau_s \to \infty} \frac{\partial A_5(\tau_r, \tau_s)}{\partial \tau_r} = \lim_{\tau_s \to \infty} \frac{\mu L \phi^2 (1 + \tau_r)^{-\sigma - 1}}{2F[(1 + \tau_s)^\sigma - \phi]} = 0
\]

Second, we show that the first term in (19) is negative. This is to show that \( \lim_{\tau_s \to \infty} \frac{\partial y^*_r}{\partial \tau_r} = \mu \phi A_6[(1 + \tau_r)^\sigma - \phi] < 0 \)

when \( \tau_r \) ensures an interior solution of \( \lambda^*_c \in (0,1) \). That is, we show \( A_6 < 0 \). For sufficiently large \( \tau_s \), we get
\[
\lim_{\tau_s \to \infty} \lambda^*_c = \frac{A_7}{2(1 + \tau_r)^\sigma - \phi(2 + \alpha \tau_r)}
\]

Since the denominator of \( \lim_{\tau_s \to \infty} \lambda^*_c \) is always positive, the interior solution condition of \( \lambda^*_c \) is given by \( A_7 > 0 \).

Because \( A_6 \) is decreasing in \( \tau_r \) and \( A_7 \) is increasing in \( \tau_r \), we need to show that \( A_6 < 0 \), when \( A_7 = 0 \). Thus, eliminating \( \tau_r \) in \( A_6 < 0 \) and \( A_7 = 0 \), we have
\[
\phi > \hat{\phi} \equiv \frac{\left[ \sqrt{4\sigma (\sigma - 1) + \mu^2 - 2\sigma \mu + \mu} \right]^\sigma}{2^{\sigma - 1}(\sigma - 1)^{\sigma - 1}(1 - \mu) \left[ \sqrt{4\sigma (\sigma - 1) + \mu^2 + 2\sigma - 2 - \mu} \right]} \in (\sqrt{e}/2, 1)
\]

where \( \hat{\phi} \) is monotonic in \( \sigma \) and \( \mu \). Consequently, when \( \phi > \hat{\phi}, A_6 < 0 \) and \( \lim_{\tau_s \to \infty} \partial y^*_r / \partial \tau_r < 0 \). Thus, the first term in (19) is negative.

Since (19) is always negative for small \( t \) and sufficiently large \( \tau_s \), country \( r \) does not choose a tariff that yields an interior solution \( \lambda^*_c \in (0,1) \).

(b) **Corner solutions.** When \( \lambda^*_c = 0 \), we want to show that the indirect utility as given by \( V^*_r \) in (16) is decreasing in \( \tau_r \), so that the best reply for country \( r \) is \( \tau_r = 0 \). Since \( \partial V^*_r / \partial \tau_r < 0 \) is readily verified, \( \tau^*_s \gg \tau^*_r = 0 \) is a Nash equilibrium.

Finally, when \( \lambda^*_c = 1 \), we have the utility in \( r \) \( V^{cc}_r \) is given by \( V^*_r \) in (16). Since \( V^*_r |_{\tau_r = 0} > V^{cc}_r |_{\tau_r \gg \tau^*_s} \) is easily shown, there is no Nash equilibrium when \( \lambda^*_r = 1 \). Hence, \( \tau^*_r \gg \tau^*_s = 0 \) is a Nash equilibrium.  

\[\blacksquare\]
Appendix C. Computations of Nash equilibria

We set $\mu = 0.24, \sigma = 2.7, L = 100, F = 1$.

(i) When the transport cost is intermediate $t = 1.21 \in (t_1, t_2) = (1.16, 1.28)$, there exist both the symmetric equilibrium $\tau_r^* = \tau_s^* = 1/(\sigma - 1)$ and a continuum of asymmetric equilibria $\tau_s^* \gg \tau_r^* = 0$ and $\tau_r^* \gg \tau_s^* = 0$ as illustrated in Fig. 1. The contours are iso-utilities in country $r$. The domain left to the dashed curve $\lambda_r^{\text{int}} = 0$ is the corner solution $\lambda_r^* = 0$, the gray domain (B) below the dashed curve $\lambda_r^{\text{int}} = 1$ is the corner solution $\lambda_r^* = 1$, and the remaining domain between $\lambda_r^{\text{int}} = 0$ and $\lambda_r^{\text{int}} = 1$ is the interior solution $\lambda_r^* \in (0, 1)$. Examining the contours, we can get that country $r$’s best reply is line segment $B_1B_2$, dotted curve $B_3B_4B_5$ and domain B. Because country $s$’s best reply is symmetric about the 45 degree line, Nash equilibria are given by the intersections of the two best replies: $B_1B_2$ ($\tau_s^* \gg \tau_r^* = 0$, $(V_r^*, V_s^*) = (1.3, 1.361)$), $B_4$ ($\tau_r^* = \tau_s^*, V_r^* = V_s^* = 1.307$) and $B_5B_7$ ($\tau_r^* \gg \tau_s^* = 0$, $(V_r^*, V_s^*) = (1.361, 1.3))$.

(ii) When the transport cost is small $t = 1.05 \in (1, t_1) = (1, 1.16)$, we have a continuum of asymmetric equilibria $\tau_s^* \gg \tau_r^* = 0$ and $\tau_r^* \gg \tau_s^* = 0$, which are illustrated in Fig. 2. Unlike Fig. 1, the intersection $B_4'$ is no longer a symmetric equilibrium. Examining the contours, we get that country $r$’s best reply is line segment $B_1B_2$ and gray domain B. Nash equilibria are therefore given by the intersections of the two best replies: $B_1B_2$ ($\tau_s^* \gg \tau_r^* = 0$, $(V_r^*, V_s^*) = (1.345, 1.36))$ and $B_6B_7$ ($\tau_r^* \gg \tau_s^* = 0$, $(V_r^*, V_s^*) = (1.36, 1.345)$).

[Insert Fig. 1 and Fig. 2 about here]

References


Figure 1: Nash equilibria when the transport cost is intermediate ($t=1.21$)

Figure 2: Nash equilibria when the transport cost is small ($t=1.05$)