Welfare Effects of Import Tariff and Export Subsidy Games

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Abstract
This paper integrates the conventional models of reciprocal tariffs, countervailing duties, and reciprocal export subsidies into one framework and examines the welfare effects of these trade policies. We consider two types of countries (home and foreign countries) and two types of firms (home and foreign firms) and focus on the relationships between marginal costs and shifts in the welfare of countries. Then, we find that in a subgame perfect Nash equilibrium, reciprocal tariffs (not countervailing duties or reciprocal export subsidies) definitely prevail. This result may explain the fact that we rarely see countervailing duties in practice and that countries have difficulties with tariff reduction.

JEL Classification: F12 ; F13

1. Introduction
In his seminal paper (1953-4), Johnson shows which country gains from reciprocal tariffs. After his work was published, many contributions to trade wars and retaliation have been offered. The present paper integrates the conventional models of reciprocal tariffs, countervailing duties, and reciprocal export subsidies into one framework and examines the welfare effects of import tariff and export subsidy games with Cournot duopoly.

In previous literature on the tariff-tariff regime (i.e., tariff wars), Kuga (1973) calcu

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lates welfare using the tariff policies of various countries. He shows that a policy equilibrium exists wherein no country has an incentive to alter its own tariff policy; Gros (1987) uses Krugman's monopolistic competition model (1980) to demonstrate that tariff wars between two countries of equal size lead to a welfare loss.¹

With regard to the subsidy-tariff regime (i.e., countervailing duties), Dixit (1988) considers the home country's optimal trade policy in response to a foreign government's subsidies. He presents some theoretical support for tariffs in an international oligopoly, where the tariffs depend on the size of the effect in demand and the extent of the market competition. In Collie (1991), we find a home country that uses tariff gains from foreign export subsidies.²

Moreover, for the subsidy-subsidy regime, Brander and Spencer (1985) reveal that a country may increase its welfare by providing export subsidies to its firms, and Collie (1993) argues that a country is better off with subsidies only when its firms are significantly more competitive than rival firms.³ However, it should be noted that these researchers devote their works to the situation in which firms sell all their goods solely in a third country.⁴

In this paper, unlike previous papers, we investigate the relationships between a firm's production costs and shifts in the welfare of countries arising from trade wars, by using a simple Cournot model with two types of countries (home and foreign countries) and two types of firms (home and foreign firms) that produce homogeneous goods.⁵ For the purpose of studying the home government's optimal response to the foreign trade policy, this paper focuses on the policy game in which the foreign country

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⁴ The reciprocal market model, including the subsidy-subsidy regime, is treated in Dixit (1984); however, he considers the policy mix of import tariffs, export subsidies, and subsidies for domestic sales, and does not examine the home country's optimal response to a foreign country's optimal policy.

⁵ However, Collie (1993) studies the relationship between the costs of firms that sell all their goods in a third country and the welfare of countries in the subsidy-subsidy regime.
determines the trade policy before the home country does so and considers a subgame perfect Nash equilibrium (see figure 1).

First, we consider the situation wherein both the foreign and home governments impose tariffs on imports. It is then found that both types of countries do not benefit when each has firms with similar production technology: on the other hand, the home (foreign) country gains from tariffs if the home (foreign) firms have a disadvantage in production costs, to some extent.

Next, we consider the case in which both countries provide export subsidies. In this case, there are four possible results. If both firms have relatively small (large) costs, both countries are better (worse) off with reciprocal export subsidies; on the other hand, when the home (foreign) firms have a cost advantage to some extent, only the home (foreign) country is better off. This sharply contrasts with the results found in Collie (1993). He shows a country gains from subsidies only when its firms are significantly more competitive than rival firms and there is no possibility that both countries are better off. The market structure feature marks the difference between Collie (1993) and this paper. Collie (1993) considers only a third country market, while we consider home and foreign markets; therefore, export subsidies in this paper affect not only the firms’ profit but also the countries’ consumer surplus.

Thirdly, we consider the case in which the foreign government provides export subsidies (imposes tariffs) and the home government imposes tariffs (provides export subsidies). We then find that countries using import tariffs gain from such trade wars, while countries using export subsidies are always worse off. Note that in the subsidy-tariff reg-
ime (i.e., in the case of countervailing duties), the optimal rate of export subsidy is negative, whereas in the tariff-subsidy regime, it is positive. This correlates to Wang (2004). He shows that if the existing tariff is sufficiently high, foreign export subsidization occurs and the countervailing duties are zero.

Finally, we consider the subgame perfect Nash equilibrium in policy games. We then find that the home country imposes tariffs, regardless of the trade policies adopted by the foreign country; additionally, if the home country levies tariffs, the foreign country does the same. In other words, in a subgame perfect Nash equilibrium, tariff wars definitely prevail. This may explain the fact that countervailing duties are rarely used in practice and that it is difficult for governments to reduce tariffs.

The remainder of this paper is organized as follows. Section 2 considers the firms' behaviors. Section 3 investigates the welfare effects of trade wars. Section 4 considers the subgame perfect Nash equilibrium in policy games, and the last section presents our conclusions.

2. The Firms' Behaviors

The game considered in this paper is as follows: in the first stage, the foreign government determines the trade policy; in the second stage, the home government determines the trade policy; and in the third stage, the home and foreign firms determine their outputs (see figure 1). We must solve the game backwards to arrive at the subgame perfect Nash equilibrium. Thus, in this section, we first consider the firms' behavior.

Consider two firms: one is in the home country and the other is in the foreign country. In both countries, the firms produce homogeneous goods and engage in Cournot competition. That is, both countries export goods to each other. We assume that the home and foreign markets are segmented and that the export transport cost is zero. Then, the total profits of each firm is

\[ \Pi_i = \pi_i = (\pi_i^f - c_i) x_i^f + (\pi_i^h - c_i - t_i + s_i) x_i^h, \quad \text{for } i, j = h, f, \]

where \( h \) and \( f \) denote home and foreign firms, respectively, \( \pi_i \) represents the profits of firm \( i \) in market \( j \), \( \pi_i^f \) is the price of the good in market \( i \), \( c_i \) is the constant marginal cost.

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6) We do not consider the policy mix of import tariffs and export subsidies since it may be hard for governments to provide such a full treatment of protection to a particular industry.

7) The WTO shows that the number of cases of initiated countervailing duties during the period July 2002-June 2003 was only 13 (WTO (2004) pp. 43-45).
of firm $i$, $x_i$ is the output of firm $i$ in market $j$. $t_i$ is the tariff rate determined by government $j$, and $s_i$ is the rate of export subsidy determined by government $i$. In addition, we assume a linear demand function, that is, $p^i = \alpha - x_i - x_j$, $(\alpha > c_i)$.  

Then, Cournot competition in the third stage yields firm $i$'s equilibrium outputs:

$$x_i = (\alpha - 2c_i + c_j + t_i - s_i)/3 \tag{2}$$

$$x_i = (\alpha - 2c_i + c_j - 2t_i + 2s_i)/3. \tag{3}$$

Here, we define country $i$'s welfare as follows:

$$W_i = \pi_i + \pi_j + CS_i + t_i x_i - s_i x_i. \tag{4}$$

where $CS_i$ is the consumer surplus of country $i$: $CS_i = (x_j + x_i)^2/2$.

3. The Welfare Effects of Import Tariff and Export Subsidy Games

3.1. Tariff-Tariff Regime

In this subsection, we consider the situation wherein both countries impose tariffs (do not provide export subsidies). As already mentioned, we assume that the home government determines the tariff rate after the foreign government: however, whether the home government determines its trade policy before or after the foreign government's determination of the tariff rate is independent of our result in this regime, since the market is segmented and the firms' cost functions are linear.  

From the first order condition of (4), the tariff rate, which is announced by the government of country $i$, is

$$t_i = (\alpha - c_i)/3 \tag{5}$$

In order to compare the welfare in the tariff-tariff regime to that in free trade, we calculate the welfare of both countries. Then, we get

$$W_i' = \overline{W}_i = (-7\alpha^2 + 56\alpha c_i - 40c_i^2 - 42\alpha c_j + 24c_i c_j + 9c_j^2)/162, \tag{6}$$

where $W_i'$ and $\overline{W}_i$ are the welfare of country $i$ in the tariff-tariff regime and in free trade, respectively. Let us represent the numerator of (6) as $f_i(c_i, c_j)$ and set $\alpha = 1$ without loss of generality: then, we obtain

$$f_i(c_i, c_j) = -7 + 56c_i - 40c_i^2 - 42c_j + 24c_i c_j + 9c_j^2. \tag{7}$$

If (7) assumes a positive value, it can be said reciprocal tariffs enhance the welfare of

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8) Such a linear example is, needless to say, subject to common criticism. The usual defense of analytical convenience applies (see Dixit (1988), Collie (1993), and Qiu (1995)).

9) In other words, there are no strategic relationships between home and foreign governments. Tanaka (1993a) considers this type of tariff war. He argues that tariff wars can enhance world welfare by saving transport cost.

10) In table 1, we summarize the welfare of the home and foreign countries in each regime.
country $i$.

In addition, we assume interior solutions; therefore, in order to assume a positive value for firms' outputs, the following should hold:

(8) $x_f^i > 0 \Leftrightarrow c_i < (3c_f + 1)/4$.

Figure 2 depicts the loci of (7). The curves of $f_i(c_h, c_f)$ and $f_f(c_h, c_f)$ indicate the pairs of $c_h$ and $c_f$ which assume $W''_h - \bar{W}_h = 0$ and $W''_f - \bar{W}_f = 0$, respectively. Then, the home (foreign) country is better off with reciprocal tariffs in area I(III); on the other hand, both countries are worse off in area II. This indicates that if the home (foreign) firms have a disadvantage in production costs, relative to the foreign (home) firms' costs to some extent, reciprocal tariffs enhance home (foreign) welfare: further, if both firms have similar production technology, both countries are worse off (i.e., the prisoners' dilemma occurs).

There is a very simple reason why the country with a cost disadvantage is better off as a result of the reciprocal tariffs. If the home firm is a minor one, tariffs imposed by the home government will extract large rents from the foreign firm and, therefore, there exists the possibility that the gains of the home country are bigger than the rents obtained by the foreign country. Thus, the home country's welfare with reciprocal tariffs can be better than that in free trade.
3.2. Subsidy-Subsidy Regime

In this subsection, we investigate the case in which both countries provide export subsidies (do not impose tariffs). As in subsection 3.2, the order of a government's determination of its trade policy is independent of our result.

From the first order condition, we obtain the optimal rate of export subsidy of country $i$ as follows:

$$s_i = (\alpha_i + c_i - 2c_i)/4.$$

Note that (9) can be either positive or negative.

In order to compare the welfare in the subsidy-subsidy regime to that in free trade, we calculate the welfare of both countries: then, we obtain the following equation:

$$W^*_i = \frac{1}{288} \left( 7\alpha_i - 50c_i + 43c_i^2 - 28ac_i - 164ac_i + 65c_i^2 + 64c_i^2 \right),$$

where $W^*_i$ is the welfare of country $i$ in the subsidy-subsidy regime. If (10) is positive, it can be said that reciprocal subsidies enhance the welfare of country $i$. In order to verify this, we represent the numerator of (10) as $g_i(c_i, c_j)$ and set $\alpha=1$ without loss of generality:

$$g_i(c_i, c_j) = 7c_i - 50c_i + 43c_i^2 - 28c_i - 164c_i + 64c_i^2.$$

In addition, since we assume interior solutions, we obtain the following equation:

$$x! > 0 \Leftrightarrow c_i < (2c_i + 1)/3.$$

Note that under (12), the optimal rate of export subsidy indicated by (9) is always positive.

In figure 3, (11) is depicted. The curves of $g_i(c_i, c_i)$ and $g_i(c_i, c_j)$ show the pairs of $c_k$ and $c_l$ which assume $W_k^* - \bar{W}_k = 0$ and $W^*_i - \bar{W}_i = 0$, respectively. Then, area I(III) indicates that only the home (foreign) country is better off; on the other hand, both countries are worse (better) off in area II(IV). This indicates that if both firms have relatively large (small) production costs, both countries are worse (better) off with reciprocal subsidies; further, when the home (foreign) firms have a cost advantage to some extent, only the home (foreign) country gains.

These results differ significantly from the model of a third country market, such as that proposed by Eaton and Grossman (1986) and Collie (1993). Export subsidies in our model can enhance consumer surplus and the effect becomes large when the firms' production costs are smaller. Thus, there exists the possibility that reciprocal export subsidies enhance the welfare of both countries.
3.3. Subsidy-Tariff Regime

Next, we study the case in which the foreign government determines the rate of export subsidy (or export tax) instead of import tariffs before the home government determines the tariff rate. In other words, this subsection considers countervailing duties.

From the first order conditions, we obtain the optimal tariff rate of the home country and the optimal subsidy rate of the foreign country:\[11:\]

\begin{align*}
(13) & \quad t_h = \frac{13\alpha - 12c_f - c_h}{40} \\
(14) & \quad s_f = \frac{4c_f - 3c_h - \alpha}{40}.
\end{align*}

Note that (13) is positive, while (14) can assume either a positive or negative value. This indicates that the foreign government may impose an export tax.\[12\]

From the above calculation, we obtain the following equations:

\begin{align*}
(15) & \quad W_{h}^{opt} - W_h = \frac{(127\alpha^2 - 38\alpha c_h - 57c_h^2 - 216\alpha c_f + 152c_h c_f + 32c_f^2)/2400} \\
(16) & \quad W_{f}^{opt} - W_f = \frac{(-373\alpha^2 - 638\alpha c_h - 157c_h^2 + 1384\alpha c_f + 952c_h c_f - 1168c_f^2)/3600}.
\end{align*}

where $W_{i}^{opt}$ for $i = f, h$ is the welfare of country $i$ in the subsidy-tariff regime. Then.

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11: Dixit (1984) argues that the home country’s best policy is to ban imports if $c_h < c_f - s_f$. Again, this study does not consider the home country’s optimal response to the foreign country’s optimal rate of export subsidy. The full optimum calculation of the home country’s tariffs (but not of foreign export subsidies) is found in Dixit (1988).

trade wars in this regime enhance home (foreign) welfare if (15) (16) is positive. To verify this, let us represent the numerator of (15) and (16) as $F_h(c_h, c_f)$ and $F_f(c_h, c_f)$, respectively, and set $\alpha = 1$ without loss of generality; then, we obtain

(17) \[ F_h(c_h, c_f) = 127 - 38c_h - 57c_h^2 - 216c_f + 152c_h c_f + 32c_f^2 \]

(18) \[ F_f(c_h, c_f) = -373 - 638c_h - 157c_h^2 + 1384c_f + 952c_h c_f + 1168c_f^2. \]

In addition, to assume a positive value for firms' outputs, the following equations should hold:

(19) \[ x_f^f > 0 \iff c_f < (4c_f + 9)/13, \quad x_f^f > 0 \iff c_f < (3c_f + 1)/4. \]

Note that under (19), the foreign optimal rate of export subsidy indicated by (14) becomes negative, that is, the foreign government must impose an export tax. This indicates that the home government always succeeds with countervailing duties. This result is consistent with that obtained by Oiu (1995).

Figure 4 depicts the loci of (17) and (18). The curves of $F_h(c_h, c_f)$ and $F_f(c_h, c_f)$ indicate the pairs of $c_h$ and $c_f$, which assume $W_{s}^{x} - \bar{W}_{s} = 0$ and $W_{f}^{x} - \bar{W}_{f} = 0$, respectively. Then, we find that the home country wins trade wars in all possible areas, while the foreign country always loses.

The home country can extract the monopoly power of both foreign firms and the foreign public treasury if the foreign country provides export subsidies to their firms. Moreover, if the foreign government imposes an export tax, it enhances the monopoly power of the home firms. Therefore, the home country always wins trade wars in this
regime, while the foreign country always loses. Thus, the home country would need to use import tariffs when the foreign country provides export subsidies (or imposes an export tax).

3.4. Tariff-Subsidy Regime

Lastly, in this section, we study the case wherein the home government determines the rate of export subsidy after the foreign government determines the tariff rate.\(^{13}\)

From the first order condition, we obtain

\begin{align}
  (20) \quad s_h &= (2\alpha - 8c_h + 6c_f)/20 \\
  (21) \quad t_f &= (3\alpha - 2c_h - c_f)/10.
\end{align}

Let us now observe whether or not trade wars in this regime enhance home and foreign welfare. From the above calculation, we get

\begin{align}
  (22) \quad W_i^{s*} - \bar{W}_i &= (-41\alpha^2 - 46\alpha c_f + 31c_f^2 + 128\alpha c_h - 16c_h c_f - 56c_f^2)/450 \\
  (23) \quad W_i^{f*} - \bar{W}_i &= (2\alpha^2 + 2\alpha c_f + 3c_f^2 - 6\alpha c_h - 8c_h c_f + 7c_f^2)/30,
\end{align}

where \(W_i^s\) for \(i = h, f\) is the welfare of country \(i\) in the tariff-subsidy regime. Then, if \((22)\) ((23)) is positive, trade wars enhance home (foreign) welfare. To verify this, denoting the numerator of \((22)\) and \((23)\) as \(G_h(c_h, c_f)\) and \(G_f(c_h, c_f)\), respectively, and setting \(\alpha = 1\), we obtain

\begin{align}
  (24) \quad G_h(c_h, c_f) &= -41 - 46c_f + 31c_f^2 + 128c_h - 16c_h c_f - 56c_f^2 \\
  (25) \quad G_f(c_h, c_f) &= 2 + 2c_f + 3c_f^2 - 6c_h - 8c_h c_f + 7c_f^2.
\end{align}

We assume interior solutions; therefore, the following equations should hold:

\begin{equation}
  (26) \quad x_i > 0 \Leftrightarrow c_i < (1 + c_h)/2, \quad x_i' > 0 \Leftrightarrow c_i < (1 + 3c_f)/4.
\end{equation}

Note that under \((26)\), the optimal subsidy rate denoted by \((20)\) is always positive. This sharply contrasts with the case of countervailing duties.

Figure 5 depicts the loci of \((24)\) and \((25)\). The curves of \(G_h(c_h, c_f)\) and \(G_f(c_h, c_f)\) show the pairs of \(c_h\) and \(c_f\), which assume \(W_i^{s*} - \bar{W}_i = 0\) and \(W_i^{f*} - \bar{W}_i = 0\), respectively. Then, trade wars enhance foreign welfare in all possible areas; on the other hand, the home country is always worse off. This indicates that trade wars in this regime are always good for the foreign country, while they are bad for the home country. This result is similar to that obtained in subsection 3.3. Note, however, that the optimal rate of export subsidy is always positive in this subsection. Again, such relationships between the optimal rate of export subsidy and import tariffs have already been indicated by

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\(^{13}\) We do not consider this unrealistic; however, there are few works on this type of regime.
4. Policy Equilibrium

At this point, we consider the policy equilibrium. First, upon imposing the rival country's tariffs, should the home government use import tariffs or export subsidies? We have already found the welfare of a country in the tariff-tariff and tariff-subsidy regimes (see table 1). Then, we obtain

\[ W_k^t - W_h^t = \frac{(97 + 124c_h - 248c_f^2 - 318c_f + 372c_hc_f - 27c_f^2)}{2025}. \]

If (27) is positive, tariffs are better than subsidies for the home country. To verify this, we represent the numerator of (27) as \( \phi(c_h, c_f) \):

\[ \phi(c_h, c_f) = 97 + 124c_f - 248c_f^2 - 318c_h + 372c_hc_f - 27c_f^2. \]

In figure 6, (28) is depicted. The curve of \( \phi(c_h, c_f) \) shows the pairs of \( c_h \) and \( c_f \), which assume \( \phi(c_h, c_f) = 0 \). Then, we find that in all possible areas, tariffs are better for the home country. This indicates that the home country choose tariffs when the foreign country imposes them.

Next, we have to consider the home government's optimal response in the case where the foreign country provides export subsidies. From subsection 3.2 and 3.3. we obtain

\[ W_k^s - W_h^s = \frac{(103 - 232c_h - 623c_h^2 + 26c_f + 1478c_hc_f - 752c_f^2)}{3600}. \]

Let us represent the numerator of (29) as
### Table 1  Home and Foreign Welfare in Each Regime ($\alpha = 1$)

<table>
<thead>
<tr>
<th>Regime</th>
<th>(Home Welfare)</th>
<th>(Foreign Welfare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Trade</td>
<td>$\bar{W}_h = \frac{8 - 16c_h + 17c_f^2 + 4c_f - 10c_h c_f + 5c_f^2}{18}$</td>
<td>$\bar{W}_f = \frac{8 - 16c_h + 17c_f^2 + 4c_f - 10c_h c_f + 5c_f^2}{18}$</td>
</tr>
<tr>
<td>Tariff-Tariff</td>
<td>$W_h'' = \frac{65 - 124c_h + 113c_f^2 - 6c_f - 102c_h c_f + 34c_f^2}{162}$</td>
<td>$W_f'' = \frac{65 - 124c_h + 113c_f^2 - 6c_f - 102c_h c_f + 34c_f^2}{162}$</td>
</tr>
<tr>
<td>Subsidy-Subsidy</td>
<td>$W_h'' = \frac{15 - 34c_h + 35c_f^2 + 4c_f - 36c_h c_f + 16c_f^2}{32}$</td>
<td>$W_f'' = \frac{15 - 34c_h + 35c_f^2 + 4c_f - 36c_h c_f + 16c_f^2}{32}$</td>
</tr>
<tr>
<td>Subsidy-Tariff</td>
<td>$W_h'' = \frac{3581 - 8114c_h + 6629c_f^2 + 952c_f - 5144c_h c_f + 20c_f^2}{7200}$</td>
<td>$W_f'' = \frac{409 + 54c_h + 281c_f^2 - 872c_f - 616c_h c_f + 744c_f^2}{1200}$</td>
</tr>
<tr>
<td>Tariff-Subsidy</td>
<td>$W_h'' = \frac{53 - 124c_h + 123c_f^2 - 122c_h c_f + 18c_f + 52c_f^2}{150}$</td>
<td>$W_f'' = \frac{23 - 47c_f + 47c_f c_f + c_h - 47c_h c_f + 23c_f^2}{45}$</td>
</tr>
</tbody>
</table>

![Fig. 6](attachment:image.png)

(30) \[ \Theta(c_h, c_f) = 103 - 232c_h - 623c_h^2 + 26c_f + 1478c_h c_f - 752c_f^2. \]

In figure 6, (30) is depicted. The curve of $\Theta(c_h, c_f)$ shows the pairs of $c_h$ and $c_f$, which assume $\Theta(c_h, c_f)$. Then, we find that in all possible areas, tariffs are better for the home country. This indicates that the home country choose tariffs when the foreign country provides export subsidies. Consequently, we find that the home country does not use an export subsidy as a countervailing policy.

Finally, we consider the foreign country's choice of trade policy. We have already found that the home country definitely uses tariffs; therefore, we need to verify the welfare of the foreign country in the tariff-tariff regime and subsidy-tariff regime. From
subsections 3.1 and 3.3, we obtain

\[(31) \quad W^H - W^S = (1957 - 1256c_f + 2512c_f^2 - 2658c_h - 3768c_hc_f + 3213c_f^2)/32400.\]

If (31) is positive, tariffs are better than subsidies for the foreign country. To verify this, we represent the numerator of (31) as \(\Gamma(c_h, c_f)\):

\[(32) \quad \Gamma(c_h, c_f) = 1957 - 1256c_f + 2512c_f^2 - 2658c_h - 3768c_hc_f + 3213c_f^2.\]

In figure 7, (32) is depicted. The curve of \(\Gamma(c_h, c_f)\) shows the pairs of \(c_h\) and \(c_f\), which assume \(\Gamma(c_h, c_f) = 0\). Then, we find that in all possible areas, tariffs are better for the foreign country if the home country uses tariffs. This indicates that the foreign country always chooses tariffs.

The findings in this section suggest that the tariff-tariff regime inevitably prevails in a subgame perfect Nash equilibrium. On the basis of this result, we ascertain why it is difficult for countries to reduce tariffs relative to export subsidies and why countervailing duties are rarely used in practice.

5. Conclusions

The results in this paper demonstrate that countries tend to use tariffs instead of export subsidies. This is consistent with the actual trade policy observed in the world. However, reciprocal tariffs can enhance the welfare of, at most, one country; in many cases, both countries are worse off. Thus, we argue that the endeavor to eliminate
tariffs is important for the improvement of world welfare.

References


