Trans-boundary Pollution

and

Strategic Environmental Policy

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Abstract:

We use a three country-one good oligopoly model to analyze the impact of a Free Trade Areas (FTA) between countries 1 and 2 on tariffs and pollution taxes in the presence of both local and trans-boundary pollution. We show that FTA between countries 1 and 2 does not necessarily lower tariffs imposed by FTA members on country 3 while tariffs imposed by country 3(rest of the world) will higher. Furthermore, FTA will lower pollution taxes imposed by FTA members while it will raise taxes imposed by rest of the world. We show that under FTA while the environmental taxes are lower for all three countries tariffs imposed by FTA members are lower but the tariff imposed by country 3 is higher.

Keywords: FTA; Trans-boundary Pollution; Optimum Tariff; Environmental Tax; Welfare; Imperfect Competition.

JEL Classification Codes: F10; F13; F15

Trans-boundary Pollution and Strategic Environmental Policy

1. Introduction:

The growing body of literature on preferential trade agreement (PTA) and strategic environmental policy has analyzed the impact of trade liberalization on tariff and environmental tax or pollution tax (see Bakshi and Ray Choudhury(2008), Bagwell and Staiger(1997), Barrett(1994), Bond et al(2004), Burguet and Sempere(2003), Freund(2000), Hamilton and Requate(2004), Kennedy(1994), Krishna(1998), Panagaria(2000), Tanguay(2001)). In the literature on PTA several authors, using a three country-one good Cournot oligopoly model, have shown that free trade areas, FTA, (PTA with zero tariff) where two of the three countries remove tariffs on each other's import will lead to a lower tariff imposed by FTA members while leaving tariffs imposed by the third country (rest of the world) unchanged (see Krishna(1998), Bagwell and Staiger(1997)). Bond et al(2004) has also shown that FTA induces members to reduce tariffs while rest of the world may increase tariffs. In the literature on strategic environmental policy Barrett(1994) and Kennedy(1994) have shown that bilateral tariff reduction will lower environmental taxes. This is known as "ecological dumping". In the absence of tariffs environmental tax may be used as a rent extracting instrument. In other words, by lowering taxes environmental policy is being used as a substitute for trade policy to give domestic firm a competitive advantage. While Tanguay(2001) and Bakshi and Ray Choudhury(2008) have incorporated trans-boundary pollution in a Cournot duopoly model and confirmed that trade liberalization will lower environmental taxes, Burguet and Sempere(2003) used a model with local pollution to argue that tax may increase under certain conditions. A bilateral reduction in tariff will increase output and lower price. But it also damages the environment. This reduces the incentive for the government to use environmental policy strategically to gain competitive advantage and increases incentive for higher environmental protection. On the other hand, lower tariff revenue reduces appeal for import and increases that of export and thus reduces incentive for environmental protection. The effect on environmental tax depends on these two opposite effects. As Burguet and Sempere(2003) have shown, either of these effects can dominate.

While models used in Krishna(1998), Bond et al (20040 and Freund(200) do not consider the implication of environmental damage, the literature on strategic environmental policy uses a duopoly model and thus ignores the possibility of trade diversion. Furthermore, Barrett(1994), Burguet and Sempere(2003), Hamilton and Raquate(2004) and Kennedy(1994) only consider local pollution. In this paper, we incorporate both local and trans-boundary pollution in a three country-one good Cournot oligopoly model to analyze the impact of an FTA on tariffs and taxes. Our findings regarding tariff are two-fold. First, trans-boundary pollution leads to a lower optimum tariff. Secondly, while FTA may or may not lower tariffs imposed by FTA members, tariff imposed by rest of the world (third country) will definitely increase. This contradicts the

"tariff complementarity effect" suggested by Bagwell and Staiger(1997). Finally, we show that while FTA lowers taxes in the member countries it raises tax in rest of the world.

The paper is organized as follows. In the second section, we provide the basic model and In section III, we derive optimum tariff and tax and analyze the effect of FTA on tariff and tax.. In the last section we provide some concluding remarks.

2. Model:

We consider a reciprocal dumping model of trade (see Brander and Krugman (1983) and Brander and Spencer (1985a and 1985b)) with three firms located in three countries, Home (1), Foreign (2) and Rest of the World (3). Each firm sells in all three countries. Brander and Krugman (1983) has shown how rivalry among oligopolistic firms may lead to 'dumping' where each firm perceives each country as a separate market and makes separate quantity decisions for each. This is an extension of the 'segmented market' argument made by Helpman (1982). In each of the countries, demand for the good is given by an inverse demand function,

$P_j = A_j - \sum_i q_j^i$, i,j = 1, 2, 3, where P_j, A_j *and* q_j^i represent price of output in jth market, a constant and output sold by firm i in the jth market respectively. A_j may be interpreted as "choke price" (see Tanguay (2001)).

In each country government maximizes welfare by choosing environmental tax, e^i and import tariff, t^i with i = 1, 2, 3. We assume that d_i, for i = 1, 2, 3, represents damage caused by pollution emitted by each unit of output. We simplify the analysis by assuming constant and identical marginal costs of production and marginal damages in all three countries given as follows:

$c_i = c$ and $d_i = d$ for i = 1, 2, 3.

We also assume that $(A_j - c - d) > 0$ for $j = 1, 2, 3$. This is necessary for a solution to exist. Following Burguet and Sempere (2003), Hamilton and Requate (2004) and Tanguay (2001), we consider a two-stage game. In the first stage Home, Foreign and Rest of the World governments choose e^i and t^i for i = 1, 2, 3. In the second stage, after observing the choices of the first stage, firms choose their output. It needs to be pointed out that while Burguet and Sempere (2003), Hamilton and Requate (2004) and Tanguay (2001) use a two-country model, Hamilton and Requate (2004) uses a two-country model with an intermediate good. Our paper extends their model to include a third country but does not include the intermediate good. Finally, we incorporate trans-boundary pollution following Tanguay (2001) and Bakshi and Ray Choudhury (2008).

3. Main Results:

(3.1) Optimal Tariff and Tax.

We solve the second stage first. Firm j chooses q_i^j for i, j = 1, 2, 3 by maximizing profit, π^j, given t^i and e^j where $\pi^j = \sum_i [A_i - Q_i - c_i] q_i^j - \sum_{i \neq j} t^i q_i^j - e^j Q^j$ for i , j =1, 2, 3. Note that $Q_i = \sum_j q_i^j$, $Q^j = \sum_i q_i^j$, e^j and t^i represent consumption in ith nation, production in jth nation, environmental tax in jth nation and tariff imposed by ith nation respectively. Given t^i and e^j, i , j = 1, 2, 3, first order conditions (F.O.Cs) yield the following solutions for q_i^j :

$$q_i^j = \frac{1}{4}\left\{A_i - c - 2t^i - 3e^j + \sum_{i \neq j} e^j\right\}$$

$$q_i^i = \frac{1}{4}\left\{A_i - c + 2t^i - 3e^i + \sum_{i \neq j} e^j\right\} \qquad (1)$$

Finally, note that $\pi^j = \sum_i (q_i^j)^2$ for i , j=1, 2, 3.

Government, in the first stage, maximizes welfare, W_i, and chooses t^i and e^i where,

$$W_i = CS_i + \pi^i + TR_i + e^i Q^i - d\,Q^i - rd \sum_{j \neq i} Q^j$$

Note, for all i, j =1, 2, 3, $CS_i = \frac{1}{2}(A_i - P_i)Q_i = \frac{1}{2}Q_i^2$, $TR_i = t^i \sum_{i \neq j} q_i^j$, $e^i Q^i$ and dQ^i represent consumers' surplus, tariff revenue, tax revenue and environmental damage respectively. Trans-boundary pollution is introduced through the parameter r where r represents fraction of total costs of foreign pollution that enters national welfare. Also, following Burguet and Sempere (2003) we assume that all three countries have identical demand. That is, $A_j = A$ for all j = 1, 2, 3.

Using (1), FOCs yield the following solutions for optimum tariff , tax and output, for all i,j,k =1, 2, 3; $k \neq i$ and $k \neq j$,

$t^i = 0.28125(A - c - d) + 0.75rd$

$e^i = d - 0.1875\ (A - c - d) - 0.375rd$

$$q_i^i = 0.25(A - c - 3e^i + \sum_j e^j + \sum_{j \neq i} t_j^i)$$

$$q_j^i = 0.25(A - c - 3e^i - 3t_i^j + \sum_j e^j + t_k^j)$$

$$Q^i = Q_j = 0.75(A - c - e) - 0.5t^i \qquad (2)$$

Note that if $r = 0$ then $t^i = 0.2812(A - c - d)$ and $e^i = d - 0.1875(A - c - d)$. Therefore, it follows that trans-boundary pollution lowers both optimum tariff and tax. Introduction of trans-boundary pollution leads to two opposite effects on national welfare in terms of environmental damage and firms' profits. On the one hand, since $r < 1$, increase in pollution cost due to increase in domestic production is higher than the increase in pollution cost due to increase in import. Therefore, national governments have an incentive to lower tariffs to encourage import and discourage domestic production. On the other hand, lower tariffs also lower domestic output and hence lower profit. Therefore, governments have an incentive to encourage domestic production and discourage import by raising tariff. It is clear that the trans-boundary pollution effect dominates the profit effect. This leads to a lower optimum tariff. A similar argument also explains why pollution tax is lower with trans-boundary pollution. A lower tax makes domestic production more attractive and import less attractive. Hence local pollution increases and trans-boundary pollution decreases. Again higher domestic output leads to higher profit. A higher tax has the opposite effect. Therefore, in the case of tax, the profit effect dominates leading to a lower optimum tax.

From (1) and (2), it is clear that marginal damage is directly related to environmental tax and inversely related to domestic output. Also, marginal damage is inversely related to optimum tariff. Note that relatively higher marginal damage will make domestic production relatively less attractive and import relatively more attractive. This is what Tanguay(2001) has called "Pollution-Shifting effect" where a lower tariff and a higher environmental tax will lead to a lower level of pollution at home at the expense of a higher level of pollution abroad. Hence, government has an incentive to encourage import by lowering tariff. In fact, if marginal damage is high enough, optimum tariff may be negative. In other words, if marginal damage is sufficiently high then "Pollution-Shifting effect" may replace tariff by an import subsidy.

(3.2) Effect of FTA on tariff and pollution tax

In this section we analyze the impact of trade liberalization on tariff and tax where two of the three countries form an FTA among themselves. Suppose, without loss of generality, countries 1 and 2 form an FTA where they remove tariff on import from each other while maintaining a tariff on import from country 3. We denote tariff imposed on imports from country 3 by countries 1 and 2 by t_F^1 and t_F^2 respectively. Also, t_F^3 represents the tariff imposed on imports

from countries 1 and 2 by country 3. We let, for i = 1, 2, 3, Q^{iF} , Q_{iF} , q_{iF}^{j} and e^{iF} represent consumption, production, output and tax respectively under FTA.

In the second stage firms maximize profit under FTA, π_F^i , given by, for i , j = 1, 2, i≠ *j*

$$\pi_F^i = \sum_j (A_j - Q_{jF} - c)q_i^j - (A_3 - Q_{3F} - c - t^3)q_{iF}^3 - e^{iF}Q^{iF} \text{ and}$$

$$\pi_F^3 = \sum_i (A_i - Q_{iF} - c - t^i)q_i^3 - (A_3 - Q_F^3 - c)q_{3F}^3 - e^{3F}Q^{3F}$$

FOCs yield the following solutions for i , j =1, 2 and k = 1, 2, 3,i≠ *j*

$$q_{jF}^i = \frac{1}{4}(A_j - c - 3e^i + \sum_{k \neq i} e^k + t^j)$$

$$q_{3F}^3 = \frac{1}{4}(A_3 - c - 3e^3 + \sum_i e^i + 2t^3) \qquad (3)$$

For i = 1, 2, 3, letting CS_{iF} and TR_{iF} denote consumers' surplus and tariff revenue respectively under FTA, governments choose tariff and tax, t^{iF} and e^{iF} respectively, by maximizing W_{iF} , welfare under FTA where, for j=1, 2, 3,

$$W_{iF} = CS_{iF} + \pi_F^i + TR_{iF} + (e_F^i - \mathrm{d})Q_F^i - rd(\textstyle\sum_{i \neq j} Q^{\mathrm{j}})$$

Optimal tariff and tax levels are given as follows. For i,j =1,2 and i ≠ j,

$t_F^i = 0.0764(\mathrm{A} - \mathrm{c} - \mathrm{d}) + 0.1905rd$

$t_F^3 = 0.3055(\mathrm{A} - \mathrm{c} - \mathrm{d}) + 0.7944rd$

$e_F^i = d - 0.3076(\mathrm{A} - \mathrm{c} - \mathrm{d}) - 0.8204rd$

$e_F^3 = d - 0.1867(\mathrm{A} - \mathrm{c} - \mathrm{d}) + 1.99rd \qquad (4)$

From (4), it is clear that in the absence of trans-boundary pollution (r = 0) higher marginal damage leads to lower tariff and higher tax. Therefore, in the absence of trans-boundary pollution, marginal damage and tariff are inversely related (Dasgupta and Lee (2010)). But the relation between marginal damage and tariff is not so clear once trans-boundary pollution is introduced in the model. It can be easily checked that for tariff to be inversely related to marginal damage a necessary condition is $r < 0.4$. It is interesting to note that same condition holds for both FTA members and the rest of the world (country 3). As damage increases domestic production becomes less attractive relative to import since $r < 1$. However, as r becomes large ($r > 0.4$), the cost imposed by trans-boundary pollution may become large enough to induce

national governments to raise tariffs (rather than lower tariffs) in response to higher damage. Note that since $r < 1$ it is clear from (4) that the direct relation between marginal damage and tax holds for all three countries even in the presence of trans-boundary pollution.

Next, we consider the effect of FTA on tariff and tax in the presence of trans-boundary pollution. From (2) and (4) we get, for i=1,2,

$$t_F^i - t^i = 0.9405rd - 0.2048\,(A - c - d) \qquad (5)$$

It follows from (5) that $t_F^i \gtrless t^i$ if and only if $\frac{rd}{(A-c-d)} \gtrless 0.22$.

This result is a departure from the one obtained in literature on preferential trade agreement (see Bond et al(2004)) which states that an FTA lowers tariff imposed by FTA members on rest of the world. This is the well-known tariff-complementarity effect (see Bagwell and Staiger(1997)). From (5), it is clear that if $r = 0$ the tariff-complementarity effect continues to hold. However, in the presence of trans-boundary pollution, this result may or may not hold. A bilateral removal of tariffs by countries 1 and 2 will result in higher imports into these countries. This will also lead to higher pollution since $r > 0$. If $r > 0.22\frac{(A-c-d)}{d}$, FTA-members have incentive to reduce import from the rest of the world. This explains why, for a high r, countries 1 and 2 may raise tariffs on country 3. Again, using (2) and (4) we get

$$t_F^3 - t^3 = 0.0243(A - c - d) + 1.5444rd \qquad (6)$$

Since (6) is positive, for country 3, an FTA between countries 1 and 2 clearly leads to a higher tariff. This differs from the result found in the literature on preferential trade agreement where an FTA between countries 1 and 2 leaves the tariff imposed by country 3 unchanged (Bagwell and Staiger(1997) and Dasgupta and Lee(2011)). However, it is consistent with the result found in preferential trade literature when only local pollution is considered ($r = 0$).

Finally, we consider the effect of an FTA between countries 1 and 2 on tax.

From (2) and (4) we get,

$$e_i^F - e^i = -.1201(A - c - d) - 0.4454rd \qquad (7)$$

Clearly,$(e_i^F - e^i) < 0$. This is consistent with one of the main results of strategic environmental policy literature. Authors such as Barrett (1994) and Kennedy (1994) have shown that trade liberalization lowers environmental protection by lowering pollution tax. It appears that trans-boundary pollution provides an additional reason to encourage domestic production. This is especially true given that tariff as an instrument of protection against each other is no longer available for the FTA members. However, comparing (4) with (2) shows that

$(e^3 - e_F^3) < 0$

FTA between countries 1 and 2 raises tax in the rest of the world (country 3). We have shown elsewhere that if only local pollution is considered FTA between countries 1 and 2 will lower tax in rest of the world (See Dasgupta and Lee (2010)). It is well-known that both tariffs and taxes can be used to protect domestic industries by raising tariffs and/or lowering taxes. However, the presence of trans-boundary pollution and higher tariff make pollution tax less attractive and less necessary as an instrument of protection of domestic industry.

4. Conclusion:

We have shown, using a three country -one good model, that in the presence of trans-boundary pollution an FTA between two of the three countries does not necessarily lower tariff imposed by FTA members on the rest of the world (country 3) while tariffs imposed by the rest of the world will definitely increase. Therefore results obtained in preferential trade literature (see Krishna (1998), Bond et al (2004)) do not necessarily hold when both local and trans-boundary pollution are present. Also, results in the strategic environmental policy literature indicate that free trade leads to lowering of environmental tax. Although this result continues to hold for FTA members in our model it does not hold for the rest of the world where an FTA leads to a higher environmental tax. When trans-boundary pollution is introduced it adds an additional dimension to the tradeoff between domestic production and import. Domestic production means higher profit and higher damage while import means lower damage than domestic production but also lower profit. Therefore, the final outcome regarding tariff and tax depends on relative strength of profit and environmental damage.

Endnotes

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