“Intra-industry trade with pollution concerned cooperation”

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Intra-industry trade with pollution concerned cooperation

Abstract

The authors develop a two-country, two-firm intra-industry trade model. Each firm is operating at its home country and producing homogeneous goods to be consumed in both countries. Governments apply quantity restriction on pollution. Every individual country is affected from the pollution generated during the production process of its own firm. The model shows that efficiency in pollution abatement technology plays a crucial role on welfare maximizing effort of governments. A critical level of pollution abatement technology determines the preponderance of environmental misgivings in welfare maximizing behavior. The more efficient the firms in pollution abatement technology, the less stricter the governments will be in their policies to reduce negative environmental externalities.

Keywords: intra-industry trade, pollution abatement, policy coordination.
Jel Classification: F18, H23.

Introduction

Debates over globalization have been going on for decades. However, recently a new dimension has come out. This is the relationship between international trade and environment. Globalization is associated with liberalization of international trade. It is argued that this is beneficial since the apparent increase in real world income has been attributed to the liberalization of international trade. Fruits of international trade have been put forward since the early economists. However, recently environmentalists argue against the trade liberalization by considering the environmental consequences of international trade.

Environmentalists argue that higher economic activity will be associated with a decrease in environmental quality. Moreover, less developed countries will adopt less tough environmental standards in order to gain an advantage in international trade. Copeland and Taylor (1994-a) set up a north-south model in order to investigate the relationship between national income, pollution and international trade. In their model, two countries are producing goods with different pollution effects. They figure out that technologically developed country specializes in clean goods and its environmental policies are stricter. Besides they show that free trade increases pollution. Furthermore, an increase in North's production possibilities frontier increases pollution, while any improvement in South's production possibilities frontier reduces pollution.

Copeland and Taylor (1994-b) examine that how pollution is effected from national income levels and trade opportunities. Their findings show that higher the income inequality across countries, higher the level of global pollution due to free trade. Secondly, they show that if factor prices are equalized due to trade, than human capital abundant countries are more advantageous. Thirdly, if pollution permits are subject to free trade, then pollution decreases. Finally, environmental policies are useless when they are used for trade objectives.

Intra-industry trade is one of the forms of international trade. It is clear that intra-industry trade has its own characteristics. Environmental pollution in an intra-industry trade case may be generated through consumption or production of goods. One of the main concerns of governments when making policy is the environmental damage arising during the production of goods that are subject to intra-industry trade. It is very common that there exists a two-way trade of identical goods between countries in which the countries are subject to pollution generated during the production process of these goods.

When commodities differ, it is inter-industry trade and for the trading of similar commodities it becomes intra-industry trade. Balassa (1966) is one of the earliest economists who noticed the importance of intra-industry trade. Krugman (1979) states that demand diversity due to product differentiation is a strong motive for intra-industry trade and domestic goods cannot satisfy the diversity in demand. Therefore, intra-industry trade occurs inherently. Linder (1961) suggests that the intra-industry trade is reasonable to occur between developed part of the world and the rest of the world. Hamilton and Kniest (1991) state that intra-industry trade may be a result of population growth. As population grows, demand for slightly differentiated products will increase. Brander and Krugman (1983) argue that reciprocal dumping, dumping of firm into the home country of rival firm, can occur in a natural way due to the oligopolistic competition between firms. Thus, they show that reciprocal dumping can occur without the motivations such as transportation costs and economies of scale. They also show that if transport costs are low opening trade increases welfare of countries.

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Intra-industry trade and its effects on environment is a recent topic. Kayalica and Kayalica (2005) develop a two-country – two-firm model with identical goods to study the effects of trans-boundary pollution. They show that a higher consumption tax in one country associates with a lower tariff in that country. They also conclude that revenue neutral reform increases consumption tax and reduces import tariffs, with the Pareto-improving tax structure. Therefore, non-cooperative Nash equilibrium is sub-optimal.

Benarroch and Weder (2006) construct a two-country model in order to investigate the relationship between intra-industry trade in intermediate products, pollution and increasing returns to scale. In their model, production occurs in two stages, intermediate and final good production to show the effect of intermediate products on pollution. They figure out that international trade may cause lower pollution or may lead to lower pollution per unit of output at least in one country.

Fung and Maechler (2007) build a price-setting duopoly model of intra-industry trade in order to obtain the effects of trade liberalization on environment. Their findings show that trade liberalization effects environment due to two factors: nature of pollution and the country with open economy or not. They show that both transboundary pollution, and trade liberalization affect the dirty country positively. However, if the pollution is local, then the effect of trade liberalization on environment is negative. Therefore, the overall welfare effect is ambiguous. Kayalica and Yilmaz (2006) construct a partial equilibrium model in order to analyze consumption based pollution externalities in a reciprocal dumping type of trade. In a two stage non-cooperative game they show that removing subsidies does not effect pollution. Besides emphasizing the tax increases caused by uniform taxing.

Another interesting dimension of the relationship between intra-industry trade and environment is the awareness of the society about environment. Aidt (2005) analyzes the intra-industry trade and environment relation by considering the social awareness. In his two country model, he defines three groups of citizens based on their preferences on consumption goods and environmental quality to incorporate environmental awareness into his model. It is shown that if pollution has a transboundary nature or the society is concerned with the pollution in a local context; the rise in environmentalism reduces pollution. On the contrary, if pollution is immobile and the society is concerned with global pollution in, the rise in environmentalism may effect pollution positively or negatively. An empirical study for the intra-industry trade between Korea and Philippines, analyzes the impact of transboundary pollutions on foreign investments and the wealth (Eun and Jung, 2009). The study uses regression model that proves the previous transboundary pollution studies. It is concluded that a model based on common pollution goals has a positive effect on both countries' pollution. However, income negatively affected on Korea's environmental pollution and positively affected the trade between the two countries.

Swart (2013) studies the heterogeneity with respect to pollution parameter on intra-industry trade of final goods, for both developed and developing countries. Closed economy, open economy with no impediments and open economy with transportation costs are analyzed. Swart (2013) finds out that developing country trading with a developed country will have negative effect both on production amounts and pollution; both types of countries will have better wealth under trade and open economy with lower transportation costs will be positively affected when compared with the countries with no impediments.

Yomogida and Taruhi (2013) study the controversial pollution taxes for countries performing intra-trade. They conclude that in case of a cleaner home firm with small difference of technology total externality effect will be positive with optimal tax policies. Yet, under positive externality effect optimal emission tax causes higher home country welfare.

In this paper we study the production based generated pollution externalities. We developed a partial equilibrium model in which there are two countries and two firms. Each firm is operating at its home country. Firms are producing homogeneous goods to be consumed in both countries. The governments' policy instrument is quantity restriction on pollution. Every individual country is affected from the pollution generated during the production process of its own firm. The technology for abating the pollution is available to both firms. Agents play a two-stage non-cooperative game. In the first stage, governments determine the quantity restriction levels on pollution given the firms' output levels. In the second stage, firms choose their output levels for any given level of policy instruments.

We propose the model we developed in the following chapter. This will consist of the optimal policies set under non-cooperative and cooperative behavior of the governments as well as the comparative statics at equilibrium. The second section will compare non-cooperation and cooperation. The Final section will summarize the achievements and contributions in the field.

1. Model framework

We develop an intra-industry type, two-country, two-firm model. Each country hosts one firm, which produces homogenous good to be consumed in both countries. It is assumed that each country has different production technologies. Both markets are segmented and firms face different demand conditions in each market. We assume linear inverse demand functions as follows.

$$p_h = \alpha - (x_h + y_h), \tag{1}$$

$$p_f = \alpha - (x_f + y_f). \tag{2}$$

Countries are labeled with h (home) and f (foreign). Supply of home country's firm is x; producing x_h for its domestic demand and x_f to respond the demand in the foreign country. Supply of foreign country firm is y. It produces y_h for home country's demand and y_f for its domestic demand. Firms face with different prices in each country distinguished with p_h and p_f. Since the markets are segmented, each firm takes other firm's output decision for each market constant when deciding its own output. Total output of each firm is given with the following equation.

$$D_i = x_i + y_i,\ i = h, f. \tag{3}$$

Therefore we have the following profit functions for each firm.

$$\pi_h = (p_h - k_h)\, x_h + (p_f - k_h)\, x_f, \tag{4}$$

$$\pi_f = (p_f - k_f)\, y_f + (p_h - k_f)\, y_h. \tag{5}$$

Profits of firm h and firm f are π_h and π_f. Marginal cost is k_i ($i = h, f$) for each firm. Marginal cost structure of firms is given as follows:

$$k_h = c_h + \mu\,(\theta - z_h),$$

$$k_f = c_f + \mu\,(\theta - z_f).$$

Marginal cost structure is composed of two parts: c_i is the production cost and (μ ($\theta - z_i$)) is the pollution abatement cost. Each government determines a quantity restriction per unit of output (z_i, where $i = h, f$) on the pollutants emitted. Therefore, firms have to abate the pollution in the amount of $\theta - z_i$ where θ is the gross pollution per unit of output. Thus, firms are subject to an abatement cost of $\mu(\theta - z_h)$ where μ is the abatement cost for per unit of output.

The welfare of each country is composed of three parts, consumer surplus (CS), producer surplus (PS) and disutility of pollution (DP). Welfare of each country is given with the following equations.

$$W_h = CS_h + PS_h - DP_h\,, \tag{6}$$

$$W_f = CS_f + PS_f - DP_f\,. \tag{7}$$

1.1. Non-cooperative environmental policy. In this section, the non-cooperative solution of our model is examined. There is a two-stage game between countries. In the first stage of our model, governments determine the pollution quota given the reaction functions of later stages and given the policy level of the other government. In the final stage, firms determine their output level given the quota. The problem is solved with backwards induction.

1.1.1. Stage 2: Firms determine the output levels. Firms give their decisions in a Cournot-Nash fashion. Since the markets are segmented, firms determine their output levels separately for each market. From the first order conditions we obtain the optimal output levels of the firms as follows:

$$x_h = 1/3(c_f - 2c_h + \alpha - z_f\mu + 2z_h\mu\ \theta\mu), \tag{8}$$

$$x_f = 1/3(c_f - 2c_h + \alpha - z_f\mu + 2z_h\mu - \theta\mu), \tag{9}$$

$$y_h = 1/3(-2c_f + c_h + \alpha + 2z_f\mu - z_h\mu - \theta\mu), \tag{10}$$

$$y_f = 1/3(-2c_f + c_h + \alpha + 2z_f\mu - z_h\mu - \theta\mu). \tag{11}$$

Comparative static analysis on the outcomes of stage 2 shows that due to any improvement in the foreign country's production technologies which associate with a decrease in the marginal cost of firm f, firm h decreases the output level for both domestic and foreign market and firm f increases the output level for both domestic and foreign market. Any increase in demand associates with a higher output level for both firms. If foreign government increases the pollution quota, firm h decreases its output levels for both home and foreign market and firm f increases its output level for both home and foreign market. However, the effect of any change in the unit cost of abating the pollution on the output decisions of firms is ambiguous and depends on the magnitude of the pollution quotas and gross pollution as it can be seen from equations below.

$$\partial x_h/\partial\mu = 1/3(-z_f + 2z_h - \theta), \tag{12}$$

$$\partial x_f/\partial\mu = 1/3(-z_f + 2z_h - \theta), \tag{13}$$

$$\partial y_h/\partial\mu = 1/3(2z_f - z_h - \theta), \tag{14}$$

$$\partial y_f/\partial\mu = 1/3(2z_f - z_h - \theta). \tag{15}$$

Due to any change in pollution abatement technology output decisions of firms depend on the magnitude of ($-z_f + 2z_h - \theta$) and ($-z_h + 2z_f - \theta$). When the condition of ($2z_h > (z_f + \theta)$) holds, domestic firm determines a lower output level due to an improvement in pollution abatement technology. When the condition of ($2z_h < (z_f + \theta)$) holds, domestic firm determines a higher output level due to an improvement in pollution abatement technology. The conditions are ($z_h + 2z_f - \theta < 0$) and ($z_h + 2z_f - \theta > 0$) for foreign firm and can be explained in the same way.

When home country determines a sufficiently high level of pollution quota such that ($2z_h > (z_f + \theta)$), then firm h chooses lower output levels for both domestic and foreign market due to any improvement in pollution abatement technology. The reason can be explained through the second order derivatives. Assuming that the condition of ($2z_h > (z_f + \theta)$) holds, when home government puts a higher pollution quota for everything else constant, the decrease in output levels of firm h due to an improvement in pollution abatement technology is higher, since it is more profitable for the firm h to produce with a higher marginal cost of abatement when the pollution quota is higher.

1.1.2. Stage 1: Governments determine quota. In the first stage governments determine the pollution quotas in order to maximize their individual welfare. Firstly, we substitute the equilibrium values of stage two, which are the output decisions of firms, into the welfare functions of countries. Secondly, first-degree derivative of W_h with respect to z_h and W_f with respect to z_f are equated to zero. Expressions obtained are as follows:

$$1/9(-6(c_f - 2c_h + \alpha) + (7c_f - 17c_h + 6z_f - 24z_h +$$

$$+ 10\alpha + 6\theta)\mu + (-7z_f + 17z_h - 10\theta)\mu 2) = 0,$$

$$1/9(-6(c_h + \alpha) + c_f(12 - 17\mu) + \mu(7ch + 6z_h +$$

$$+ 10\alpha + 6\theta - 7z_h\mu - 10\theta\mu + z_f(-24 + 17\mu))) = 0.$$

In order to find the optimal values of the pollution quotas determined by the welfare maximizing governments, above equations are solved for z_h and z_f simultaneously. Values obtained are as follows:

$$Z_h = (c_f(-6 + 7\mu) + c_h(21 - 44\mu + 20\mu^2) - (\alpha - \theta\mu)(15 - 37\mu + 20\mu^2))/(\mu(45 - 61\mu + 20\mu^2)), \quad (16)$$

$$Z_f = (c_h(-6 + 7\mu) + c_f(21 - 44\mu + 20\mu^2) - (\alpha - \theta\mu)(15 - 37\mu + 20\mu^2))/(\mu(45 - 61\mu + 20\mu^2)). \quad (17)$$

Now by substituting the equilibrium values of z_h and z_f into the expressions obtained, we have our final results. Thus, the formal framework of our analysis is completed. When we check the second order conditions and stability conditions of stage 1, our findings do not hold for every value of unit cost of pollution abatement, μ. The solution interval is determined by second order conditions. Thus, our model is valid between an upper and lower limit of μ schematized as below identity[1].

$$\mu_1 < \mu < \mu_2.$$

[1] The second order conditions and stability conditions only hold under a specific value-interval of μ, the per unit abatement cost. In order to save space we do not present the calculations here. However, they are available on request.

1.1.3. Comparative statics. Our findings of the comparative statics analysis are presented in the Table below.

Table 1. Results of comparative statics for non-cooperation case

	z_h	
	$\mu < \bar{\mu}$	$\mu > \bar{\mu}$
c_h	+	-
c_f	+-	+
α	-	+
θ	+	-

Each cell shows the sign of derivative of z_h in the columns with respect to the parameters in the rows for unit cost of abatement both below and above a critical level. If pollution abatement technology is efficient, pollution quota of home country increases due to any improvement in production technology of home firm and decreases due to any improvement in the production technology of foreign firm. If pollution abatement technology is not efficient, pollution quota of home country decreases due to any improvement in production technology of home firm and increases due to any improvement in the production technology of foreign firm. The pollution quota changes in the same direction with the gross pollution due to a change in the gross pollution for small values of unit cost of abatement. However, it changes in the opposite direction with gross pollution due to a change in gross pollution for large values of unit cost of abatement. Secondly, for low values of unit cost of pollution abatement, pollution quota decreases as demand increases, however for high values of unit cost of pollution abatement, pollution quota increases as demand increases. Effect of the change in the demand or gross pollution on the components of the welfare is the reason of this fact. When gross pollution or demand changes, the components of welfare change in different direction. In the interval determined by second order conditions, the outcome of the negative and positive effects on welfare determines the direction of the change in policy arguments due to the change in parameters of the model. The analysis is analogous for the z_f case and therefore, omitted.

1.2. Cooperative environmental policy. In this section, the cooperative solution of the above model is examined. Once again, there is a two-stage game between countries. Different from the previous section, governments determine a uniform pollution quota cooperatively at the first stage of the game. The rest of the game is the same with the previous section. Since the problem is solved with backwards induction method, solution to the second stages are exactly the same. Therefore, only the first stage of the game will be examined.

1.2.1. Stage 1: Governments determine a uniform quota. In the first stage, governments determine a uniform pollution quota in order to maximize the total welfare, which is the sum of their individual welfare. Firstly, we substitute the equilibrium values of stage two, which is the output decision of firms into the welfare functions of countries. Then we add the sum of these welfare functions. By totally differentiating the total welfare function with respect to z, the uniform quota level (i.e., the sum of equations (6) and (7)) we obtain the following results. Note that $zh = zf = z$ and hence, $dzh = dzf = dz$:

$$dW_T = 1/9(6(c_f + c_h - 2\alpha) - 4(2(c_f + c_h + 3z - 2\alpha) - 3\theta)\mu + 16(z - \theta)\mu^2)dz.$$

In order to find the optimal values of the pollution quota determined, we equate coefficient of d_z to zero and solve for z. Results are as follows.

$$Z = (4\mu - 3)(2\alpha - 2\theta\mu - c_f - c_h)/(4\mu(3 - 2\mu)).$$

Now by substituting the equilibrium values of z into total welfare function, we have our final results. Once again, our model is valid between an upper and lower limit of μ. We find that the second order condition holds if and only if $3 > 2\mu$.

1.2.2. Comparative statics. Next, we shall have a look at the comparative statics of this section. Using the condition for the second order condition to hold we have the following criteria for μ.

$4\mu, > 3$.

Table 2. Results of comparative statics for cooperation case

	z	
	$4\mu > 3$	$4\mu < 3$
c_h	–	+
c_f	–	+
α	+	–
θ	–	+

Once again, each cell shows the sign of derivative of z in the columns with respect to the parameters in the rows for unit cost of abatement both below and above a critical level. If μ is sufficiently low, i.e., pollution abatement technology is efficient, uniform pollution quota increases with increasing marginal costs. If μ is sufficiently high, i.e., that is pollution abatement technology is not efficient, uniform pollution quota decreases with decreasing marginal costs. This is quite straightforward. With sufficiently efficient environmental technology that is available to firms in both countries, governments cooperatively relax the environmental standards when other costs (production costs) are relatively increasing. An increase in the gross pollution per unit of output also makes the governments to increase (decrease) emission quota when the abatement technology is sufficiently small (large). Finally, when (sufficiently) higher abatement cost meets with higher market size (i.e., bigger α) governments impose less severe (more relaxed) emission standards. However, the governments impose stricter standards when the opposite is realized.

2. Non-cooperation vs. cooperation

In the preceeding sections, in the cooperation and non-cooperation case, we have achieved the values of pollution quotas. In this stage we will compare those results. Values of policy arguments are a function of demand, production technologies of firms, pollution abatement technology and gross pollution as illustrated below.

$Z_h^{nc} = f(\alpha, c_h, c_f, \mu, \theta)$,

$Z_f^{nc} = f(\alpha, c_h, c_f, \mu, \theta)$,

$Z^c = f(\alpha, c_h, c_f, \mu, \theta)$.

For simple identification we denote the non-cooperative and cooperative values of policy arguments with superscript n^c and c, respectively. In order to compare the pollution quotas determined by governments in the non-cooperative and cooperative case, we obtain the difference of these values. As it is illustrated below, the difference is a function of market size, production technologies of firms, pollution abatement technology and gross pollution.

$\Delta z_h = f(\alpha, c_h, c_f, \mu, \theta)$,

$\Delta z_f = g(\alpha, c_h, c_f, \mu, \theta)$.

In order to investigate the relationship between Δz (i.e., the difference between non-cooperative and cooperative optimal levels of z) and μ, c_f and c_h; we can make some numerical simulation and give values to α and θ such that $\alpha - \theta\mu$ is always positive. While attending values to α and θ, we also know that μ changes in an interval determined by second order conditions. We assume that α is equal to 100, whereas $\theta > 0$. Since maximum value of μ is 1.3, it is safe to attend 50 to θ. It can be shown that our results will not be affected from the values attended to α and θ. Finally, we will construct a scenario making assumptions about the production technologies of firms to investigate how Δz changes with μ. It will be assumed that home country's firm's marginal cost is significantly larger than the foreign country's firm.

In the scenario, c_h is taken as 40 and c_f is taken as 1. In the graph below, it can be seen that Δz_h is positive for the low values of μ and negative when μ is higher than a critical level. On the other hand, Δz_f is negative for the low values of μ and positive when μ is higher than a critical level. That is when marginal cost is very high in the home country with respect to foreign country and abatement technology is efficient, cooperation in environmental policy let the home government to determine a lower pollution quota and let the foreign government to determine a higher pollution quota. However, when the abatement technology is not efficient, cooperation in environmental policy let the home government to determine a higher pollution quota and let the foreign government to determine a higher pollution quota. In the graph below, the situation is illustrated.

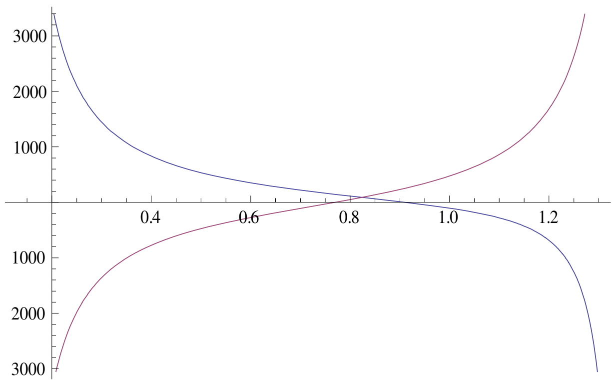

Fig. 1. Change of differences of pollution quotas with unit cost of abatement

The reason can be explained as follows. As it was discussed in previous sections, the welfare function of countries is composed of production surplus, consumer surplus and disutility of pollution. Welfare increases through the first two elements when production increases. However, welfare decreases through the disutility of pollution when production increases. Thus, there are two opposite effects of changing the production level. In our scenarios there are two crucial variables; abatement technology and production technology. The more efficient the firms in production technology, the more willing be the governments to increase their welfare through production surplus and consumer surplus through increased production. The second crucial variable is abatement technology. The more efficient the firms in abatement technology, the more willing be the governments to increase welfare through decreasing disutility of pollution by decreasing production level. In our scenario, home country's firm is significantly inefficient in production technology relative to the foreign country's firm. In this respect, it is advantageous for firm *h* to increase welfare through disutility of pollution by decreasing production level. So, home government always has an incentive to decrease production level. When pollution abatement technology is inefficient, home government has one more motivation to decrease disutility of pollution. Thus, when pollution abatement technology is inefficient, home government prefers to increase pollution quota by cooperation. On the other hand, foreign firm is efficient in production technology relative to home firm, which is an incentive to increase production level. But it is inefficient in abatement technology, which is an incentive to decrease production level. Foreign government prefers to decrease pollution quota by cooperation, because its efficiency in production technology is a stronger incentive than its inefficiency in abatement technology.

Secondly, if firms are efficient in abatement technology, governments behave in the opposite way. In this case, home firm is inefficient in production technology but efficient in abatement technology. While the inefficiency in production let the home government to decrease production level, efficiency in abatement technology let the home government to increase production level. Since the inefficiency in production is a stronger incentive, home government prefers to decrease production level by decreasing pollution quota by cooperation. On the other hand, in foreign country, both production technology and abatement technology are efficient. Thus, both reasons let foreign government to increase production level through increasing pollution quota by cooperation.

Conclusion

We constructed an intra-industry two-country type, leading for two-firm partial equilibrium model in which agents maximize their objective functions through a three-stage game. In the first stage, governments set their environmental policies. In the second stage, firms determine output levels for both domestic and foreign market.

The model is studied under two scenarios, non-cooperative and cooperative environmental policies. When governments are determining pollution quotas non-cooperatively, each government maximizes its own welfare. When they cooperate, they determine a uniform pollution quota by maximizing total welfare that is the sum of individual welfares of countries. Comparative statics analysis for both non-cooperation and cooperation cases revealed the importance of pollution abatement technology on policy making. When governments are changing the environmental policies due to a structural change such as change in production costs, demand and gross pollution, they have to consider the opposite effects on welfare. While welfare is affected positively from producer surplus and consumer surplus with increasing production, it is negatively affected via disutility from pollution with decreasing production. Pollution abatement technology plays its key role at this point.

If pollution abatement technology is efficient, governments prefer to increase output level by making policies in response to structural changes. The reason is that effective pollution abatement technology allows governments to increase pollution quota without causing severe environmental damage. This means they prefer to increase welfare via production surplus and consumer surplus. On the other hand, if pollution abatement technology is not efficient, governments prefer to decrease production level in order to avoid severe environmental problems. That is, while maximizing the welfare, governments prefer to decrease pollution rather than increasing the production surplus and consumer surplus. We have reached the same results while analyzing the cooperation case.

We also compare the pollution quotas determined cooperatively and non-cooperatively. In order to examine this, we use numerical values to some variables. We assumed that domestic firm is significantly inefficient in production technology relative to foreign firm. Our analysis revealed that when marginal cost of domestic firm is very high with respect to foreign firm and abatement technology is efficient, cooperation in environmental policy let the home government to determine a lower pollution quota and let the foreign government to determine a higher pollution quota. However, when the abatement technology is not efficient, cooperation in environmental policy let the home government to determine a higher pollution quota and let the foreign government to determine a higher pollution quota. It is advantageous for firm h to increase welfare through disutility of pollution by decreasing production level. Therefore, home government always has an incentive to decrease production level. When pollution abatement technology is inefficient, home government has one more motivation to decrease disutility of pollution. Thus, when pollution abatement technology is inefficient, home government prefers to increase pollution quota by cooperation. On the other hand, foreign firm is efficient in production technology relative to home firm, which is an incentive to increase production level. But it is inefficient in abatement technology, which is an incentive to decrease production level. Foreign government prefers to decrease pollution quota by cooperation, because its efficiency in production technology is a stronger incentive than its inefficiency in abatement technology.

References

1. Aidt, T.S. (2005). The rise of environmentalism, pollution taxes and intra-industry trade, *Economics of Governance*, 6, pp. 1-12.
2. Balassa, Bela. (1966). Tariff reductions and trade in manufactures among industrial countries, *American Economic Review*, 6, pp. 466-473.
3. Brander, J. and Krugman, P. (1983). A reciprocal dumping model of international trade, *Journal of International Economics*, 15, pp. 313-21.
4. Benarroch, M. and Weder, R. (2006). Intra-industry trade in intermediate products, pollution and internationally increasing returns, *Journal of Environmental Economics and Management*, 52, pp. 675-689.
5. Copeland, B.R. and Taylor, M.S. (1994a). North south trade and environment, *The Quarterly Journal of Economics*, 109 (3), (Aug., 1994), pp. 755-787.
6. Copeland, B.R. and Taylor, M.S. (1994b). Trade and transboundary pollution, *The American Economic Review*, 85 (4). (Sep., 1995), pp. 716-737.
7. Eun, W., Jung, M.H. (2009). An Empirical Study on Intra-Industrial Trade and Environmental Pollution Loadings: Korea-Philippines and Korea-Singapore Trade, *Journal of Korea Trade*, 13 (4), pp. 21-40.
8. Fung, K.C., Maechler, A.M. (2007). Trade liberalization and Environment: The case of intra-industry trade, *The Journal of International Trade and Environment: An International and Comparative Review*, 16 (1), pp. 53-69.
9. Hamilton, C. and Kniest, P. (1991). Trade liberalization, structural adjustment and intra-industry trade: a note, *Weltwirtschaftliches Archiv*, 127 (2), pp. 356-367.
10. Kayalica, M.O. and Yilmaz, E. (2006). Intra industry trade and consumption-generated pollution externalities, *Yapi Kredi Economic Review*, 17 (1).
11. Kayalica, M.O. and Kayalica, O. (2005). Transboundary Pollution from consumption in a reciprocal dumping model, *Global Economy Journal*, 5 (2).
12. Krugman, P.R. (1979). Increasing returns, monopolistic competition and international trade, *Journal of international economics*, 9, pp. 469-479.
13. Linder, S.B. (1961). *An essay on trade and transformation*, New York: John Wiley and Sons.
14. Swart, J. (2013). Intra-industry trade and heterogeneity in pollution emission, *The Journal of International Trade & Economic Development*, 22 (1), pp. 129-156.
15. Yomogida, M. and Tarui, N., (2013). Emission Taxes and Border Tax Adjustments for Oligopolistic Industries, *Pacific Economic Review*, 18 (5), pp. 644-673.