Increasing worldwide environmental consciousness and environmental policy adjustment

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Abstract

Increasing worldwide environmental consciousness has been driving countries in the world to adjust their environmental policies. Conventional wisdom often suggests tightening environmental policy, but this paper challenges that wisdom. By using an oligopoly model, we show that, in the case of local pollution, a country that confronts increasing environmental consciousness tightens or slackens its environmental policy depending on the relative cost competitiveness to its rivals. However, in the case of global pollution, all countries in the world always tighten their environmental policies as worldwide environmental consciousness rises. These results are robust in the case of unilateral increase in environmental consciousness and in cases of efficient policy settings whether or not domestic consumption is taken into consideration.

Keywords: environmental consciousness, Nash equilibrium policy, efficient policy, environmental policy adjustment

JEL Classification: F18, Q58

Introduction

Public concern about environmental degradation is growing domestically and internationally. Although tightening environmental policies to meet increasing environmental consciousness is intuitive, some instances may be purposefully designed to deviate from this wisdom. For example, although there is global awareness of the need to reduce greenhouse gas emissions, major coal exporting nations such as Australia still protect their production of coal.[1] The U.S. Supreme Court overturned the Environmental Protection Agency's (EPA) landmark air pollution rule in 2015 because of the huge cost of the regulation to power plants.[2] As a result, the following question may be raised: What factors cause governments that confront increasing environmental consciousness to slacken their environmental policies?

Most existing literature from the strategic trade policy point of view concentrates on how governments can help domestic firms gain advantages in imperfectly competitive international markets by easing their environmental policies on transboundary pollution.[3] Little attention has been paid to the effects of environmental consciousness from the economic aspect. The purpose of this paper is to investigate how governments should adjust their environmental policies when worldwide environmental consciousness increases.

Only a few exceptional studies explore this issue. Hirazawa and Takita (2005)

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[1] In early 2015, Australia's prime minister backed down from his position on the issue of the production of coal in Queensland's Galilee Basin. See ABC news on September 10, 2015 (http://www.abc.net.au/environment/articles/2015/09/10/4309937.htm). Australia also became the first developed country to repeal its carbon tax (http://www.wsj.com/articles/australia-repeals-carbon-tax-1405560964).

[2] See the detailed report in the *New York Times* (June 29, 2015; http://thehill.com/policy/energy-environment/246423-supreme-court-overturns-epa-air-pollution-rule).

[3] The literature on so-called "strategic environmental policy" is large and growing. It is argued that, in the absence of trade policy to protect domestic industries, governments might seek to relax environmental policies to give their domestic producers an advantage or increase their welfare. See Barrett (1994), Kennedy (1994), Ulph (1996), Copeland and Taylor (2004), and Lapan and Sikdar (2011).

introduce environmental awareness to the model in Hatzipanayotou et al. (2002) to investigate the effects of becoming more conscious of cross-border pollution in a financial-aid recipient (developing country) on the welfare of the donor (developed country). Endres (1997) considers a model of two identical countries suffering from pollution to examine the relationship between environmental consciousness and the deviation of the Nash equilibrium emissions from social optimum levels. Vogel (2012) constructs a political economy model to analyze the effects of interest group activities (such as campaigning and lobbying) on the quality of the environment. Endres (1997) and Vogel (1999) conclude that governments will tighten their environmental policies if environmental consciousness goes up. Hirazawa and Takita (2005) find that an increase in a recipient's environmental awareness reduces the level of transboundary pollution and benefits the donor. In their results, however, the increasing environmental awareness has no effect on the developing country's emission tax rate.

This paper differs from previous literature in three key respects. First, it models the strategic interactions between two large heterogeneous firms (countries) with different cost competitiveness. Second, it explores the environmental policy adjustment after a rise in environmental awareness for both local pollution and global pollution. Baksi (2014) find that regional trade liberalization has effects on the equilibrium pollution tax in the participating countries and nonparticipating countries, but the effects are different between local pollution and global pollution; we expect that an increase in environmental consciousness of local pollution also has a different influence on a government's policy from that of global pollution. Third, instead of using pollution taxes to represent a government's policy toward environmental issues in most literature, this paper employs emission standards. Our results show that a government that faces increasing environmental consciousness may tighten or slacken its environmental policy depending on its relative cost competitiveness to its rival.

The rest of this paper is organized as follows. Section 2 presents the model. Sections 3 and 4 discuss the environmental policy adjustment for local pollution and global pollution, respectively. Model extensions are delivered in section 5. Some concluding remarks are contained in section 6.

1. The model

Two firms, A and B, located in different countries, A and B, export a homogeneous good to a third market with the linear inverse demand $P = \alpha - (Q^A + Q^B)$, $\alpha > 0$. Pollution emissions associated with output levels cause damage either to the local economy (denoted as local pollution) or to all countries in the world (denoted as global pollution). By considering firms' profits and environmental impacts, both governments set emission standards (E^i, $i = A, B$) as their own environmental policies.[4] Let the emission-output ratio equal one for both firms.[5] The cost of abating a level of emissions $(Q^i - E^i)$ is $(Q^i - E^i)^2 / 2\text{b}$ which reflects the existence of the diminishing marginal returns in the abatement technology. If the pollution is local, country i suffers the environmental damage $(E^i)^2 / 2$ that results from its firm's emissions E^i.[6] If the pollution is global, countries in the world suffer the environmental damage $(E^A + E^B)^2 / 2$, which results from global emissions $(E^A + E^B)$. The model is a two-stage game, where each government chooses the level of emission standard in stage one, and each firm sets its output in

[4] Lax (weak) environmental policy represents governments that allow firms to emit more pollution.
[5] The units are chosen such that each unit of output produces a unit of pollution. Moreover, the consideration is confined to production-related pollution rather than consumption-related pollution.
[6] The quadratic environmental damage function implies that the emissions affect the environment at an increasing scale, that is, every unit of emission causes a greater damage than the previous unit.

stage two. The game is solved by backward induction to obtain a subgame perfect Nash equilibrium.

Firm i maximizes its profit,

$$\pi^i = (P - C^i)Q^i - (Q^i - E^i)^2 / 2, \quad i = A, B \tag{1}$$

where C^i is the constant marginal cost to firm i. Solving $\frac{d\pi^A}{dQ^A} = 0$ and $\frac{d\pi^B}{dQ^B} = 0$ simultaneously, the Cournot-Nash equilibrium output levels at the second stage are

$$Q^A = \frac{1}{8}[2\alpha - 3(C^A - E^A) + (C^B - E^B)], \tag{2}$$

$$Q^B = \frac{1}{8}[2\alpha + (C^A - E^A) - 3(C^B - E^B)]. \tag{3}$$

Equations (3) and (4) show that stricter environmental policy (lower E^A) will cut the equilibrium output of firm A and raise the output of firm B.

While the solution to the second stage of the game as a function of environmental policies (E^A and E^B) is obtained, it can now be used to analyze the first stage, where both governments simultaneously set their emission standards (E^A and E^B) to maximize their own welfare functions. In the following two sections, we will derive the optimal emission standards and evaluate how they are affected when worldwide environmental consciousness changes under two cases: local pollution and global pollution.

2. Environmental policy adjustment in the case of local pollution

Let ϕ be a subjective nonnegative indicator that shows the worldwide consciousness (or concern) about environmental damage.[7] As ϕ increases, people in the world are more concerned about environmental damage, which results in more welfare reduction. Hence, we can specify country $i's$ welfare in the local pollution case as following:

$$W^i = \pi^i - \phi (E^i)^2 / 2, \quad i = A, B \tag{4}$$

which is given by the profit of its domestic firm's (π^i) net of welfare reduction $\phi(E^i)^2/2$ from environmental damage $(E^i)^2/2$, which results from pollution emissions (E^i). Using (2) and (3), the Nash equilibrium emission standards are derived by solving $\frac{dW^A}{dE^A} = 0$ and $\frac{dW^B}{dE^B} = 0$ simultaneously:

$$E^A = \frac{9G^B[(15+24\phi)G - 8(1+\phi)]}{(32\phi+23)(7+16\phi)}, \tag{5}$$

$$E^B = \frac{9G^B[(15+24\phi) - 8(1+\phi)G]}{(32\phi+23)(7+16\phi)}, \tag{6}$$

where $G^A = (\alpha - C^A)$ and $G^B = (\alpha - C^B)$ are the absolute cost competitiveness of firm A and B, respectively, and $G = \frac{G^A}{G^B} = \frac{(\alpha - C^A)}{(\alpha - C^B)}$ is firm $A's$ relative cost competitiveness (in terms of firm B). From (5) and (6), we can evaluate the effects of change in environmental consciousness (ϕ) on the optimal emission standards:

$$\frac{\partial E^A}{\partial \phi} = \frac{72G^B[(431+1024\phi+512\phi^2) - (627+1920\phi+1536\phi^2)G]}{(32\phi+23)^2(7+16\phi)^2}, \tag{7}$$

$$\frac{\partial E^B}{\partial \phi} = \frac{72G^B[(431+1024\phi+512\phi^2)G - (627+1920\phi+1536\phi^2)]}{(32\phi+23)^2(7+16\phi)^2}. \tag{8}$$

Equations (7) and (8) lead to the following proposition:

[7] The same specification for environmental consciousness can be found in Endres (1997).

Proposition 1. *In the case of local pollution, when environmental consciousness rises, country A tends to tighten, but country B tends to slacken, its own environmental policies if firm $A's$ relative cost competitiveness is high enough. However, both countries will tighten their environmental policies if the cost competitiveness of the two firms is close.*

Proof. Six lines in Fig.1 are drawn by setting Q^A, Q^B, E^A, E^B, $\frac{\partial E^A}{\partial \phi}$ and $\frac{\partial E^B}{\partial \phi}$ to zero.[8] Under the assumption of Q^A, Q^B, E^A and E^B being nonnegative, these lines partition the space into three regions:

$$\text{region Ⅰ}: \frac{\partial E^A}{\partial \phi} < 0, \frac{\partial E^B}{\partial \phi} > 0,$$

$$\text{region Ⅱ}: \frac{\partial E^A}{\partial \phi} < 0, \frac{\partial E^B}{\partial \phi} < 0,$$

$$\text{region Ⅲ}: \frac{\partial E^A}{\partial \phi} > 0, \frac{\partial E^B}{\partial \phi} < 0.$$

Given the initial level of ϕ, if the difference of cost competitiveness between the two firms is large enough (i.e., the value of G is far enough away from one), it is likely to fall into region Ⅰ or Ⅲ, where one country tightens and the other slackens its own environmental policies when environmental consciousness rises. However, it will fall into region Ⅱ when the cost competitiveness in both firms is close (i.e., the

[8] The lines of $Q^A = 0$ and $Q^B = 0$ are drawn based on the values of Q^A and Q^B derived from substituting (5) and (6) into (2) and (3), respectively. It is noted that both lines of $Q^A = 0$ and $E^A = 0$ are identical, and both lines of $Q^B = 0$ and $E^B = 0$ are the same in Fig.1.

value of G is close to one). Therefore, both countries will tighten their environmental policies.

The economic interpretation is simple. In the model of two countries competing with each other in a third market, the optimal emission standard is specified as the point at which profits shifted away from the competitor equal the marginal environmental damage. The higher firm $A's$ relative cost competitiveness (G), the higher the profits that can be shifted away to firm B, and the lower the profits that can be shifted away from firm B.[9] Since increasing environmental consciousness (ϕ) raises the marginal environmental damage (ϕE^i), if firm $A's$ relative cost competitiveness (G) is high, it is less likely to shift enough profit from firm B by increasing emission standards to compensate for the increase in marginal environmental damage. Therefore, country A has an incentive to tighten its environmental policy. However, with a high value of G, it is more likely that country B will shift enough profit from firm A by increasing its emission standards. Country B then tends to slacken its environmental policy.

3. Environmental policy adjustment in the case of global pollution

If the pollution is global, the emissions generated by one firm can damage not only the country where the firm is located but also other countries as well. Therefore, we can define country $i's$ welfare as follows:

$$W^i = \pi^i - \phi (E^A + E^B)^2 / 2, \quad i = A, B \tag{9}$$

[9] The profit levels for both firms and the difference are $\pi^A = \frac{3(G^B)^2(37+128\phi+64\phi^2)[(15G-8)+8\phi(3G-1)]^2}{2(23+32\phi)^2(7+16\phi)^2}$, $\pi^B = \frac{3(G^B)^2(37+128\phi+64\phi^2)[(15-8G)+8\phi(3-G)]^2}{2(23+32\phi)^2(7+16\phi)^2}$ and $\pi^A - \pi^B = \frac{3(G^B)^2(37+128\phi+64\phi^2)(G^2-1)}{2(23+32\phi)(7+16\phi)}$. Hence, $\pi^A > \pi^B$ if G>1.

where $\phi(E^A + E^B)^2 / 2$ is the welfare reduction from environmental damage resulting from global emissions $(E^A + E^B)$. As discussed in section 3, the Nash equilibrium emission standards can be derived as

$$E^A = \frac{9G^B[(15+32\phi)G - 8(1+4\phi)]}{7(23+64\phi)}, \tag{10}$$

$$E^B = \frac{9G^B[(15+32\phi) - 8(1+4\phi)G]}{7(23+64\phi)}. \tag{11}$$

From (10) and (11), we have

$$\frac{\partial E^A}{\partial \phi} = -\frac{288G^B(G+1)}{(23+64\phi)^2}, \tag{12}$$

$$\frac{\partial E^B}{\partial \phi} = -\frac{288G^B(G+1)}{(23+64\phi)^2}, \tag{13}$$

where $\frac{\partial E^A}{\partial \phi} = \frac{\partial E^B}{\partial \phi} < 0$. This leads to the following proposition:

Proposition 2. *In the case of global pollution, both countries will tighten their environmental policies as environmental consciousness rises.*

The economic intuition is similar to that in Proposition 1. However, global pollution enlarges the marginal environmental damage ($\phi(E^A + E^B)$), which increases the cost of allowing slackened environmental policies. Hence, both countries will tighten their environmental policies.

4. Model extensions

The basic model discussed in sections 3 and 4 will be extended to discuss three cases: The first is the case where environmental consciousness rises in one country but not in the other. The second is the case where there is no domestic consumption and environmental policy is set to maximize global welfare. The third is the case where domestic consumption is taken into account and environmental policy is set to maximize global welfare.

4.1 Unilateral increase in environmental consciousness

The basic model discussed in the previous two sections aims to examine the effects of increasing worldwide environmental consciousness. In the real world, developed countries in particular are more aware of environmental quality, while developing and less-developed countries are less concerned with or even ignorant of environment degradation. If this is the case, how can governments adjust their policies?

To simplify the model, we assume that ϕ is nonnegative in country A and is zero in country B. In other words, country A cares about its environment, while country B does not. In the case of local pollution, we can rewrite equation (4) as $W^A = \pi^A - \phi(E^A)^2/2$ for country A, and $W^B = \pi^B$ for country B. The Nash equilibrium emission standards are derived by solving $\frac{dW^A}{dE^A} = 0$ and $\frac{dW^B}{dE^B} = 0$ simultaneously:

$$E^A = \frac{9G^B(15G-8)}{(161+296\phi)}, \tag{14}$$

$$E^B = \frac{9G^B[(15+24\phi)-8(1+\phi)]}{(161+296\phi)}, \tag{15}$$

The effects of change in environmental consciousness (ϕ) on the optimal emission standards are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{-2664 G^B (15G - 8)}{(161 + 296\phi)^2}, \tag{16}$$

$$\frac{\partial E^B}{\partial \phi} = \frac{648 G^B (15G - 8)}{(161 + 296\phi)^2}. \tag{17}$$

Under the assumption of Q^A, Q^B, E^A and E^B being nonnegative, as shown in Fig. 2, we have a result located in region I, where $\frac{\partial E^A}{\partial \phi} < 0$ and $\frac{\partial E^B}{\partial \phi} > 0$. This demonstrates that, regardless of relative cost competitiveness, a country with higher (no) environmental awareness inclines to tighten (slacken) its environmental policy if environmental consciousness rises and pollution damages the local environment. Those results are very intuitive. The explanation is that raising the marginal environmental damage in country A causes no damage to country B when environmental consciousness (ϕ) increases.

In the case of global pollution, we can rewrite equation (4) as $W^A = \pi^A - \phi(E^A + E^B)^2 / 2$ for country A and $W^B = \pi^B$ for country B. The Nash equilibrium emission standards are as follows:

$$E^A = \frac{9G^B[(15 + 8\phi)G - 8(1 + 3\phi)]}{7(23 + 32\phi)}, \tag{18}$$

$$E^B = \frac{9G^B[(15 + 24\phi) - 8(1 + \phi)G]}{7(23 + 32\phi)}. \tag{19}$$

The effects of change in environmental consciousness (ϕ) on the optimal emission standards are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{-2664 G^B (1 + G)}{(23 + 32\phi)^2} < 0, \tag{20}$$

$$\frac{\partial E^B}{\partial \phi} = \frac{648 G^B (1 + G)}{(23 + 32\phi)^2} > 0. \tag{21}$$

An increase in environmental consciousness (ϕ) in the case of global pollution enlarges marginal damage to country A but causes no damage to country B. Equations (20) and (21), similar to the local pollution case, shows that country A tightens but country B slackens its emission standards.

4.2 Efficient environmental policy without consideration of domestic consumption

Literature on strategic trade policy under imperfect competition markets shows that the optimal Nash equilibrium policy that maximizes one country's welfare deviates from the efficient policy that maximizes global welfare. Kennedy (1994) decomposes the deviation into three effects. The rent capture effect (RCE) illustrates that a government has the incentive to unilaterally adopt slackened policy to shift profit from foreign rivals. The pollution shifting effect (PSE) demonstrates that government tends to tighten its policy to reduce domestic output (and hence domestic pollution) and increase foreign output (and hence foreign pollution). The transboundary externality effect (TEE) implies that a country that neglects the effects of pollution generated inside its boundary on foreign countries is inclined to slacken its policies. If the sum of RCE and TEE is greater than PSE, the Nash equilibrium policy is laxer than the efficient policy. In the other case, the Nash equilibrium policy is tighter than the efficient policy. This subsection attempts to examine how government adjusts policy if the efficient policy is supported.

To investigate the efficient policy under the local pollution case, we have global welfare (W) as the sum of both countries' welfare ($W^A + W^B$), where W^A and W^B are evaluated in equation (4). The efficient emission standards are derived by solving $\frac{dW}{dE^A} = 0$ and $\frac{dW}{dE^B} = 0$ simultaneously:

$$E^A = \frac{3G^B[(7+10\phi)G - 6(1+\phi)]}{(1+4\phi)(13+16\phi)}, \tag{22}$$

$$E^B = \frac{3G^B[(7+10\phi) - 6(1+\phi)D]}{(1+4\phi)(13+16\phi)}. \tag{23}$$

Compared to the results in (5) and (6), we find that the efficient emission standards in (22) and (23) can be greater, equal to, or less than those in Nash equilibrium emission standards. The reason for the deviation can be explained from the three effects mentioned in Kennedy (1994) and discussed above. It is noted that TEE vanished under the local pollution case. Therefore, if RCE is greater than PSE, the emission standard in Nash equilibrium is greater than the efficient emission standard.

The effects of change in environmental consciousness (ϕ) on the efficient emission standards are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{6G^B[(165+384\phi+192\phi^2) - (173+448\phi+320\phi^2)G]}{(1+4\phi)^2(13+16\phi)^2}, \tag{24}$$

$$\frac{\partial E^B}{\partial \phi} = \frac{6G^B[(165+384\phi+192\phi^2)G - (173+448\phi+320\phi^2)]}{(1+4\phi)^2(13+16\phi)^2}. \tag{25}$$

Under the assumption of Q^A, Q^B, E^A, and E^B being nonnegative, as shown in Fig. 3, we also can partition the space into three regions under a Nash equilibrium regime, as in Fig. 1. The economic implications are similar to Proposition 1, in which relative cost competitiveness plays an important role for policy adjustment under an efficient policy regime.

In the global pollution case, W^A and W^B are evaluated in equation (9) in global welfare ($W = W^A + W^B$). The efficient emission standards are derived by solving $\frac{dW}{dE^A} = 0$ and $\frac{dW}{dE^B} = 0$ simultaneously:

$$E^A = \frac{3G^B[(7+32\phi)G - (6+32\phi)]}{(13+64\phi)}, \tag{26}$$

$$E^B = \frac{3G^B[(7+32\phi)-(6+32\phi)D]}{(13+64\phi)}. \quad (27)$$

Compared to the results in (10) and (11), we find that the efficient emission standards in (26) and (27) can be greater, equal to, or less than those in Nash equilibrium emission standards. The explanation for the deviation can be inferred by comparing the sum of RCE and TEE with PSE. If PSE is smaller, the Nash equilibrium emission standard will be smaller than the efficient emission standard.

The effects of change in environmental consciousness (ϕ) on the efficient emission standards under the global pollution case are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{-96G^B(G+1)}{(13+64\phi)^2} < 0, \quad (28)$$

$$\frac{\partial E^B}{\partial \phi} = \frac{-96G^B(G+1)}{(13+64\phi)^2} < 0. \quad (29)$$

Equations (28) and (29) suggest that both countries need to tighten environmental policy in an efficient policy regime under the global pollution case.

4.3 Efficient environmental policy with consideration of domestic consumption

The models built in previous sections assume that firms in both countries export all products to a third country (Brander and Spencer, 1985). The Brander-Spencer model framework, which excludes domestic consumption (and hence consumer surplus in social welfare), not only simplifies model calculation but also identifies the role of the rent-shifting effect (i.e., the rent capture effect in Kennedy, 1994) in policy settings. A more general framework would incorporate domestic consumption into the model to examine the impact of environmental consciousness on policy adjustment.

To this end, we adopt an intraindustry trade structure and follow the model documented in Benchekroun and Yildiz (2011). We define inverse demand functions in country A and B as $P^A = \alpha - (Q^{AA} + Q^{BA})$ and $P^B = \alpha - (Q^{AB} + Q^{BB})$, respectively, where P^A and P^B are prices in both markets, Q^{ij} are firm $i's$ output sold in country j, $i, j = A, B$. Profit functions for each firm can be written as $\pi^i = (P^i - C^i)Q^{ii} + (P^j - C^i)Q^{ij} - (Q^{ii} + Q^{ij} - E^i)^2 / 2$, $i, j = A, B, i \neq j$. In the local pollution case, the welfare function for each country comprises consumer surplus, the firm's profit, and environmental damage, and can be written as $W^i = [\int_0^{(Q^{ii}+Q^{ji})} P^i(v)dv - P^i(Q^{ii} + Q^{ji})] + \pi^i - \phi(E^i)^2 / 2$, $i, j = A, B, i \neq j$. The global welfare (W) is measured by the sum of both countries' welfare ($W^A + W^B$). Following the backward induction process, the efficient emission standards derived by solving $\frac{dW}{dE^A} = 0$ and $\frac{dW}{dE^B} = 0$ simultaneously are as follows:

$$E^A = \frac{2G^B[(29 + 77\phi)G - 23(1 + \phi)]}{(1 + 9\phi)(13 + 25\phi)}, \tag{30}$$

$$E^B = \frac{2G^B[(29 + 77\phi) - 23(1 + \phi)G]}{(1 + 9\phi)(13 + 25\phi)}. \tag{31}$$

The effects of change in environmental consciousness (ϕ) on the efficient emission standards are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{6G^B[(989 + 3450\phi + 1725\phi^2) - (1039 + 4350\phi + 5775\phi^2)G]}{(1 + 9\phi)^2(13 + 25\phi)^2}, \tag{32}$$

$$\frac{\partial E^A}{\partial \phi} = \frac{6G^B[(989 + 3450\phi + 1725\phi^2)G - (1039 + 4350\phi + 5775\phi^2)]}{(1 + 9\phi)^2(13 + 25\phi)^2}. \tag{33}$$

Under the assumption of Q^A, Q^B, E^A and E^B being nonnegative, we also obtain a graph like that in Fig. 3 and partition the space into three regions. Compared to Fig. 3, the differences when we include domestic consumption are the intercepts in the vertical axis: here they are 1.294, 1.2609, 1.0506, 0.9518, 0.7931 and 0.7727, while in

Fig. 3 they are 1.3636, 1.1667, 1.0485, 0.95376, 0.85714 and 0.7333. The result shows that, although domestic consumption is taken into account, the relative cost competitiveness is still the key factor to determine policy adjustment, as clarified in proposition 1.

In the global pollution case, the welfare function for each country can be written as $W^i = [\int_0^{(Q^{ii}+Q^{ji})} P^i(v)dv - P^i(Q^{ii}+Q^{ji})] + \pi^i - \phi(E^i + E^j)^2/2$, $i, j = A, B, i \neq j$. The efficient emission standards are as follows:

$$E^A = \frac{2G^B[(29+200\phi)G - (23+200\phi)]}{(13+100\phi)}, \quad (34)$$

$$E^B = \frac{2G^B[(29+200\phi) - (23+200\phi)]}{(13+100\phi)}. \quad (35)$$

The effects of change in environmental consciousness (ϕ) on the efficient emission standards under global pollution case are as follows:

$$\frac{\partial E^A}{\partial \phi} = \frac{-600G^B(G+1)}{(13+100\phi)^2} < 0, \quad (36)$$

$$\frac{\partial E^B}{\partial \phi} = \frac{-600G^B(G+1)}{(13+100\phi)^2} < 0. \quad (37)$$

Equations (28) and (29) suggest that both countries need to tighten environmental policy in an efficient policy regime under the global pollution case.

5. Conclusion

This paper attempts to examine how exporting countries should adjust their environmental policies when worldwide environmental consciousness increases. In the basic model without consideration of domestic consumption, we set up an oligopoly game where two large heterogeneous firms (countries) sell all their output in a third market. Governments move first by choosing environmental policies (emission standards). Firms take these standards as given and compete with each other by choosing output levels. Pollution emissions associated with output levels are either local pollution or global pollution.

This paper shows that, in the local pollution case, a country with high enough cost advantage over its rival has incentives to tighten its environmental policies as worldwide environmental consciousness increases, while while the rival country has incentive to slacken its policies. However, both countries will tighten their environmental policies if firms' cost competitiveness in the two countries is close. In the global pollution case, regardless of relative cost competitiveness, both countries always tighten their environmental policies. These results and the direction of environmental policy adjustment are still valid even in the case of unilateral increase in environmental consciousness, and whether or not domestic consumption is taken into consideration in the case of efficient policy settings.

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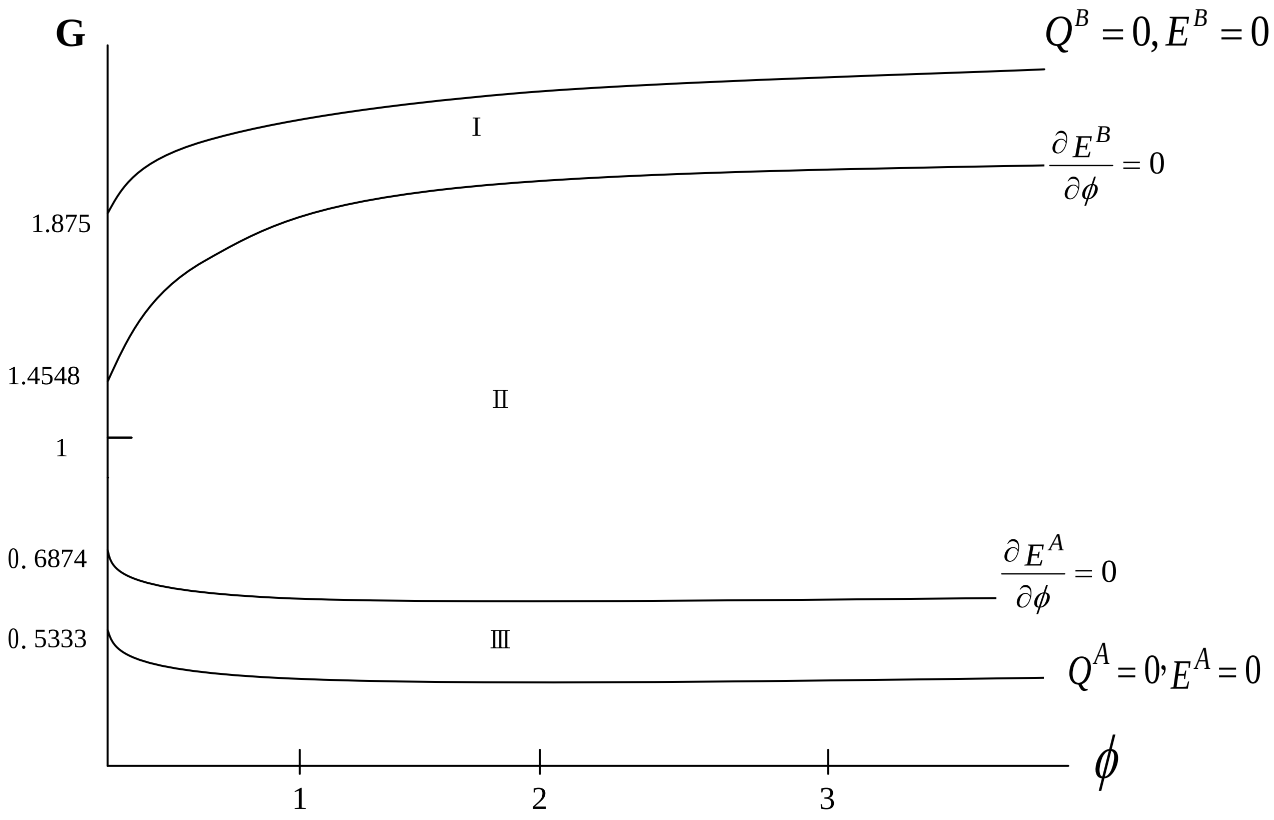

Fig.1: Environmental policy adjustment in the case of local pollution

region Ⅰ ： $\frac{\partial E^A}{\partial \phi} < 0$ ， $\frac{\partial E^B}{\partial \phi} > 0$,

region Ⅱ ： $\frac{\partial E^A}{\partial \phi} < 0$ ， $\frac{\partial E^B}{\partial \phi} < 0$,

region Ⅲ ： $\frac{\partial E^A}{\partial \phi} > 0$ ， $\frac{\partial E^B}{\partial \phi} < 0$.

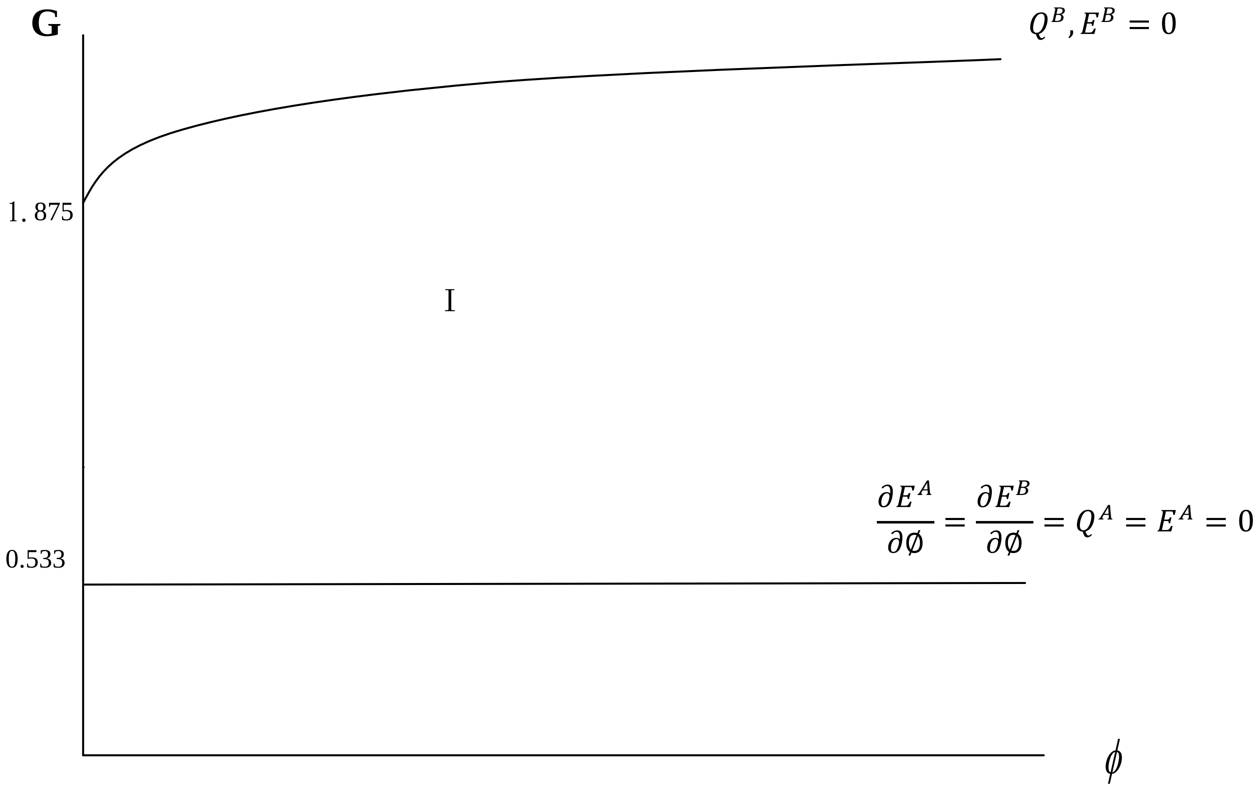

Fig.2: Unilateral increase in environmental consciousness and environmental policy adjustment in the case of local pollution

region I ： $\frac{\partial E^A}{\partial \phi} < 0$， $\frac{\partial E^B}{\partial \phi} > 0$,

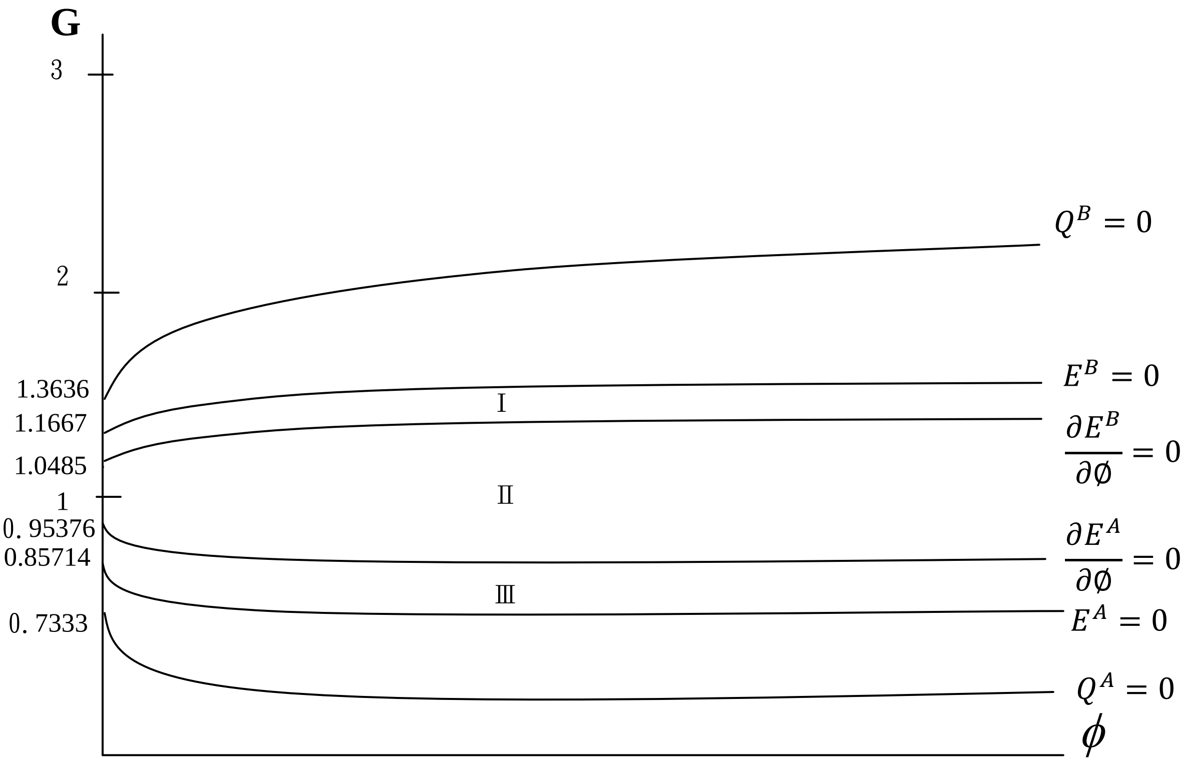

Fig 3: Efficient environmental policy adjustment without domestic consumption consideration in the case of local pollution

region Ⅰ： $\frac{\partial E^A}{\partial \phi} < 0$， $\frac{\partial E^B}{\partial \phi} > 0$,

region Ⅱ： $\frac{\partial E^A}{\partial \phi} < 0$， $\frac{\partial E^B}{\partial \phi} < 0$,

region Ⅲ： $\frac{\partial E^A}{\partial \phi} > 0$， $\frac{\partial E^B}{\partial \phi} < 0$.