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## ENVIRONMENTAL QUALITY AND THE GAINS FROM TRADE

HORST SIEBERT\*

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Countries experience welfare gains if they engage in trade. Does this also hold if environmental quality is taken into consideration? And to what extent are the gains from trade altered when effects of trade on environmental quality are not ignored? Assume a two-commodity world with commodity 1 being a pollution-intensively produced commodity. Let the home country have a comparative price advantage in commodity 1 and – after trade has taken place – let the home country specialize in the production of the pollution-intensively produced commodity. As a result of trade then emissions will increase and environmental quality in the home country will decline. Environmental disruption will reduce the overall benefits to society from trade, and *a priori*, it cannot be ruled out that the environmental losses may overcompensate the conventional gains from trade. This problem will be analyzed in *Section II* of this paper with *Section I* presenting the basic assumptions.

Now assume the home country wants to protect itself against a deterioration of its environmental quality by enacting an appropriate environmental policy – for instance, by levying emission taxes. The problem then arises how environmental policy will affect comparative advantage and the gains from trade. This question is studied in *Section III*. In the final section some extensions are indicated and some conclusions are drawn.

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I. ASSUMPTIONS

The frame of reference is a two-sector economy in which production generates pollutants as a joint product. More specifically, the following assumptions are made:

*A 1* The home country is small compared to the rest of the world so that after trade takes place the relative price  $p = p_1/p_2$  in the home country is determined by the world market.

*A 2* The production of commodities  $i = 1, 2$  generates pollutants as a joint product. For simplifying purposes there is only one type of pollutant. It is assumed that the quantity  $S_i^p$  of pollutants emitted rises proportionally or progressively with output, *i.e.*

$$S_i^p = H_i(Q_i) \quad \text{with } H_i' > 0, H_i'' \geq 0 \quad (1)$$

*A 3* In order to keep the model as simple as possible we assume only one type of resource,  $R$  and a production function

$$Q_i = F_i(R_i) \quad \text{with } F_i' > 0, F_i'' < 0 \quad (2)$$

*A 4* Resources may also be used for pollution abatement purposes. Let  $S_i^r$  indicate the quantity of pollutants reduced in Sector  $i$ .

$$S_i^r = F_i^r(R_i^r) \quad \text{with } F_i^{r'} > 0, F_i^{r''} < 0 \quad (3)$$

According to equation (3) pollutants are prevented from entering the environment. Additionally it could be assumed that a technology exists that reduces pollutants ambient in the environment (water treatment).

*A 5* Net emissions ( $S$ ) are defined as the difference between emissions generated and emissions reduced

$$S_i = S_i^p - S_i^r \quad (4)$$

Pollutants ambient in the environment  $S$  are defined as

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$$S = \sum S_i \quad (5)$$

A 6 Pollutants ambient in the environment cause damage to environmental quality  $U$

$$U = G(S) \quad \text{with } G' < 0, G'' < 0 \quad (6)$$

A 7 Commodity demand is given by

$$C_i = C_i(p, Y) \quad \text{with } p = p_1/p_2 \quad (7)$$

denoting the relative commodity price.

A 8 In order to close the model, we assume that the government spends the tax income received in form of transfers to households. Consequently, gross national product and personal disposable income are defined as

$$Y = p Q_1 + Q_2 \quad (8)$$

Note that  $Y$  includes transfers not explicitly shown and that  $p$  is consumers price and not producers price. If  $Y$  would be defined with respect to producers price,  $p^*$ , emission taxes (and transfers) would appear explicitly on the right side of equation (8).

A 9 The resource input can be used for both production and pollution abatement, and is given

$$R_1 + R_2 + R_1^r + R_2^r = \bar{R} \quad (9)$$

A 10 A situation is assumed in which the environment is used as a common property receiving emissions without the polluter being charged (*Section II*). In *Section III* we assume that the government levies an emission tax  $z$  on net emissions  $S_i$ , with  $z$  being changed parametrically.

A 11 Firms maximize profits and regard commodity prices, factor price ( $r$ ) and the emission tax as given. The conditions for profit maximizing factor demand are given as

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$$\begin{aligned} r &= (p - zH'_1) F'_1(R'_1) \\ r &= (1 - zH'_2) F'_2(R_2) \\ r &= zF'_i(R'_i) \end{aligned} \quad (10)$$

which yields the usual conditions for  $z = 0$ .

A 12 If trade takes place, the balance of payments must be in equilibrium

$$pE_1 + E_2 = 0 \quad (11)$$

with

$$E_i = C_i - Q_i \quad (12)$$

## II. GAINS FROM TRADE AND ENVIRONMENTAL LOSSES

1. In a situation where no environmental policy is undertaken and  $z = 0$ , gains from trade exist if trade increases welfare. Assume a social welfare function

$$W = W(C_1, C_2, U) \quad (13)$$

Recalling assumptions (1), (4), (5), (6), (11) and (12), observing that  $p dE_1 + E_1 dp + dE_2 = 0$  and that  $E_1 = 0$  in the autarky situation and finally evaluating commodities at the price  $p$  of the trade situation, we have for the change in welfare

$$dW = \left[ \frac{\partial W}{\partial C_2} \left( p \frac{dQ_1}{dQ_2} + 1 \right) + \frac{\partial W}{\partial U} G' \left( H'_1 \frac{dQ_1}{dQ_2} + H'_2 \right) \right] dQ_2 \quad (13')$$

2. Assume  $dQ_2 < 0$ , so that the country specializes in the production of commodity 1. The first expression in 13' is positive, if

$$p > - \frac{dQ_2}{dQ_1} = {}^{\circ}p$$

where  ${}^{\circ}p$  is the autarky price of the home country. This is the known condition that country 1 must have a comparative advantage for

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commodity 1 if it specializes in the production of that commodity after trade takes place.

3. With respect to the second term, two cases have to be distinguished. First, if  $(H'_1 dQ_1/dQ_2 + H'_2) > 0$  or, due to  $dR_2 = -dR_1$ ,  $H'_1 F'_1 < H'_2 F'_2$  commodity 2 is the pollution-intensive commodity since  $H'_i F'_i$  measures the marginal tendency of pollution of using a resource in Sector  $i$ . The result is as follows: If a country specializes in the production of the less pollution-intensively produced commodity, the usual gains from trade are increased by an improvement in environmental quality. The country reduces the output of the pollution-intensively produced commodity, the conventional gains from trade are enhanced by an improvement in environmental quality and the country exports pollutants via trade to the rest of the world.

Second, if  $H'_1 F'_1 > H'_2 F'_2$ , the second term in 13' is negative. As a result we have the following outcome: If a country specializes in the production of the pollution-intensively produced commodity the welfare gains from trade (in the usual definition) are offset by a deterioration in environmental quality. *A priori* it cannot be ruled out that in the case of a strong preference for environmental quality and of a high marginal damage (in the physical sense) due to high levels of pollutants already in the environment the welfare loss associated with the deterioration in environmental quality may over-compensate the conventional gains from trade.

### III. THE TRADE-OFF BETWEEN ENVIRONMENTAL QUALITY AND THE GAINS FROM TRADE

1. In *Section II* it was assumed that no environmental policy is undertaken. Another way of looking at the reduction in the welfare gains from trade due to an environmental deterioration is that the comparative price advantage of a country is not expressed correctly if prices do not include all social costs of production. Assume now that the country undertakes environmental policy. How will that policy affect the gains from trade? Is there a trade-off between the gains from trade and environmental quality? To answer this question we need to discuss how welfare is affected if environmental policy is undertaken when trade is taking place in the initial situation. We

only consider the case in which the country specializes in the production of the pollution intensively produced commodity.

We are interested in the sign of the expression

$$\frac{dW}{dz} = \frac{\partial W}{\partial C_2} \left( \bar{p} \frac{dC_1}{dz} + \frac{dC_2}{dz} \right) + \frac{\partial W}{\partial U} \frac{dU}{dz} \quad (14)$$

2. In order to analyze how welfare is affected in an open economy if environmental policy is introduced we use the system of equation (1)–(4), (7)–(12) consisting of 19 equations and the 18 variables  $S_i^p, S_i, S_i^r, Q_i, R_i, R_i^r, Y, C_i, r, E_1$  and  $E_2$ , with  $p$  determined by the world market. The definition of  $Y$  states that total demand is equal to income, and the balance of payments equilibrium requires that the excess demand of the economy expressed in terms of commodity 2 is equal to zero, so that in a two-sector-model the definition of  $E_2$  is redundant and can be omitted. Substituting and differentiating with respect to  $z$  we have

$$\begin{bmatrix} 1 & 0 & p & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & -pF_1'C_{2Y} & -F_2'C_{2Y} & 0 & 0 \\ 0 & 0 & 1 & F_1'C_{2Y} & -F_2'C_{1Y} & 0 & 0 \\ 0 & 0 & 0 & a_1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & a_2 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & -zF_1^{r'} & 1 \\ 0 & 0 & 0 & zF_2^{r'} & zF_2^{r'} & zF_2^{r'} & 1 \end{bmatrix} \cdot \begin{bmatrix} dE_2 \\ dC_2 \\ dE_1 \\ dR_1 \\ dR_2 \\ dR_1^r \\ dr \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ -H_1'F_1'dz \\ -H_2'F_2'dz \\ F_1^r dz \\ F_2^r dz \end{bmatrix} \quad (15)$$

with

$$C_{2Y}' = 1 - pC_{1Y}'$$

$$a_i = zH_i''F_i'^2 - (p_i - zH_i')F_i'' > 0$$

Assume commodity 2 is imported and commodity 1 is exported so that  $E_2 > 0$  and  $E_1 < 0$  when environmental policy is undertaken. Noting that the conditions stated are sufficient conditions so that the results may also occur with other constellations of the parameters, we have the following results:

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$$\frac{dE_2}{dz}, \frac{d(-E_1)}{dz} < 0: H'_1 F'_1 > H'_2 F'_2 \quad (16 \text{ i})$$

$$F'_1 C'_{2Y} + F'_2 C'_{1Y} > 0 \quad (16 \text{ ii})$$

$$F'_1 C'_{2Y} a_2 > F'_2 C'_{1Y} a_1 \quad (16 \text{ iii})$$

$$\frac{dC_2}{dz} < 0: H'_1 F'_1 > H'_2 F'_2 \quad (17 \text{ i})$$

$$C'_{2Y} > 0 \quad (17 \text{ ii})$$

$$\frac{dR_1}{dz} < 0: H'_1 F'_1 > H'_2 F'_2 \quad (18)$$

Without any condition additional to those already stated in the assumptions we have from equation (V) in the *appendix* and from the resource constraint

$$\frac{dR'_i}{dz} > 0 \quad (19)$$

3. With the introduction of environmental policy, resource use in the pollution-intensive sector (and its output) will decline. Environmental policy makes the production of the pollution intensive commodity more costly. Consequently we can expect that the volume of exports will decline. This will be the case if demand conditions are such that the internal demand for commodity 1 rises with the introduction of environmental policy. Observe that income  $Y$  will decline with an improvement in environmental quality due to resources used in abatement activities being withdrawn from production (see below). Therefore, internal demand for commodity 1 will rise, if commodity 1 is inferior ( $C'_{1Y} < 0$ ) and if demand for commodity 2 is more income-elastic than for commodity 1 in absolute terms,  $|C'_{1Y}| > |C'_{2Y}|$ .

Such an exceptional condition is not a necessary one, however. Assume a positive income elasticity of demand for both commodities. Then it may already be sufficient that the demand for commodity 2 is more income elastic than for commodity 1<sup>1</sup>. This ensures that with

1. For a more detailed presentation of the results compare *Beiträge zur angewandten Wirtschaftsforschung*, Institut für Volkswirtschaftslehre und Statistik, Universität Mannheim, Discussion Paper 85/77.



income  $Y$  declining, the fall in demand for commodity 1 is smaller than for commodity 2. This relatively income-inelastic demand for the pollution-intensively produced commodity prevents internal demand from falling and makes sure that exports are reduced.

Whereas resource use in Sector 1 decreases, and whereas the resource will be used additionally in the abatement activity of Sector 1, the result on the resource use in Sector 2 is ambiguous if Sector 2 is the less pollution intensive. This is due to the fact that resources used in the pollution abatement of Sector 1 may be withdrawn from Sector 1 only. Also if resources are used in the pollution abatement of Sector 2, they may come from Sector 1<sup>2</sup>.

From equation (19) we also know that resources used in the abatement activity of Sector 1 will increase. Further, we have  $\sum dR_i^*/dz > 0$  and consequently  $\sum dR_i/dz < 0$ . These results, however, do not rule out the possibility that resource use increases in Sector 2.

Internal demand for commodity 2 will decline if a positive marginal propensity to spend for commodity 2 prevails.  $C'_{2Y} > 0$  does not insure, however, that the quantity of imports will increase.

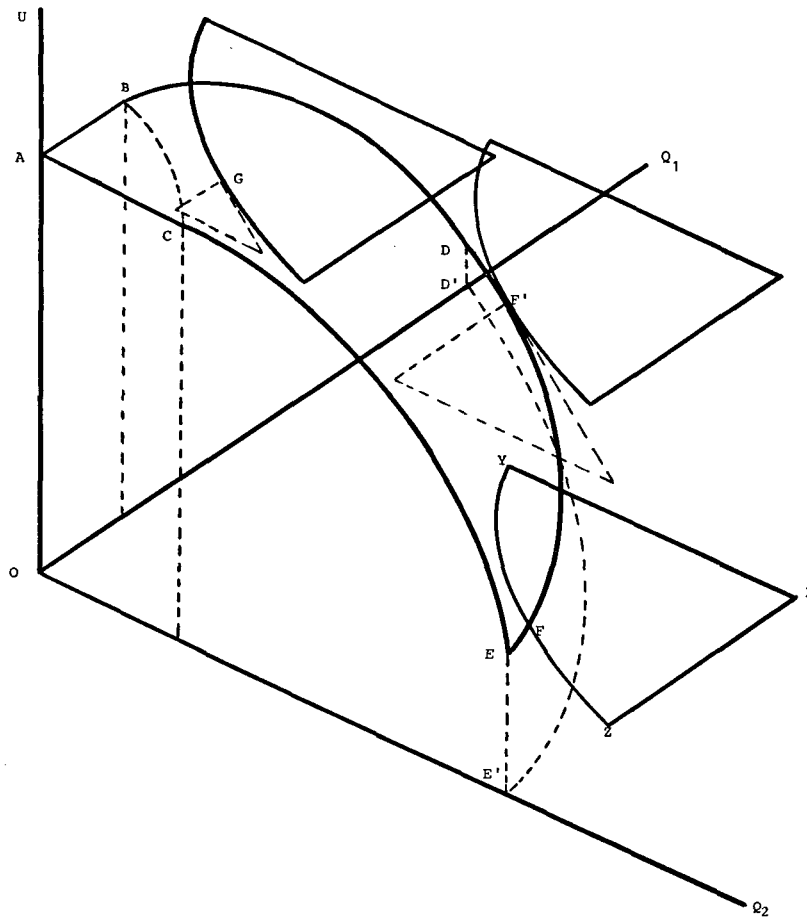
National income as defined in equation (8) will decline if commodity 1 is the pollution-intensively produced commodity. Observe that it is assumed that taxes are transferred to households, thus having an income effect. It would be more realistic to assume that tax receipts are spent for other purposes such as monitoring environmental quality or administrating environmental programs. Then additional resources would be withdrawn from the private sector and the aforementioned results with respect to resource use will become even more likely.

Environmental quality will increase with the introduction of the emission tax. Using (1)–(6), (9) and solutions III–IV in the *appendix* we have

$$\frac{dU}{dz} = G' \left[ H'_1 F'_1 \frac{dR_1}{dz} + H'_2 F'_2 \frac{dR_2}{dz} + F'_2 \left( \frac{dR_1}{dz} + \frac{dR_2}{dz} \right) \right] > 0 \quad (20)$$

4. Pollutants are reduced because of the reallocation of the resource between Sectors 1 and 2 and because the resource is used in

2. Observe, however, that from equations (V) and (VI) in the *appendix*, resource use in Sector 1 is more sensitive to the emission tax than in Sector 2, *i.e.*  $|dR_1/dz| > |dR_2/dz|$ .



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$Q_1 = 0$ . Curve  $BC$  ensures the full employment of resources with no pollutants entering the environment (the assimilative capacity is assumed to be zero). If production of commodity 1 is increased (for  $Q_2 = 0$ ) starting at  $B$ , resources are withdrawn from pollution abatement and environmental quality declines for two reasons: (a) increased production with an increasing quantity of pollutants, and (b) withdrawal of resources from pollution abatement. A similar argument holds for increasing the output of commodity 2 with  $Q_1 = 0$  starting at point  $C$ .

If  $R_1^* = 0$ , no resources are used for abatement in Sector 1 ( $D$ ). Similarly point  $E$  shows a situation where  $R_2^* = 0$ .  $DD' > EE'$  indicates that commodity 1 is produced relatively more pollution-intensively. Also it is assumed that  $H_1'F_1' > H_2'F_2'$  is not offset by a comparative advantage of pollution abatement in Sector 1. Curve  $DE$  and its projection to the  $Q_1$ - $Q_2$  plane ( $D'D'$ ) represent the traditional transformation curve with no resource being used in pollution abatement.

In order to keep the diagram simple we do not draw the transformation space of the rest of the world but only its production block ( $XYZ$ ) which lies horizontally and cuts into the transformation space of the home country at  $F$ . Relative price in the home country differs from the world price in the autarky-point  $F$ .

Assume a no-trade situation  $F$  with both the home country and the rest of the world undertaking no environmental policy and  $^op < p$ . If trade takes place gains from trade occur as shown by the trade triangle associated with point  $F'$ . Environmental quality for the home country, however, has declined. This is the argument presented in Section II, above.

Consider now situation  $F'$  with the home country levying an emission tax and the rest of the world having no environmental policy. In this case our results indicate that  $Q_1$  will decrease,  $U$  will increase and  $Q_2$  may rise or fall. If we define an iso-price-line for varying  $z$ , we know that this line will move in such a direction that  $dQ_1/dz < 0$  and  $dU/dz > 0$ . If internal demand for commodity 1 does not fall too much, which we have ruled out, exports of the home country are reduced and, with  $p$  given, the quantity of imports falls. Gains from trade are smaller – compare the trade triangle at point  $G$ . The gains from trade have been reduced by environmental policy. The im-

provement in environmental quality is only possible by reducing the gains from trade<sup>3</sup>.

5. Substituting the results into equation (14) we have

$$\frac{dW}{dz} = \left( \frac{\partial W}{\partial C_2} + \frac{\partial W}{\partial U} \frac{G'}{z} \right) \frac{dY}{dz} \quad (21)$$

We know that  $dY/dz < 0$ , *i.e.* the commodity bundle measured in units of commodity 2 decreases due to environmental policy. Consequently we have from equation (21)

$$\frac{dW}{dz} \geq 0: z \frac{\partial W}{\partial C_2} \leq - \frac{\partial W}{\partial U} G' \quad (21')$$

The term on the right side of equation (21') indicates prevented marginal environmental damage. The term on the left side denotes the emission tax in value terms, namely the emission tax  $z$  in real terms (*i.e.* in quantity units of commodity 2) evaluated with the marginal utility of commodity 2. Welfare will increase if in the initial situation the emission tax in value terms is lower than prevented marginal environmental damage. Welfare will not increase if the emission tax in a given situation is set according to marginal environmental damage prevented. And welfare will fall if in the initial situation the emission tax is set higher than marginal damage prevented.

This result confirms the well-known rule for the setting of the emission tax according to marginal damage prevented in a closed economy for an open economy. It should be pointed out that (21') is the result of an explanation model and not an optimization model. Using the equations of our open economy as restrictions in an optimization model, it can be shown that the shadow price for emissions must be set according to marginal damage prevented.

3. Due to the small-country assumption the relative price for the rest of the world must be identical in  $F$ ,  $F'$  and  $G$ , so that the production point of the rest of the world does not change. Also the production block of the rest of the world is drawn very small. Observe that in the real world the side of the trade triangle cannot be longer than the side of the production block.

Since  $zH'_1 = p - r/F'_1$  and  $zH'_2 = 1 - r/F'_2$ , (21') can also be expressed as

$$\frac{dW}{dz} > 0: \frac{\partial W}{\partial C_2} < \frac{\partial W}{\partial C_2} \frac{r}{F'_2} - \frac{\partial W}{\partial U} G'H'_2 \quad (21'')$$

or

$$\frac{\partial W}{\partial C_2} p < \frac{\partial W}{\partial C_2} \frac{r}{F'_1} - \frac{\partial W}{\partial U} G'H'_1 \quad (21''')$$

In (21'') the right side indicates the social costs of producing commodity 2, namely private marginal costs in real terms ( $r/F'_2$ ) evaluated with the marginal social utility of commodity 2 and environmental damage attributable to commodity 2. The right side of equation (21''') denotes the social costs of producing commodity 1. The left side of both equation denotes the marginal social value of the two commodities<sup>4</sup>.

Welfare will increase with environmental policy if in the initial situation (before environmental policy is undertaken) the marginal social costs of producing a commodity (private plus environmental costs) are higher than the value of that commodity.

Since for  $z = 0$  the relative price must be equal to private marginal costs of production, environmental costs are not accounted for. Introducing an emission tax will reduce  $R_1$ , whereas  $F'_1$  will rise and marginal private costs of production will fall<sup>5</sup>. Also pollutants of Sector 1 will be reduced, marginal damage will be reduced due to a lower quantity of emissions and the marginal evaluation of the environment will fall since its quality increases (making the usual assumptions about welfare functions). Consequently, after all adaptations have taken place, commodity price and the social costs of production will be equal [compare equation (10)].

If in (21'') and (21''') the evaluation of a commodity is higher than its social costs of production before environmental policy is under-

4. In (21'')  $p$  is the relative price of commodity 1, measuring one unit of commodity 1 in quantity units of commodity 2. Multiplying  $p$  with  $\partial W/\partial C_2$  indicates social value of one unit of commodity 1.

5. It is assumed that the increase in  $F'_1$  is not offset by a possible rise in  $r$ .

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taken, environmental policy cutting back production and reducing emissions will reduce social costs even further. In this case, welfare will decline and environmental policy should not have been undertaken in the first place.

6. As a limiting case we have the possibility that with environmental policy and with an increase in environmental quality the home country loses its comparative advantage by pricing herself out of the world market. Assume the closed country levies an emission tax  $z^a$ . Then the autarky price  $p^a$  is given by

$$p^a = \frac{r(z^a)}{F'_1(z^a)} + z^a H'_1(z^a)$$

Let  $z^h$  denote the emission tax in the open economy. Then we have from  $p^a < \bar{p}$  as a necessary condition for trade to occur (in the direction assumed) that

$$p^a = \frac{r(z^a)}{F'_1(z^a)} + z^a H'_1(z^a) < \bar{p} < \frac{r(z^h)}{F'_1(z^h)} - z^h H'_1(z^h) \quad (22)$$

If equation (22) holds, the home country will continue to export the pollution-intensively produced commodity, however with a reduced volume. If the left side of (22) does not hold, either the trade equilibrium with environmental policy is identical to the autarky solution with environmental policy, or the direction of trade may be reversed<sup>6</sup>.

7. Finally, if a closed country opens up for trade and undertakes environmental policy at the same time, *i.e.* it moves from point *F* in *Diagram 1* to point *G*, the change in welfare is indicated by equations (13') and (14). Whereas equation (14) can be interpreted as the welfare effect of a marginal variation of the emission tax, equation (13') describes a qualitative variation, that changes the market equilibrium conditions of the closed economy into a balance of payment restraint.

6. Assume the emission tax is set according to marginal damage prevented. Then further inspection of equation (22) allows a comparison on the level of emission taxes in the autarky case and the trade case, if  $p^a < \bar{p}$  is to hold.

IV. EXTENSIONS AND CONCLUSIONS

The following two questions have not been included in the analysis. First, in reality we observe that for a variety of reasons countries tend not to use emission taxes as environmental policy instruments but emission norms and other administrative devices (*e.g.* permits). In this case the question arises whether the country can increase its welfare by introducing a tariff on the non-pollution-intensively produced import substitute. This is an inducement to produce more of the less pollution-intensively produced commodity. The gains from trade may be reduced and environmental quality will rise. Note, however, that in addition to the problems discussed in the theory of an optimal tariff, a tariff will only improve environmental quality by a sectoral change which comes about through a change in relative price from the demand side. Similarly as a product tax on the pollution-intensively produced commodity, a tariff lacks the incentive to reduce pollutants through abatement processes.

Second, if the assumption of the small-country case is given up, opening up a country for trade is accompanied by an improvement in the terms of trade. Also, if environmental policy is undertaken in an initial situation with trade, the terms-of-trade effect will influence the total change in welfare.

In the small-country case we have as conclusions: If a country exports its pollution-intensively produced commodity, its gains from trade are accompanied by a decline in its environmental quality. If environmental policy is undertaken under these circumstances environmental quality will be improved but gains from trade will be reduced. With the introduction of environmental policy, resource-use in the pollution intensive sector (and its output) will decline. Moreover, the quantities exported and imported will fall, and pollution abatement will be increased. There will be an overall welfare gain from environmental policy as long as marginal social costs of producing the commodity (including environmental costs) are higher than the marginal value of the commodity in consumption or as long as the emission tax is lower than marginal environmental damage.

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## APPENDIX<sup>7</sup>

1. The determinant  $\Delta$  is positive. For the change in the excess demand we have

$$\frac{dE_2}{dz} = \frac{p}{\Delta} \{F'_1 C'_{2y} D_1 + F'_2 C'_{1y} D_2\} = - \frac{1}{p} \frac{dE_1}{dz} \quad (\text{I})$$

with the submatrices

$$D_1 = a_2 (F_1^{r*} + F_2^{r*}) (zH'_1 F'_1 + r) - z^2 F_1^{r*} F_2^{r*} (H'_1 F'_1 - H'_2 F'_2) \quad (\text{I}')$$

$$D_2 = -a_1 (F_1^{r*} + F_2^{r*}) (zH'_2 F'_2 + r) - z^2 F_1^{r*} F_2^{r*} (H'_1 F'_1 - H'_2 F'_2) \quad (\text{I}'')$$

2. The change in the home demand for commodity 2 is given by

$$\frac{dC_2}{dz} = \frac{C'_{2y}}{\Delta} \{pF'_1 D_1 - F'_2 D_2\} \quad (\text{II})$$

3. For the change in the resource use we have

$$\frac{dR_1}{dz} = \frac{D_1}{\Delta} \quad \text{and} \quad \frac{dR_2}{dz} = - \frac{D_2}{\Delta} \quad (\text{III})$$

4. The change in resource use in the abatement activity is given by

$$\frac{dR_1^r}{dz} = - \frac{F_2^{r*}}{\Delta} \{a_1 (zH'_2 F'_2 + r) + a_2 (zH'_1 F'_1 + r)\} \quad (\text{IV})$$

5. For the change in income we have from equation (8)

$$\frac{dY}{dz} = \frac{1}{\Delta} \{pF_1 D_1 - F_2 D_2\} \quad (\text{V})$$

## REFERENCES

- D'ARGE R.C. and KNEESE A.V.: 'Environmental Quality and International Trade', *International Organization*, Vol. 26 (1972), pp. 419-465.  
 BAUMOL W.J.: *Environmental Protection, International Spillovers and Trade*, Stockholm 1971.

7. For a more detailed presentation of the results compare *Beiträge zur angewandten Wirtschaftsforschung*, *op. cit.*



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- GERELLI E.: 'Problèmes Economiques Internationaux de l'Environnement: Commerces Internationaux et Pollution Transfrontière', *Schweizerische Zeitschrift für Volkswirtschaftslehre und Statistik*, Vol. 108 (1972), pp. 439-451.
- MARKUSEN J. R.: 'International Externalities and Optimal Tax Structures', *Journal of International Economics*, Vol. 5 (1975), pp. 15-29.
- PETHIG R.: 'Pollution, Welfare and Environmental Policy in the Theory of Comparative Advantage', *Journal of Environmental Economics And Management*, Vol. 2 (1976), pp. 160-169.
- SIEBERT H.: 'Comparative Advantage and Environmental Policy: A Note', *Zeitschrift für Nationalökonomie*, Vol. 34 (1974), pp. 397-400.
- SIEBERT H.: 'Environmental Control, Economic Structure and International Trade', in: INGO WALTER (Ed.), *Studies in International Environmental Economics*, 1976, pp. 29-56.
- SIEBERT H.: 'Environmental Protection and International Specialization', *Weltwirtschaftliches Archiv*, Vol. 110 (1974), pp. 494-508.
- SIEBERT H.: 'Die Grundprobleme des Umweltschutzes. Eine wirtschaftstheoretische Analyse', in: *Soziale Probleme der modernen Industriegesellschaft*, Schriften des Vereins für Socialpolitik, NF, Bd. 92 I und II, Berlin 1977, pp. 141-182.
- WALTER I.: *International Economics of Pollution*, New York 1975.
- WALTER I.: 'International Trade and Resource Diversion: The Case of Environmental Management', *Weltwirtschaftliches Archiv*, Vol. 110 (1974), pp. 482-493.
- WALTER I. (Ed.): *Studies in International Environmental Economics*, New York 1976.

#### SUMMARY

The paper analyzes the trade-off between environmental quality and the gains from trade. For a world with pollutants as a joint product of output it is shown that gains from trade by exporting a pollution-intensively produced commodity are accompanied by a loss of environmental quality and that improving environmental quality will adversely affect the gains from trade. The paper analyzes with a two sector model which adjustment processes occur, if a country undertakes environmental policy. The results are explained diagrammatically. A condition is specified for a positive change in welfare from environmental policy taking into consideration the reduction in the gains from trade. Finally, the paper suggests that in an open economy emission taxes have to be set according to the same rule as in a closed economy, namely in the optimum the emission tax must equal marginal environmental damage prevented.

#### ZUSAMMENFASSUNG

Der Artikel diskutiert den Zielkonflikt zwischen Verbesserung der Umweltqualität und den Gewinnen aus Aussenhandel. Für eine Welt mit Emissionen als Kuppelprodukt der Produktion wird gezeigt, dass erstens Gewinne aus Aussenhandel beim Export eines schadstoffintensiv produzierten Gutes von einem Verlust an

#### ENVIRONMENTAL QUALITY AND THE GAINS FROM TRADE

Umweltqualität begleitet sind und dass zweitens die Verbesserung der Umweltqualität die Gewinne aus Handel tangiert. Der Artikel analysiert mit Hilfe eines Zwei-Sektor-Modells, welche Anpassungsprozesse erfolgen, wenn ein Land Umweltpolitik betreibt. Die Resultate werden graphisch veranschaulicht. Es wird eine Bedingung für eine Wohlfahrtsverbesserung nach Umweltpolitik formuliert, die die Rechnung der Gewinne aus Handel in Betracht zieht. Der Artikel kommt zu dem Resultat, dass in einer offenen Volkswirtschaft die Emissionssteuer nach der gleichen Regel zu setzen ist, die von geschlossenen Volkswirtschaften bekannt ist, nämlich: die Emissionssteuer muss dem verhinderten Grenzschaten entsprechen.

#### RÉSUMÉ

L'article traite le conflit d'objectifs qui existe entre l'amélioration de la qualité de l'environnement et les avantages de l'échange internationale. On y montre que pour un monde dont les sous-produits sont des déchets nuisants, premièrement, les profits du commerce extérieur à l'exportation d'un bien d'une intense propriété polluante, sont toujours accompagnés d'une perte de la qualité de l'environnement, et deuxièmement l'amélioration de celle-ci est corollaire d'une réduction des avantages de l'échange internationale. L'article analyse au moyen d'un model bisectoriel, les procès d'adaptation qui ont lieu dans un pays pratiquant une politique écologique. On peut observer les résultats selon une courbe graphique. Y est formulée une condition pour le progrès du bien-être en conséquence d'une politique écologique, condition qui tient en considération le compte des avantages de l'échange internationale. L'article en vient au résultat que dans une économie ouverte l'imposition d'une taxe sur les déchets nuisants doit être établie selon la même règle que celle déjà connue des économies sans l'échange internationale, plus précisément: la taxation des sous-produits polluants doit correspondre au dommage marginal.