An Estimation of the Pollution Content of Trade in Korea*

Il-Chung Kim
Dongguk University

This paper involves the argument of whether environmental control measures have a significant effect on the pattern of trade. We estimate pollution loadings of Korean trade and relative impact indices of the Korean industries to analyze how vulnerable Korean competitiveness in the international market is to increased environmental costs. The results show that in Korea pollution control charges are approximately trade-neutral in the aggregate, while they have substantial effects on the pattern of trade at the industry level. These are consistent with other studies in the sense that pollution controls do affect the comparative advantage in each country.

I. Introduction

Several economists [D'Arge and Kneese (1972), James (1974), Walter (1972, 1974), Siebert (1974, 1979), Grubel (1976), Pethig (1976), Asako (1979), McGuire (1982), Baumol and Oates (1988)] have discussed the issues of environmental pollution within an open economy. Some insisted that environmental control would affect the pattern of trade through the induced reallocation of resources and the changes in the structure of prices in the domestic economy, which were brought about either by pollution abatement investment or by the imposition of taxes. Others proposed that international trade had a significant effect on environmental pollution in domestic economy. In fact, most countries have different endowments of an environmental assimilative capacity and of different pollution standards, reflecting different social preferences of environmental qual-

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ity. Thus, each contributes a certain amount toward meeting the standard which will in turn affect the pattern of trade.

There have been, however, a relatively limited number of empirical studies on the impact of environmental control on international trade. They have had as well controversial results from it. The U.S. Department of Commerce (1975) indicated that the trade impact of environmental control was not singificant, at least in the short run. Walter (1973), Richardson and Mutti (1976) agreed with the Department. They concluded, however, that the impact on individual industries could be quite substantial. OECD (1978)'s studies supported their results. A study from the U.S. arrived at similar results as the former, while parallel studies by the Netherlands, Italy and Japan offered conclusions comparable to the latter. More recently, Pasurka (1984) investigated the magnitude of the impact that EC costs had on price in the U.S. in 1977. His result also showed that the typical sort of variation in impact was likely to occur across industries and that the average impact on prices was modest. Robison (1988), more vigorously, found that the impact of marginal changes in industrial pollution abatement costs on the U.S. balance of trade was negative for most industries, growing with trade volume.

This paper confronts the issues of whether environmental control costs incurred by industry are significant enough to affect international trade. For this, we utilize Walter's model (1973) to estimate the environmental control loadings of exports and imports by industry in Korea. By doing it, we may be able to determine whether environmental control costs actually incurred by industry are fundamentally export-biased or import-biased or in a trade-neutral pattern. If Korean exports are inherently more pollution intensive than imports, Korean performance in the international market is more vulnerable to increased environmental costs than it would be otherwise.

II. Model

Pollution can be classified into two types with respect to polluting sources — production pollution and consumption pollution. The former occurs during the production process, while the latter occurs during consumption, use or disposal of goods. These two have quite different issues for international trade. Controls on production pollution shift the costs to the producer, and may result in a loss of international competitive position for exporting and import-competing firms. Product standards to control consumption pollution, on the other hand, may act as a non-tariff trade barrier to exporters who must comply with a variety of standards in different export markets. The costs of production pollution are borne in the country of origin, while the costs of consumption pollution are borne in the country of destination.[1]

We define environmental control (EC) loading for a given tradeable product or product-group as what proportion of its final value, at market prices, is attributable to internalization of environmental externalities arising in the production process (i.e. production pollution) or in rendering the product itself environmentally acceptable either in its normal use or as a residual at the end of its useful life (i.e. consumption pollution). This can be estimated by calculating the actual market price minus its hypothetical value which would be the one if individual firms fully met environmental standards for its production and consumption pollution without absorbing any additional economic resources to do so.

Then we may define "direct EC loading (DECL)"

$$DECL = (P_a - P_h) / P_a \tag{1}$$

where P_a is the actual market price of a given internationally traded product and P_h is its hypothetical value. While P_h is not an observable value, direct costs attributable to environmental control can be estimated, which are assumed to approximate $(P_a - P_h)$. Then $DECL$ can be interpreted as an estimated EC costs per dollar of sales.

It is obvious that production of raw-material and intermediate goods also generates pollutants, which incur EC costs. This may be regarded as indirect EC costs incurred by the industry or firm of a given tradeable product, which must be included in the overall EC costs. Thus, the "overall EC loading" (OECL) of it is its own $DECL$ plus that of each input weighted by the contribution of the input to final export or import value. Then we may define OECL as

$$OECL_j = [(P_a - P_h)_j + \Sigma\, \gamma_{ij}\, (P_a - P_h)_i] / P_{aj} \tag{2}$$

where j represents the traded product, i a given input and γ_{ij} the

[1]For more detail, see Pearson (1982, pp. 49–50). In Korea, for example, the consumption pollution is about 70% of total water pollution, 70% of waste disposal and 60% of sulfur dioxide, see Korea Environment Agency (1987, pp. 34–5).

contribution of i to the unit trade-value of j.[2]

$(P_a - P_h)_j$ represents direct costs and $(P_a - P_h)_i$ indirect cost which is the EC costs for inputs.[3] Hence Equation (2) represents the estimates for the overall environmental control loadings, which imply overall environmental control costs per dollar of final sales.

III. Data and Computation

It is reasonably assumed that environmental control costs consist of the following; i) current operating costs associated with environmental management, ii) depreciation charges on in-place pollution-control equipment, iii) the capital cost of in-place pollution-control equipment, and iv) current research and development expenditures.[4] It should be noted that these EC costs include costs of both production pollution and consumption pollution. The basic data for cost estimates were obtained from the Korea Environment Agency (1985).[5] Operating costs were taken directly from the Korea Environment Agency (1989).[6] The depreciation costs and the capital costs were estimated from the basic data for installment costs for

[2]Walter (1973) employed input-output coefficient for γ_{ij}. Simple input-output coefficient is not the proper one for our purpose since it ignores multi-sector multiplier effect, and thus may omit EC costs incurred by some industries for inputs. We therefore use one of the production inducing coefficents, $[I - (I - M)A]^{-1}$ for γ_{ij}, which would be thought of as the most appropriate one for our purpose.

[3]We assume constant costs; the price-response to EC costs will differ for increasing and decreasing cost industries.

[4]See Walter (1973, pp. 62-3). And see Plooy (1985) for the practical details. As most environmental economists experience, data for environmental control costs are poor in quality and diversity. This would be even worse in a less developed country, such as Korea, than in the more advanced countries. The data for EC costs used here are only for controlling water pollution in Korea, since there is no data for other types of pollution available. However, it may be reasonably assumed that the proportion of water pollution control costs to total EC costs incurred by industry would be large, taking into consideration that about 73% of the total government budget for environmental control is allocated to controlling water pollution in 1989 and in 1990. Economic Planning Board (1990) reported that total government budget for environmental control was 142.5 billion won and 72.77% of it was spent for water pollution, 3.72% for air pollution and 8.84% for waste discharge, and the rest 14.67% for other miscellaneous costs such as labor, building management and so on.

[5]The Korea Environment Agency surveyed these data with the sample size of 9,062 firms nationwide in 1988 which have permits from the government to install the water pollution treatment equipment.

[6]Walter (1973) did not have the basic data for cost estimates, such as installment cost of EC equipment and operating cost of pollution control, which is the most important for our purpose.

water pollution treatment equipment which were also taken from the Korea Environment Agency (1989).[7] R & D cost data for environmental control are not available by industry at all in Korea. Since these costs do not seem to be so much that it may not change ordinal rank of our results, we exclude these from the total EC costs.[8]

The sum of the total EC costs for each of 13 manufacturing industries and for coal mining, metal ore mining, non-ferrous ore mining, electric utilities and transportation was divided in each case by gross sales in 1988 to obtain for each sector estimated EC costs per dollar of sales. The results are shown in Table 1.[9] It may be generally said that the high EC costs per dollar of sales have a negative implications for international competitiveness. Then the table shows that environmental controls may have a relatively large adverse effect in terms of international competitiveness on such industries as metal ore mining, beverages, leather and fur, and paper and tobacco in that order. However, direct EC costs are not enough to represent international competitiveness since inclusion of

[7]The depreciation cost was derived by multiplying the depreciation ratio (KDB 1989, pp. 88, 240–63) by the corresponding total installment cost of water pollution treatment equipment. The capital cost was estimated by applying net industry rate of return to the installment cost of the water pollution treatment equipment. The net rate of return is reasonably assumed to be the Operating Profit to Net Sales (KDB 1989, pp. 87, 240–63) multiplied by Liabilities & Net Worth Turnover (KDB 1989, pp. 90, 264–75). That is, since Operating Profit to Net Sales = (Operating Profit / Net Sales) × 100 and Liabilities & Net Worth Turnover = (Net Sales / Liabilities & Net Worth) × 100, the Net Rate of Return = Operating Profit to Net Sales × Liabilities & Net Worth Turnover = (Operating Profit / Liabilities & Net Worth) × 10,000.

[8]KDB publishes annually *Survey of Facility Investment Plan*, which contains the R & D expenditures and pollution control investment by industry. The only way to estimate R & D costs for pollution control, therefore, may be to apply the component ratio of environmental control to total facility investment to the total R & D costs. The estimates, however, would not be reliable. Moreover, these would not be significant enough relative to other EC costs to distort the result, even though R & D costs for pollution abatement in Korea seem to be increasing recently.

When Plooy (1985) made international comparison of industrial pollution control costs between the Netherlands and the U.S., he has also excluded R & D costs for environmental control due to data limitations.

[9]As mentioned before, we employed the basic data for EC costs, published by Korea Environment Agency (1989), while we used the data for capital consumption allowances, the net rate of return, and total sales from KDB (1989). The problem is that these two institutions use different industrial classifications. A data correspondence was developed referring to description of product grouping in *Korea Standard Industry Classification* (1984), which is based on i) general combinations or divisions of economic activities by individual firms and ii) the characteristics of economic activities carried out by individual firms such as properties, kinds and uses of produced goods and services, and production processes, technology as well as structures.

TABLE 1

Industry	$DECL^b$
1. Coal Mining	0.236
2. Metal Ore Mining	2.867
3. Other Mining	0.022
4. Food	0.419
5. Beverages	1.470
6. Textiles	0.230
7. Leather and Fur	1.029
8. Paper and Tobacco[a]	0.659
9. Printing and Publishing	0.089
10. Industrial Chemicals	0.439
11. Other Chemical Products	0.326
12. Rubber and Plastic Products	0.042
13. Petroleum Refineries	0.068
14. Non-metallic Mineral Products	0.327
15. Primary Metals	0.484
16. Fabricated Metal, Machinery and Equipment	0.080
17. Electric Utilities	0.141
18. Transportation and Warehousing	0.325

Source: Korea Environment Agency (1989), Korea Development Bank (1989)
Note: 1. a: 1988 sales data for tobacco from Korea Tobacco and Ginseng Corporation (1989).
2. b: *DECL* = Total EC cost/sales (cents per dollar).
3. Computations are explained in footnotes 4, 7, 8 and 9.

environmental control cost on purchased inputs is generally important for computing total control costs. Moreover, Korean trade in individual industries may not always be vulnerable to increased environmental costs only in terms of their international competitiveness. This vulnerability of a given industry will be larger the more competitive its products are in the international market place, and the higher its overall environmental control loading is. We now wish to determine ordinal rank of each industry in terms of such vulnerability to increased EC costs. We first break down the industry-based estimates of the EC costs into product-based *DECL* estimates. In order to do it, we employed the 402 basic product sectors in *The Year 1985 Input-Output Table* (1988) in Korea and reduced it to 71 goods categories which were taken to utilize the basic EC data published by Korea Environment Agency (1989). Product classifications of Korea Environment Agency and I-O Table are different from each other, so that a data correspondence was developed consulting the product description of *Korea Standard Industry Classification* (1984). We used total output in each industry as a weight to segregate industry-based EC estimates into product-based ones. We then employed the relevant value of *DECL* with 1985 production inducing coefficient, $[I - (I - M)A]^{-1}$, to derive *OECL* values. We now eliminated nontraded products and product groups whose basic data were not available, reducing from 71 product categories to 41 categories. Then regarding export/import ratio as a proxy for international competitiveness we calculate the "relative impact index" by multiplying *OECL* by the export/import ratio, which implies both causes of vulnerability of a given industry such as the one mentioned earlier.[10]

IV. Pollution Loadings of Korean Trade

Table A1 in the Appendix shows all the calculation results necessary to analyze EC loadings of Korean trade. The 1st and 2nd columns of Table A1 show direct environmental-control loadings and overall environmental-control loadings by product group, respectively. If we assume like Pasurka (1984) that supply elasticities are infinite — that is, that all increased costs due to environmental control are passed along in the form of higher prices, the value of *OECL* lists the percentage increase in prices since EC costs are borne by Korean industry. The weighted averages of *DECL* and *OECL* are 0.258% and 0.849%, respectively, which are compared to Pasurka's result, 0.42% and 0.97%, respectively. This implies that the price impact of environmental control in Korea is yet relatively low, even though it would be increased taking into consideration other types of pollution such as air pollution, wastes and so on.

One might expect that the ordinal ranks of each product group for *DECL* and *OECL* are approximately the same. That is to say, the larger the value of *DECL*, the larger the value of *OECL*. This, however, is not uniformly true, as we can see in Table A1. There are several product groups, whose ordinal ranks are reversed for *DECL* and *OECL*. For example, *DECL* for limestone, ceramic and other non-metallic minerals, soaps, dyes and paints are relatively low, while *OECL* for them are relatively high. This is because such

[10]Data for exports and imports during the year 1988 were taken from *Export Statistics* (1989, pp. 35–560) and *Import Statistics* (1989, pp. 15–52). A data correspondence was developed between the various I-O product groups and the Standard Korean Trade Classification (SKTC) again referring to *Korea Standard Industry Classification* (1984).

product groups have large production inducing effects, which would increase the *OECL* values. By looking at *OECL,* we can see that environmental control loadings are relatively high in metal ore mining, non-ferrous ore mining, other non-metallic minerals, limestone / ceramic / refractory minerals, dyes, paints, soaps, beverages, and leather and fur. This result may be compared with Pasurka (1984) and the summary of several studies by Pearson and Pryor (1978).[11] Their results show that environmental control costs are highest in the raw material-processing industries — iron and steel, non-ferrous metal smelting and refining, pulp and paper, basic chemicals, petroleum refining, and perhaps cement — and electricity. EC costs in most of the industries referred to except petroleum refining and electricity, are relatively high though not highest in our findings. But it may be seen that ordinal ranks of *DECL* values by product group in our study and in theirs are not entirely the same.

We now use the estimates of *OECL* by product groups to have pollution-loading profile of Korean trade. This can be done simply by multiplying the *OECL* values in Table A1 by the value of exports and by the value of imports, respectively, for each product group. As mentioned before, we tried to correspond the product mix within each group for exports and imports to the product mix for total sales. We assume the *OECL* values of foreign suppliers to be the same as for domestic import-substituting suppliers and estimate the *OECL* values of these, since there is no estimate of *OECL* values of foreign countries available. We also assume average prices charged on exports to be the same as on domestic sales, and the imported product prices to be the same as the price of import-substituting goods. The results, given in column 4 and 5 of Table A1, show that the average *OECL* of Korean exports in 1988 was about $452.27 million or about 0.745 percent of total exports, while during the same period, that of imports was about $402.08 million, or 0.776 percent of total imports. This indicates that at least 0.776 percent of the value of Korean imports consisted of pollution-related costs, which is about 4.16% higher than the 0.745 percent estimated for Korean exports.[12]

[11]These studies are from Public Research Institute (1976), Pearson (1976), Richardson and Mutti (1976), and the U.S. Department of Commerce (1975).

[12]This result shows that the pollution content of trade in Korea is, not as we might expect, relatively low. These proportions, of course, would be increased taking other types of pollutions into account. This increase, however, would not be very high due to the weight of water pollution costs out of total costs, as mentioned before.

This difference does not appear significant and suggests that environmental regulations have similar influences on exports and imports, so that EC costs incurred by Korean exports and imports are trade-neutral, or only marginally biased in favor of Korea. In other words, it does not seem that, in the aggregate, the pollution intensity of Korean imports is much higher than that of Korean exports.

This impact of EC measures, however, has a quite different aspect in the micro-level, in terms of vulnerability to increased EC costs. The relative impact index, the last column of Table A1, shows that, other things being equal, the EC measures of trade counterparts to Korea may negatively affect international competitiveness in such industries as textiles, paperboard containers, soaps, pottery, stone quarrying, and chemical fertilizers, relative to petroleum refineries, drugs and cosmetics, machinery and organic chemicals. The former group of products are affected more either because they have substantial international competitiveness (i.e. textiles, paperboard containers, stone quarrying, etc.) or because EC loadings are very important (i.e. soaps, pottery, and leather, etc.). It should be noted especially that some products like stone quarrying have relatively low EC loadings, but relatively high relative impact index. The others such as non-ferrous ore mining, limestone, ceramic and refractory mining have relatively high EC loadings but relatively low relative impact index, since they are already characterized by a comparative disadvantage.'

It might be interesting to compare these results with Walter's results. First of all, the U.S. pollution content of trade in the late 1960s is about twice that of Korea in the late 1980s, even if pollution loadings in Korea were to be increased as other types of pollution are included in our EC costs. In both cases, the EC measures were trade-neutral in macro-level, even though it is marginally biased against the U.S. while it is marginally biased for Korea. The impact of environmental regulations on individual industries was quite different in Korea from that in the U.S.[13] This may prove that environmental control measures may affect the comparative advantage in each country at industry level.

V. Concluding Remarks

This paper has examined empirically how vulnerable Korean com-

[13]See Walter's (1973, pp. 65-6) Table 2.

petitiveness in the international market is to increased environmental costs. The empirical results suggest that in Korea environmental control charges are trade-neutral in the aggregate, while they have substantial effects on trade patterns at the industry level. That is to say, individual industries will bear a comparative disadvantage in the international market in a different way if the trade counterparts use different environmental standards as a nontariff barrier. This may be so either because each industry has different values regarding *OECL*, or because it has currently different competitiveness in the international market. These results virtually support several of the former studies related to this matter, which are introduced in this paper.

The results presented here would be important data for future research. One possible direction is, as Robison (1988) did with the U.S. data, to measure the impact of marginal increases in EC costs on trade balance for the entire economy and/or for individual industries. This may be done by applying segregated price elasticity of the Korean exports and imports to the *OECL* values listed in Table A1 under the assumption of full-cost pass-through into prices. In addition, we may be able to test the proposition discussed by Baumal and Oates (1988) that more stringent environmental control program may change the Korean comparative advantage in such a way that more high-abatement-cost goods are imported and more low-abatement-cost goods are exported. To do this, we have only to check whether *OECL* of Korean imports grows more rapidly than that of Korean exports over time.

Unfortunately, this paper confines itself to water pollution due to data limitations, and also ignores uncertainties with regard to future costs of environmental management. If these factors were included in this analysis, the results might be different. Even if Walter (1973) stated earlier that a discussion of this type could only be regarded as preliminary, therefore, this study must still be regarded as introductory. Consequently, more efforts should be made to accumulate data for environmental problems and to devise better methodology for assessing them before environmental degradation becomes a more serious factor in international trade.

Appendix

TABLE A1

Product Groups	(1) $DECL$[b]	(2) $OECL$[b]	(3) E_x/I_m	(4) $OECL \times E_x$[c]	(5) $OECL \times I_m$[c]	(6) Relative[d] Impact Index
1. Coal Mining	0.236	1.013	0	0	11799.274	0
2. Iron Ore Mining	2.867[e]	27.944	0	0	118663.002	0
3. Non-ferrous Ore Mining	2.867[e]	12.649	0.179	14128.756	78631.086	2.272
4. Stone Quarrying, Clay and Sand Pits	0.022[e]	0.958	5.790	2354.268	406.605	5.550
5. Limestone/Ceramic/Refractory	0.022[e]	5.543	0.099	377.762	3810.777	0.549
6. Other Non-metallic Minerals	0.022[e]	6.823	0.178	2483.168	13894.227	1.219
7. Food	0.419	0.944	0.625	16451.948	26289.474	0.591
8. Beverages	1.470	3.599	0.912	1493.509	1636.720	3.284
9. Tobacco[a]	0.443	0.934	1.348	842.006	624.234	1.260
10. Silks Reeling and Yarns Spinning	0.276	0.772	0.737	6624.726	8981.994	0.569
11. Weaving Textiles	0.208	0.633	4.068	21538.182	5294.221	2.576
12. Bleaching and Dyeing and Finishing Textiles	0.077	0.537	0	0	0	0
13. Made-up Textile Goods	0.255	0.950	267.584	64733.945	241.919	254.447
14. Other Textiles	0.253	1.522	9.114	18976.946	2081.987	13.873
15. Leather and Fur	1.029	3.318	1.293	77069.855	59581.165	4.292
16. Paper and Allied Products Except Containers	0.640	1.526	1.137	4589.578	4034.021	1.737
17. Manufactured Papers and Paperboard Containers and Boxes	0.641	1.841	16.177	382.239	23.627	29.792
18. Printing and Publishing	0.089	0.754	0	0	0	0
19. Organic Chemical Products	0.343	0.875	0.215	13844.399	64104.253	0.189
20. Inorganic Chemical Products	0.643	2.047	0.224	1619.722	7215.927	0.459
21. Chemical Fibers	0.626	1.959	1.161	3626.476	3123.096	2.275
22. Chemical Fertilizers and Agricultural Medicines	0.488	1.536	3.308	3622.732	1095.129	5.084
23. Drugs, Perfumes and Cosmetics	0.354	1.001	0.169	1362.166	8047.901	0.169

TABLE A1 (Continued)

Product Groups	(1) $DECL^{b}$	(2) $OECL^{b}$	(3) E_x/I_m	(4) $OECL \times E_x^{c}$	(5) $OECL \times I_m^{c}$	(6) Relative[d] Impact Index
24. Dyestuffs, Pigments and Tanning Materials	0.370	4.113	0.227	4051.823	17794.046	0.936
25. Paints, Varnishes and Lacquers	0.275	2.320	0.344	507.901	1472.629	0.800
26. Soaps	0.295	5.797	4.655	763.177	163.939	26.986
27. Other Chemical Products	0.287	1.701	0.190	1177.365	6196.466	0.323
28. Rubber and Plastic Products	0.042	0.245	3.183	6871.964	2158.763	0.781
29. Petroleum Refineries	0.068	0.148	0.527	830.201	1573.793	0.078
30. Pottery, China and Earthenwares	0.272	2.535	2.821	3605.410	1277.940	7.153
31. Glass and Glass Products	0.230	0.827	0.437	1121.427	2564.784	0.361
32. Structural Clay Products	0.498	2.916	1.642	696.144	423.940	4.789
33. Cement and Cement Products	0.596	1.735	2.073	2790.059	1345.370	3.599
34. Other Non-metallic Mineral Products	0.109	0.570	0.682	242.071	354.430	0.389
35. Primary Iron and Steel	0.572	1.721	1.279	67511.384	52769.946	2.202
36. Primary Non-ferrous Metals	0.228	0.643	0.620	8910.369	14357.208	0.399
37. Fabricated Metal Products	0.104	0.910	0.616	1239.608	2011.910	0.561
38. Machinery, Except Electrical	0.162	0.750	0.214	10343.020	48164.552	0.161
39. Electrical and Electronic Machineries	0.069	0.189	1.749	30757.243	17576.149	0.331
40. Transport Equipment	0.063	0.267	2.065	16313.026	7897.953	0.551
41. Medical, Optical, Measuring, Scientific and Controlling Equipment and Goods	0.113	0.761	0.377	4353.246	11531.057	0.287
Total	0.258	0.849	1.124	452266.620	402081.464	0.955

Source: Korea Environment Ageny (1989), Korea Development Bank (1989)
Bank of Korea (1988), Korea Foreign Trade Association (1989)

Note: 1. a: 1988 sales data from Korea Tobacco and Ginseng Corporation (1989).
2. b: Cents per dollar of final sales.
3. c: Thousands of dollars.
4. d: $OECL \times E_x / I_m$.
5. e: The sales data for metal ore mining and other mining presented in Table A1 are broken down into product-based data using total output in each industry as a weight since no segregated data for them are available.
6. Computations are explained in Section III of this paper and footnotes 4, 7, 8, 9 and 10.

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