OECD DEVELOPMENT CENTRE

Working Paper No. 91

(Formerly Technical Paper No. 91)

INTERNATIONAL TRADE AND THE TRANSFER OF ENVIRONMENTAL COSTS AND BENEFITS

by

Hiro Lee and David Roland-Holst

Research programme on:
Sustainable Development: Environment, Resource Use, Technology and Trade

OECD OCDE

December 1993
OCDE/GD(93)192

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This report was prepared as part of the Development Centre research theme on Sustainable Development: Environment, Resource Use, Technology, and Trade. Special thanks are due to Sébastien Dessus, David O'Connor, David Turnham, and Dominique van der Mensbrugghe for helpful comments. The opinions expressed here are those of the authors and should not be attributed to their affiliated institutions.

RÉSUMÉ

Les conséquences du commerce international sur l'environnement ont été examinées minutieusement et intensément au cours des dernières années, en particulier en raison de l'intérêt accru pour le multilatéralisme, le régionalisme et d'autres types d'échanges négociés. Le transfert des incidences, tant positives que négatives, sur l'environnement est inhérent à la plupart des schémas commerciaux, surtout ceux qui reflètent une technologie hiérarchique ou une stratification selon le niveau de modernisation économique. Malgré les réactions émotionnelles fréquemment déclenchées par ces problèmes, il est très difficile de préciser si, et pour qui, ces transferts sont bénéfiques ou néfastes. Dans ce document nous utilisons une analyse d'équilibre général pour examiner les relations commerciales bien établies entre deux économies différentes : celle du Japon et celle de l'Indonésie. Sur le plan historique, il apparaît que leurs échanges bilatéraux ont eu des effets environnementaux asymétriques dans les deux pays, entraînant un transfert net des coûts environnementaux du premier pays vers le second. A partir de ce lien négatif entre le commerce et l'environnement, nous étudions une série de mesures susceptibles d'atténuer l'intensité de la pollution de la production en Indonésie. Nos résultats montrent qu'il existe de nombreuses possibilités pour que les instruments économiques parviennent à une réduction significative de cette pollution et à un coût relativement bas en termes de PIB réel.

SUMMARY

The environmental implications of international trade have come under intensified scrutiny in recent years, particularly with expanded interest in multilateralism, regionalism, and other negotiated trade regimes. The transfer of environmental effects, both positive and negative, is embodied in most trade patterns, particularly those which reflect technological hierarchy or other stratification by degree of economic modernization. Despite the emotional reaction these issues often arouse, the question of whether and to whom these transfers are beneficial or detrimental is a very complex one. In this paper, we use applied general equilibrium analysis to examine a well-established trade relationship between two diverse economies, Japan and Indonesia. Historically, it appears that their bilateral trade has conferred asymmetric environmental effects on the two countries, effecting a net transfer of some environmental costs from the former to the latter. In the light of this negative link between trade and the environment, we examine a variety of policies to mitigate the pollution intensity of Indonesian production. Our results indicate that there is ample scope for economic instruments to achieve significant pollution abatement at relatively low cost in terms of real GDP.

PREFACE

This Technical Paper, part of the research programme on "Sustainable Development: Environment, Resource Use, Technology, and Trade," analyses the links between international trade and the environment in Indonesia.

Indonesia is the largest and most populous country in the rapidly developing Southeast Asian region. Indonesia's growth strategy has relied upon export expansion, beginning in primary sectors such as petroleum and forest products and more recently diversifying across an expanding industrial base. These two trends have three things in common: they are essentially trade driven; they have significant environmental implications; and they are both essential to sustainability of rising Indonesian living standards. Thus policy makers in Indonesia, and in other trade-oriented developing countries, can benefit from a better understanding of the links between trade and the environment.

The authors of this study review the historical evidence on Indonesian trade with the rest of the world and with one of its leading export markets, Japan. Using detailed data on trade and effluent emissions, they conclude that Indonesian exports have occasioned significant and detrimental environmental effects. In the absence of more focused policies to offset this trend, it is apparent that more outward orientation would be harmful to the Indonesian environment. The authors then use a general equilbrium simulation model to evaluate alternative economic instruments for achieving pollution abatement, and here the results are more positive. Even though a tradeoff between growth and abatement exists, there appears to be ample scope for individual and combined tax instruments to achieve significant pollution abatement. With more extensive empirical work of this kind, it is hoped that developing countries can take better advantage of external markets as an agent of growth without adverse environmental effects, thus conferring upon their people a better material and qualitative standard of living.

Jean Bonvin
President, Development Centre
December, 1993

I. INTRODUCTION

The environmental implications of international trade are becoming an important part of multilateral and domestic policy agendas. This is particularly the case for trade relations between developing and developed countries. For several years, an occasionally acrimonious debate has been carried on between two groups. On one hand, there are those who feel developing countries should reduce domestic environmental costs for their own welfare and that of the world as a whole. On the other, there is an argument that these countries have the right to pursue the same material aspirations, by the same means, as did the industrialized world during its developmental stages, regardless of the short-term costs or externalities this may entail. Both sides have conviction as well as evidence to sustain their arguments. Most data on effluents per unit of domestic output indicate a negative correlation with per capita income. By contrast, effluents per capita appear to be positively correlated with per capita income because of the energy use embodied in rising domestic consumption.[1] In this paper, we take a different approach to the issue of environmental costs and benefits, one which is grounded explicitly in trade relations.

If it is accepted that differing domestic practices yield different environmental effects, how might trade exert its own environmental influence? It is increasingly recognized that the import of goods and services entails an implicit transfer of environmental effects to the exporting country. Given the hierarchical nature of technology in the development process, one might infer that less developed countries would be net losers in the environmental transfer scheme which underlies trade. In the next section, we present some evidence on the embodied pollution service trade between two large trading partners at very different stages in the development process, Indonesia and Japan. The data indicate that bilateral trade between them has occasioned a large and sustained net transfer of effluents over the last 25 years. The implied unit effluent content of Indonesian exports to Japan in some years is nearly eight times that of its imports from Japan.

In section 3, we present a two-country calibrated general equilibrium (CGE) model based on a detailed social accounting matrix (SAM) for the two countries. This model is then used in section 4 to evaluate the effects of alternative policies upon the environment and on other aspects of welfare. Our basic findings indicate that, in the absence of technical substitution and innovation, more liberalized trade will lead to rising living standards and increased pollution levels, while the intensity of pollution varies with the composition of output growth. Moreover, we find that while trade policy can decisively influence domestic environmental conditions, it is an inappropriate instrument for improving the environment and living standards simultaneously. Trade liberalization can increase economy wide efficiency and raise living standards, but more specific instruments should be used for pollution abatement. The paper closes with general conclusions and some remarks about how this work might fruitfully be extended.

II. INTERNATIONAL TRADE AND PATTERNS OF EFFLUENT TRANSFER

This section presents some historical evidence on how international trade influences the transfer of environmental effects. We introduce the concept of embodied effluent trade (EET) to capture the idea that traded commodities embody an environmental service: the amount of pollution emitted domestically when goods are produced for export. For example, if countries impose different costs on pollution, the ability to pollute might become a source of comparative advantage. In such a case, one would expect to see a pattern of relatively high EET in exports from countries with low environmental standards and relatively low EET in their imports, while the opposite would prevail in countries with higher environmental standards.

The evidence we have obtained for Indonesia and Japan shows a significant degree of EET imbalance between the two countries. The data indicate that Indonesia's net embodied effluents per unit exported to Japan are over six times the reverse flow and 29 per cent higher than for its exports to the rest of the world. For Japan's part, imports from Indonesia have about twice the embodied effluent content per unit of its imports from elsewhere. This trend has remained relatively stable over the last 25 years, and the result is a sustained and significant transfer of environmental costs between the two countries.

Before reviewing the detailed results, a few definitions are required to clarify interpretation. To measure the effluent levels embodied in tradeable commodities, we began with estimates of unit effluents in domestic production. To measure domestic effluent intensity in production, we used data from the World Bank described in more detail in the next section. The figures in table 2.1 represent an effluent index, termed Linear Acute Human Health and Terrestrial Ecotoxicity (abbreviated hereafter as AHTL), aggregated from four digit ISIC emission rates.[2] The index of sectoral effluent output is defined as

$$e_i = \frac{\varepsilon_i}{\sum_{ii} \varepsilon_i q_i},$$

where ε_i denotes the sectoral AHTL emission rate per unit of output in US manufacturing and q_i denotes sector i's share in total domestic output.[3] If these indices are multiplied by 1985 US sectoral output shares, they sum to unity. For any other country, such a sum measures the effluent potential of domestic output in units relative to the United States. Thus in 1985, for example, Japanese output shares give a value of $E = \sum e_i = 0.86$, indicating that, under the same technologies, the effluent intensity of Japanese domestic production would be 14 per cent below that of the United States by this index. The comparable figure for Indonesia is 2.45.[4]

The index E then serves as an index of aggregate effluent levels for a given composition of domestic production. If (holding technology constant) the structure of the economy shifts toward relatively cleaner activities, such as services, this index will decline. It is unaffected by the absolute level of output, but simply allows comparison across countries of one representative unit of domestic product. This measure can also be used to evaluate the implicit effluent content of trade, and this is the intent of the present discussion. The index

$$E_m = \sum m_i e_i$$

measures the embodied effluent content of imports, where $m_i = M_i / \Sigma M_j$ are the sectoral import shares (by origin). If this value exceeds unity, then the composition of the country's existing imports represents (in their production) a higher level of pollution per unit than representative output in the United States. Values less than unity mean that the country's overall imports are "cleaner" than overall US domestic output. An index for effluents embodied in exports is defined analogously as $E_x = \sum x_i e_i$.

The indices E_m and E_x thus measure the embodied effluent trade (EET) for a given composition of imports and exports per unit of trade. E_m and E_x for Indonesia-Japan bilateral trade and their trade with the rest of the world are presented in Table 2.1. These estimates were constructed at five-year intervals, beginning in 1965, with detailed trade data from the United Nation's COMTRADE tables. The index of net exports of EET, or the difference $E_x - E_m$, is also given in the table.[5]

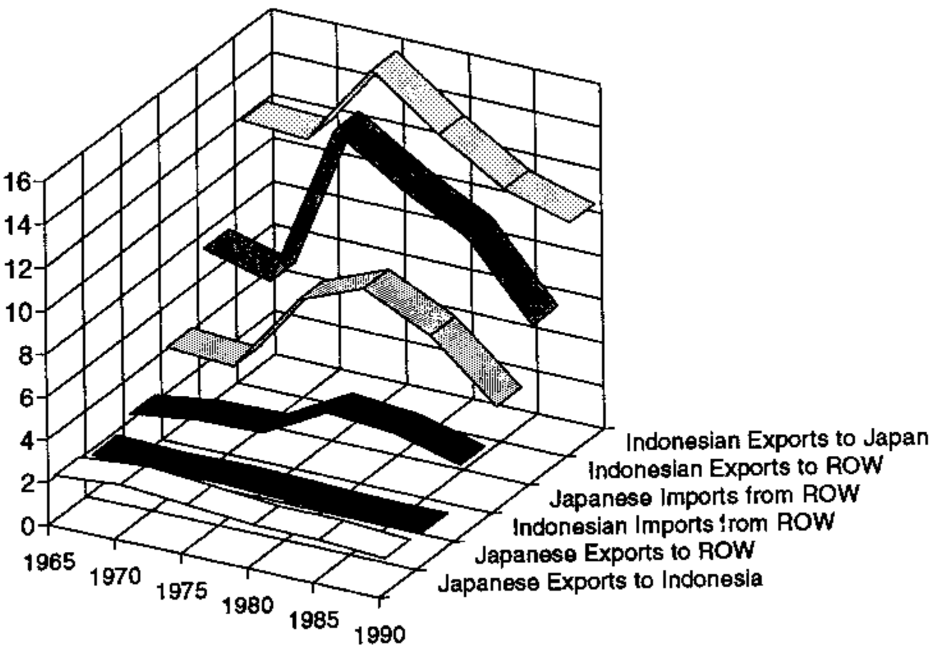
Table 2.1: Trends in Embodied Effluent Trade

Indonesia	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*Ave*
Exports to							
Japan	11.90	11.75	15.66	13.36	11.53	10.64	12.47
Rest of World	7.28	6.49	14.14	12.20	10.59	7.23	9.66
Imports from							
Japan	2.13	2.00	1.99	1.79	2.17	1.72	1.96
Rest of World	2.29	2.73	2.79	4.44	4.16	3.34	3.29
Effluent Trade Ratio (Exp/Imp)							
Japan	5.60	5.87	7.88	7.47	5.31	6.20	6.39
Rest of World	3.18	2.38	5.06	2.75	2.54	2.17	3.01
Japan							
Exports to							
Indonesia	2.08	2.33	2.07	1.80	1.80	1.62	1.95
Rest of World	1.75	1.62	1.69	1.60	1.52	1.54	1.62
Imports from							
Indonesia	10.74	11.15	15.02	13.50	12.01	10.19	12.10
Rest of World	4.09	3.87	7.63	8.86	7.39	4.78	6.10
Effluent Trade Ratio (Exp/Imp)							
Japan	.19	.21	.14	.13	.15	.16	0.16
Rest of World	.43	.42	.22	.18	.21	.32	0.30

It is quite apparent from these results that the effluent composition of trade varies from that of domestic output for both countries, but that this disparity is much greater for Indonesia. Indonesia's export industries appear to be generating three to four times as much effluent as overall domestic output, while Japanese exports are about twice the effluent intensity of domestic product as a whole. One reason for this is the omission of agriculture and services in the effluent database. Although this omission would be unlikely to bias the trade comparisons between the two countries (the two sectors are insignificant in bilateral trade), they do understate the pollution content of production for the domestic market.

The most arresting feature of Table 2.1, however, is the imbalance in direct EET between the two trading partners. This can be seen more clearly in two extreme graphs of Figure 2.1 below. Over the last two and a half decades, Indonesia's production for export to Japan has been about six times more effluent intensive than Japanese exports to Indonesia. In a long term situation of relatively balanced bilateral trade, this implies a sustained and significant transfer of environmental costs from Japan to Indonesia. Although the trend in recent years has reduced this disparity, it is still quite significant.

Figure 2.1: Trends in Embodied Effluent Trade



These results are even more striking when compared to each country's trade with the rest of the world. Indonesia's imports from Japan are about half as effluent intensive as what it buys from other countries and its exports to Japan are about 30 per cent as effluent intensive as other countries' exports to Japan. Trade between countries at different stages of modernization has long exhibited hierarchical properties which are correlated with technology levels and environmental effects.

Identification of this problem is only the first step, however, since it has implications for sustainable living standards in both countries. It is often argued that environmental damage at the early stages of industrialization is a transitory phenomenon, and cleaner technologies and resource conservation are inevitably concurrent with rising living standards. The evidence presented here may support a shifting correlation between the level of development and better environmental conditions, but it does nothing to establish a causality in either direction.

Possible explanations of these trends fall into three general categories: institutions, technology, and economic structure. In each of these general respects, the two countries have important differences which might contribute to an explanation of the effluent asymmetry in their trade patterns. The first category, institutions, includes all those influences of private and public rules and behavior, including differences in economic and environmental regulation and enforcement and behavior patterns which exploit them. Examples of this might be protection or taxation patterns which promote domestic or foreign pollution, differing levels of domestic environmental stringency, and private or public sector behavior which might facilitate the creation of pollution havens. Based on the specific evidence for Indonesia and Japan, as well as the general verdict of economic literature on this subject, we reject institutional factors as decisive in explaining these historical trends. Despite all the public attention and controversy surrounding the pollution haven issue, there is very little evidence to indicate that trade patterns between these two countries can be substantively explained by this phenomenon.[6]

Certainly, there are significant technological disparities between the two countries in a variety of industrial activities, and these might well be expected to reinforce the observed inequality of pollution levels. However, Indonesian-Japanese technology differences have no bearing on the present results, since they were obtained by applying the same (US) effluent coefficients to both countries. Although country-specific data would probably yield even larger asymmetries, the present ones are quite sufficient to justify closer inspection.

Can economic structure alone explain Indonesia's higher pollution intensities in production, both for domestic and foreign consumption? As will be apparent in a review of the data for the CGE model below, there are indeed significant differences in sectoral and trade structure between the two countries. Moreover, when these differences are compared to sectoral data on effluent intensity, it becomes apparent that, other things' (institutions, technologies, etc.) being equal, the composition of Indonesia's current economic activity is much more pollution intensive than that of Japan (its' export composition even more so). In the next section, a simulation model is developed to examine this structural problem and policies which can mitigate it more closely.

III. A TWO-COUNTRY CGE MODEL FOR INDONESIA AND JAPAN

The two-country calibrated general equilibrium (CGE) model described here is in most respects typical of comparative static, multi-sectoral, economy wide models in use today. Generally speaking, all these models simulate price-directed resource allocation in commodity and factor markets. They maintain detailed information on sectoral prices, output, trade, consumption, and factor use in a consistent framework which also accounts for aggregates such as household income, government budget, and employment. The present model (the analytics of which are summarized in Annex 1) differs from the mainstream of CGE specifications in two important ways. First, it is a detailed two-country model, so domestic supply, demand, and bilateral trade for the Indonesia and Japan are fully endogenous at a nineteen-sector level of aggregation. Trade between the two countries is thus endogenous, while their individual trade flows with the rest of the world (ROW) are each governed by the small country assumption.[7] The resulting six sets of sectoral trade flows are then governed by two endogenous price systems (Indonesia-Japan imports and exports), and four exogenous price systems (Indonesia-ROW and Japan-ROW imports and exports).

The extent of price adjustments, as well as the volume and pattern of trade creation and trade diversion, are important factors in determining the ultimate welfare effects of regional trade policy. A second important feature of the model is its differentiated product specification of the demand and supply for tradeable commodities. Domestic demand is constituted by goods which are differentiated by origin (domestic goods, imports from the bilateral trading partner, and imports from ROW) and domestic production is supplied to differentiated destinations (domestic market, exports to the trading partner, and exports to ROW). Similar devices appear elsewhere in the CGE literature, the present model uses a constant elasticity of substitution (CES) specification for demand and a constant elasticity of transformation (CET) for supply.

The Indonesia-Japan CGE model was calibrated to a 1985 social accounting matric (SAM) constructed by the authors for this purpose. The principal data source used to estimate the SAM was a 128 sector input-output table estimated by the Institute of Developing Economies in Tokyo.[8] Structural parameters of the model were obtained by calibration, direct estimation, or imputation from other sources. Calibrated values were obtainable for most share parameters, input-output coefficients, nominal *ad valorem* taxes, and tariffs from the SAM itself. Employment and capital stock data were obtained from official publications of both countries.

The data in Table 3.1 reveal significant structural differences between the two economies. These differences are quite typical of their respective stages of development and arise from three distinct but interdependent sources: endowments, demand, and degree of industrialization. A highly aggregated service sector accounts for a large proportion of total output, but Japan's share is about 10 percentage points higher than Indonesia's. Among the remaining 18 sectors, the composition of output is considerably more diversified for Japan, which has higher levels of technology and income and is thus less endowment-driven than Indonesia.

The role of demand can be seen in column 2, where lower Indonesian incomes lead to narrower emphasis on subsistence and tertiary goods and services. External demand (column 3) also plays a significant role for Indonesia, and this reinforces the endowment-driven focus on primary products (especially petroleum). Japan's demand for imports is negatively endowment-driven, and thus the two countries settle into a finely delineated relationship of comparative advantage (columns 7 and 9), with Japan's supplying a significant portion of Indonesia's advanced manufactures in exchange for Indonesian primary products.

Table 3.1: Economic Structure of Indonesia and Japan[a]

(all figures in per cent)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Indonesia	*S shr*	*D shr*	*X shr*	*M shr*	*X/S*	*M/D*	X^b/X	X^r/X	M^b/M	M^r/M	*tm*
1 AgForF	22.8	22.8	9.5	5.3	5.7	2.4	15.3	84.7	0.3	99.7	9.8
2 Petro	15.8	8.3	64.2	8.7	55.1	11.1	62.6	37.4	0.3	99.7	5.2
3 Mining	0.8	0.8	1.0	1.4	17.4	18.2	90.1	9.9	9.1	90.9	4.8
4 FoodProc	5.1	5.3	1.2	1.1	3.2	2.1	7.0	93.0	9.5	90.5	20.2
5 Textile	1.9	1.7	2.5	1.0	17.6	5.8	2.0	98.0	40.3	59.7	35.3
6 LumWood	1.4	0.8	4.4	0.0	43.8	0.2	15.2	84.8	15.9	84.1	8.6
7 PulpPapr	0.3	0.4	0.1	1.7	4.7	41.0	3.8	96.2	9.1	90.9	32.0
8 IndChem	0.1	0.7	0.2	6.4	47.0	94.5	10.0	90.0	25.7	74.3	12.8
9 OthChem	1.5	2.2	0.8	7.4	7.6	35.5	3.1	96.9	19.7	80.3	12.3
10 Plastic	0.4	0.4	0.1	0.3	2.8	7.5	0.6	99.4	47.8	52.2	27.5
11 NonMtMnr	0.9	1.0	0.1	1.4	1.5	13.8	2.8	97.2	62.9	37.1	28.7
12 Steel	0.5	0.9	0.1	3.8	4.1	46.5	45.2	54.8	63.3	36.7	9.0
13 NonfMtl	0.5	0.3	2.6	1.6	70.4	51.4	60.4	39.6	13.3	86.7	10.1
14 MetalPr	0.6	1.2	0.0	5.0	0.4	44.1	1.0	99.0	39.6	60.4	24.0
15 MchPrcls	0.6	2.7	0.2	19.3	3.2	76.2	1.1	98.9	29.9	70.1	26.6
16 ElecMch	0.4	0.8	0.4	3.6	11.4	48.5	0.1	99.9	31.3	68.7	30.8
17 TrnspEq	1.1	2.4	0.2	11.8	2.9	52.8	0.1	99.9	22.8	77.2	25.9
18 OtherMfg	0.9	1.0	0.2	0.7	2.6	7.9	34.4	65.6	39.1	60.9	34.0
19 Service	44.3	46.2	12.1	19.6	3.7	4.5	16.2	83.8	7.4	92.6	5.0
Total/Wgt Avg	100.0	100.0	100.0	100.0	13.6	10.6	47.1	52.9	20.8	79.2	16.2
Japan											
1 AgForF	4.4	5.3	0.3	13.9	0.5	15.6	0.3	99.7	5.5	94.5	4.8
2 Petro	1.9	4.0	0.7	34.9	2.6	52.5	0.2	99.8	20.6	79.4	4.7
3 Mining	0.6	1.0	0.1	7.1	1.5	41.1	5.9	94.1	2.4	97.6	0.0
4 FoodProc	3.8	4.0	0.5	2.3	0.9	3.5	1.0	99.0	2.5	97.5	16.2
5 Textile	2.0	2.1	2.3	2.9	8.2	8.4	0.9	99.1	1.5	98.5	6.8
6 LumWood	0.6	0.6	0.0	1.1	0.6	10.5	0.3	99.7	9.4	90.6	1.5
7 PulpPapr	1.3	1.3	0.5	0.9	2.7	4.3	1.6	98.4	0.1	99.9	2.7
8 IndChem	1.2	1.3	1.5	2.1	8.6	9.9	6.5	93.5	0.3	99.7	3.3
9 OthChem	2.2	2.2	3.1	2.5	10.0	6.9	2.7	97.3	0.6	99.4	3.4
10 Plastic	1.2	1.2	0.6	0.4	3.4	1.9	1.5	98.5	0.2	99.8	2.9
11 NonMtMnr	1.3	1.3	1.2	0.5	6.5	2.4	4.7	95.3	0.1	99.9	2.7
12 Steel	4.1	3.8	6.5	1.2	11.2	1.8	2.3	97.7	0.9	99.1	1.9
13 NonfMtl	0.8	1.0	0.7	5.0	7.0	29.2	1.5	98.5	5.0	95.0	2.3
14 MetalPr	2.0	1.9	2.2	0.4	8.0	1.3	5.6	94.4	0.1	99.9	3.5
15 MchPrcls	6.6	5.5	19.4	4.5	21.3	4.9	1.7	98.3	0.1	99.9	2.8
16 ElecMch	4.1	3.1	15.2	1.5	26.9	2.9	0.4	99.6	0.0	100.0	2.9
17 TrnspEq	5.1	3.5	24.3	2.1	34.3	3.5	0.7	99.3	0.0	100.0	4.2
18 OtherMfg	2.9	2.9	2.9	2.2	7.1	4.6	0.6	99.4	2.4	97.6	4.6
19 Service	53.8	54.1	18.1	14.4	2.4	1.6	0.5	99.5	4.6	95.4	0.0
Total/Wgt Avg	100.0	100.0	100.0	100.0	7.2	6.0	1.2	98.8	9.3	90.7	3.7

[a] (1) Gross output shares, (2) composite demand shares, (3) export shares, (4) import shares, (5) ratios of exports to gross output, (6) ratios of imports to total demand, (7) ratios of bilateral exports to total exports, (8) ratios of ROW exports to total exports, (9) ratios of bilateral imports to total imports, (10) ratios of ROW imports to total imports, and (11) nominal tariff rates.

The weighted averages at the bottom of each subtable give general indications about the orientation of each economy. For example, Indonesia's exports (column 3) are 13.6 per cent of its gross output, making it almost twice as export-dependent as Japan.[9] Indonesia is also more import-dependent (column 4) than Japan, although the difference here is smaller. The bilateral relationship is also much more important to Indonesia than to Japan, accounting for 47.1 per cent of its exports and 20.8 per cent of its imports on average, while the corresponding Japanese figures are 1.2 and 9.3 per cent, respectively. Finally, Indonesia has higher levels of average nominal tariff protection than Japan (16.2 versus 3.7 per cent). This, coupled with the greater trade dependence, indicates that Indonesia has greater potential for efficiency gains and structural change from trade liberalization.

Each sector in the model has effluent coefficients, linear in output, for a variety of pollutants. We have used the database for the Industrial Pollution Projection System of the World Bank to calibrate sectoral effluent coefficients.[10] This database provides emission rates, as a proportion of base-year output value, for seven air pollutants, two water pollutants, and two toxic pollutants at a four-digit SIC level of sectoral detail. The data are then mapped to four-digit output share data for Indonesia and Japan to obtain weighted emission coefficients for the 19 sectors of the model. The results of this conversion are presented in Table 3.2.

Eight of the 19 sectors could be roughly classified as pollution intensive, namely petroleum, mining, lumber and wood, pulp and paper, industrial chemicals, non-metallic minerals (consisting of cement and stone products), steel, and nonferrous metals.[11] For example, petroleum has high effluent intensities for suspended particulates (SUSP), SO_2, NO_2, and LEAD, while mining and nonferrous metals have high pollution coefficients on SUSP, SO_2, carbon monoxide (CO), the two water pollutants (BOD, SS), and the two toxic pollutants (TOX, METAL). Indonesia's heavy export dependence on petroleum is the most significant factor explaining the high effluent content of its exports, but relatively high export shares of lumber and wood and nonferrous metals also contributed to high EET in exports. By contrast, except for steel, Japan's exports are concentrated in sectors with low pollution intensities, resulting in low effluents embodied in its exports.

Table 3.2: Sectoral Effluent Intensities

Indonesia

	SUSP	SO2	NO2	FINP	LEAD	VOC	CO	BOD	SS	TOX	METAL
1 AgForF	.00	.00	.00	.000	.00005	.00	.00	.00	.00	0	0
2 Petro	11.83	35.89	7.65	.071	.01445	3.54	1.43	2.89	3.49	2544	130
3 Mining	9.24	44.35	3.65	.049	.00095	4.53	43.57	49.34	710.56	8921	6150
4 FoodProc	1.18	1.40	4.05	.372	.00005	.82	1.12	45.58	11.79	647	6
5 Textile	.89	6.23	10.83	.224	.00005	2.65	2.05	.12	.19	3284	145
6 LumWood	9.15	3.14	6.83	.108	.00005	9.25	11.76	.00	.00	4523	36
7 PulpPapr	2.98	29.49	11.93	.077	.00155	6.29	17.02	59.79	241.08	6845	33
8 IndChem	1.34	9.01	8.71	.049	.00015	9.16	12.34	56.84	127.38	29910	180
9 OthChem	1.10	12.12	5.94	.088	.00025	5.68	7.28	15.36	4.38	3739	35
10 Plastic	.31	3.00	.89	.043	.00005	9.97	.26	.01	.03	7483	197
11 NonMtMnr	10.39	15.22	16.81	5.336	.00065	1.18	3.05	.00	.00	3392	828
12 Steel	3.55	9.74	4.40	.571	.01355	2.31	33.66	.10	74.94	7643	4100
13 NonfMtl	9.07	44.90	3.39	.048	.00005	4.59	46.30	52.35	756.40	9334	6540
14 MetalPr	.56	.37	1.80	.000	.00055	9.33	.21	3.30	70.75	4593	659
15 MchPrcls	1.49	.81	.61	.000	.00045	1.82	.22	.00	.00	1562	248
16 ElecMch	.11	.38	.22	.012	.00035	4.50	.26	.01	.10	1805	314
17 TrnspEq	.33	.20	.13	.515	.00005	1.87	.05	.01	.04	1112	52
18 OtherMfg	.57	.48	.15	.448	.00005	9.08	.07	.00	.00	2707	597
19 Service	.15	.13	.04	.120	.00005	2.44	.02	.00	.00	726	160

Japan

	SUSP	SO2	NO2	FINP	LEAD	VOC	CO	BOD	SS	TOX	METAL
1 AgForF	.00	.00	.00	.000	.00005	.00	.00	.00	.00	0	0
2 Petro	11.83	35.89	7.65	.071	.01445	3.54	1.43	2.89	3.49	2544	130
3 Mining	25.33	121.56	9.99	.135	.00245	12.41	119.43	135.25	1947.70	24453	16857
4 FoodProc	1.57	1.86	5.39	.495	.00015	1.09	1.48	60.59	15.67	860	8
5 Textile	.84	5.89	10.23	.212	.00005	2.50	1.94	.11	.18	3103	137
6 LumWood	15.30	5.24	11.41	.181	.00005	15.46	19.65	.00	.00	7562	60
7 PulpPapr	.64	6.37	2.58	.017	.00035	1.36	3.68	12.91	52.06	1478	7
8 IndChem	.66	4.43	4.29	.024	.00005	4.51	6.07	27.97	62.69	14719	89
9 OthChem	1.71	18.82	9.22	.137	.00035	8.83	11.30	23.86	6.79	5807	55
10 Plastic	.11	1.06	.31	.015	.00005	3.52	.09	.00	.01	2645	69
11 NonMtMnr	7.20	10.55	11.65	3.699	.00045	.82	2.11	.00	.00	2351	574
12 Steel	3.55	9.74	4.40	.571	.01355	2.31	33.66	.10	74.94	7643	4100
13 NonfMtl	9.07	44.90	3.39	.048	.00005	4.59	46.30	52.35	756.40	9334	6540
14 MetalPr	.56	.37	1.80	.000	.00055	9.33	.21	3.30	70.75	4593	659
15 MchPrcls	.20	.11	.08	.000	.00015	.24	.03	.00	.00	206	33
16 ElecMch	.01	.05	.03	.001	.00005	.57	.03	.00	.01	229	40
17 TrnspEq	.08	.05	.03	.123	.00005	.45	.01	.00	.01	266	13
18 OtherMfg	.57	.48	.15	.448	.00005	9.08	.07	.00	.00	2707	597
19 Service	.13	.11	.03	.099	.00005	2.00	.02	.00	.00	596	131

Source: Wheeler (1991a)

Air Pollutants

SUSP: Suspended Particulates (lbs/year/$1,000)
SO2: Sulphur Dioxide (lbs/year/$1,000)
NO2: Nitrogen Dioxide (lbs/year/$1,000)
FINP: Fine Particulates (PM10) (lbs/year/$1,000)
LEAD: Lead (lbs/year/$1,000)
VOC: Volatile Organic Compounds (lbs/year/$1,000)
CO: Carbon Monoxide (lbs/year/$1,000)

Water Pollutants

BOD: Biochemical Oxygen Demand (lbs/day/$1,000,(
SS: Suspended Solids(lbs/day/$1,000,000)

Toxic Pollutants / All Media

TOX Total Toxic Release (lbs/year/$1,000,000)
METAL Bioaccumulative Metals (lbs/year/$1,000,000

The matrix of effluent coefficients by sector and type of pollutant forms the basis for calculating environmental effects resulting from policy changes, such as tariff liberalization and effluent taxes. A limitation of this approach at the moment is that there is no scope for technical substitution within sectors, and thus emissions are proportional to output regardless of relative prices and differential effluent taxes. The main advantage of this approach over previous modeling with these coefficients is the general equilibrium nature of the simulations, which allows for changing composition of domestic output, a very large medium-term source of pollution mitigation.[12]

IV. TRADE AND DOMESTIC POLLUTION IN INDONESIA

It was apparent from the evidence discussed in section 2 that Indonesia may be realizing its export potential at a disadvantage in terms of the environmental costs it absorbs vis-a-vis trading partners. In this section, the two-country CGE model is used to assess the linkages between trade, tariff and domestic tax policy, and the environment. We consider two general policy approaches to reducing or offsetting environmental costs. Both approaches seek to alter the composition of domestic production with economic instruments, the first via trade policy and tariffs, the second using taxes on effluents.[13]

The first two policy experiments, reported in Tables 4.1-4.4 below, simulated Indonesian trade liberalization by removal of nominal tariffs on all imports. In the first experiment, liberalization is assumed to be undertaken in concert with a fixed exchange rate regime, the current account balance being endogenously determined.[14] In experiment 2, the exchange rate was assumed to be flexible and the current account balance fixed. Aggregate results in both cases (Table 4.1) confirm neoclassical reasoning that the removal of trade distortions enhances the overall economic efficiency, but the real welfare gains and trade adjustments depend upon the exchange rate closure. In an actual adjustment process, one might expect to see a combination of the two effects, but in the long run the flexible exchange rate regime is more plausible.

In both experiments, Indonesian liberalization has a negligible aggregate effect on the Japanese economy, with most measures of output and income changing by a small fraction of one per cent. From an Indonesian perspective, the change is more substantial. Tariff removal leads to an increase in economy wide real output by 0.55-1.08 per cent, and employment by 2.0-2.5 per cent. Labor and capital income both increase, but capital income gains less under the fixed exchange rate regime because export industries are more capital intensive and the total exports contract in this simulation. Import and export statistics vary between the exchange rate regimes in a predictable way, while exports remain static under fixed rates and becoming more internationally competitive when the exchange rate can depreciate (5.52 per cent) in response to tariff removal. Even when the exchange rate is fixed and the economy can absorb imports without an external budget constraint, however, the balance of payments deficit only reaches 2.2 per cent of GDP.[15]

Table 4.1: Aggregate Results of Indonesian Tariff Liberalization
(per cent changes)

Indonesia	*Exp 1*	*Exp 2*
Real GDP	.55	1.08
Employment	2.05	2.49
Labor Income	2.20	2.66
Capital Income	1.10	3.47
EV Income	3.05	.68
Imports	12.98	7.58
Exports	-.78	7.20
BOP[a]	2.20	
Exch Rate		5.52

Experiment 1: Indonesian tariff removal with fixed exchange rate.
Experiment 2: Indonesian tariff removal with flexible exchange rate.

Japan	*Exp 1*	*Exp 2*
Real GDP	.0003	.04
Employment	0	.002
Labor Income	.01	.00
Capital Income	.01	.05
EV Income	.0003	.05
Imports	-.01	.18
Exports	.15	-.08
BOP[a]	.01	
Exch Rate		-.10

[a] The balance of payments increases as a percentage of GDP.
A deficit for Indonesia and a surplus for Japan.

A final aggregate statistic which deserves mention is equivalent variation (EV) income, which measures the change in real domestic income, adjusted for consumer purchasing power. In the case of fixed exchange rates, this figure indicates that Indonesian consumers experience a 3.05 per cent appreciation in their purchasing power from the tariff removal, largely through the increase in foreign borrowing. This income would of course translate into substantially higher long-run effects as it passes through the expenditure and savings-investment cycles. On the other hand, purchasing power rises by only 0.68 per cent under a flexible rate. The reason for this difference is that the fixed rate, coupled with import price cuts from tariff removal, keeps purchasing power artificially high. This result demonstrates why exchange rate overvaluation can be tempting to governments, but the long-term implications of this type of policy have been generally very negative.[16]

As is usual with trade policy, relatively small aggregate adjustments can mask dramatic shifts in the composition of sectoral trade and output. Table 4.2 gives a more detailed picture of the consequences of experiment 2, Indonesian tariff removal under flexible exchange rates. Although the data on Indonesian tariffs

(Table 3.1) do not differentiate between Japan and the rest of the world, the import adjustments vary significantly for two reasons. First, the initial trade flows from the two sources were quite different (Table 3.1, columns 9 and 10), leading to different proportional adjustments to domestic demand changes. Secondly, we assume Indonesia is a small country with respect to ROW, so it imports from this source at fixed prices while terms of trade with respect to Japan are endogenous. Thus, Japanese exporters benefit less in relative terms from Indonesian liberalization than do Indonesia's other trading partners taken as a group. A similar effect can be detected in the composition of Indonesian exports, but the exchange rate depreciation is large enough to offset most terms of trade effects.

Domestic structural adjustments in Indonesia are driven by a combination of import penetration and export expansion. These two effects generally promote expansion of primary and basic industries such as petroleum and mining, lumber, chemicals, and nonferrous metals, with moderate contractions elsewhere. Many sectors with the largest percentage output adjustments are actually quite small in the economy (Table 3.1, column 1), but petroleum accounts for 16 per cent of real domestic output and its expansion may have serious implications for the Indonesian environment as will be seen below. Given the assumption of fixed wages and labor surplus for Indonesia, the adjustment to tariff removal entails a substitution of labor for capital across most sectors. Results for Japan are again small, except for the bilateral trade adjustments discussed in the previous paragraph. Generally speaking, there is some shift of resources toward Japanese export sectors and a slight diversion of import demand in response to the depreciation of the Indonesian currency.

Table 4.2: Sectoral Results for Indonesian Tariff Liberalization (Experiment 2)

(all figures are percentage changes)

Indonesia	*Supply* *Total*	*Domestic*	*Japan*	*ROW*	*Imports* *Japan*	*ROW*	*Labor* *Demand*	*Capital* *Demand*
1 AgForF	-0.42	-0.87	3.39	7.63		8.31	2.42	-1.20
2 Petro	5.32	3.10	6.04	8.88		0.47	8.99	5.14
3 Mining	2.75	2.24	4.95	6.98	0.28	1.29	4.67	0.98
4 FoodProc	-0.55	-0.65	1.63	2.70	5.83	14.79	2.30	-1.31
5 Textile	1.79	0.97		5.57	9.51	39.21	4.12	0.45
6 LumWood	5.38	0.66	7.46	12.02			8.15	4.33
7 PulpPapr	-16.72	-17.12		-9.57	4.08	14.78	-14.5	-17.52
8 IndChem	52.59	34.94		64.44	0.70	2.26	54.32	48.87
9 OthChem	-1.49	-1.80		2.35	1.93	6.67	1.55	-2.03
10 Plastic	-0.32	-0.44		3.63	7.87	30.82	2.59	-1.03
11 NonMtMnr	-2.81	-2.85		-0.51	6.47	37.73	-0.31	-3.83
12 Steel	-4.20	-4.30	-1.55	-1.91	0.56	3.62	-0.90	-4.40
13 NonfMtl	12.11	6.52	13.09	16.36	-1.31	-5.60	14.84	10.78
14 MetalPr	-8.76	-8.76			3.87	16.38	-6.50	-9.80
15 MchPrcls	10.76	9.99		25.56	4.00	14.26	13.67	9.65
16 ElecMch	-1.91	-3.15		5.98	5.53	18.73	0.66	-2.90
17 TrnspEq	-2.24	-2.69		10.03	5.96	17.33	0.05	-3.48
18 OtherMfg	-0.54	-0.64	2.44	3.30	9.55	40.38	1.60	-1.98
19 Service	0.31	0.12	2.68	5.70	-0.12	-0.14	2.26	-1.35

Japan	*Supply* *Total*	*Domestic*	*Indonesia*	*ROW*	*Imports* *Indonesia*	*ROW*	*Labor* *Demand*	*Capital* *Demand*
1 AgForF	-0.22	-0.02		-0.21	3.39	0.13	-0.03	-0.02
2 Petro	-0.09	-0.23		0.02	6.04	-0.87	-0.23	-0.22
3 Mining	0.03	-0.09	0.28	-0.11	4.95	-0.03	-0.09	-0.08
4 FoodProc	0.03	0.03	5.83	-0.04	1.63	0.13	0.03	0.04
5 Textile	-0.08	0.03	9.51	-0.02		0.15	0.03	0.04
6 LumWood	1.00E-03	-0.08		-0.20	7.46	0.13	-0.08	-0.06
7 PulpPapr	0.03	8.02E-04	4.08	-0.06		0.14	-3.91E-03	0.02
8 IndChem	0.01	0.02	0.70	0.05		-0.05	0.02	0.03
9 OthChem	-9.19E-03	0.01	1.93	-0.03		0.10	6.51E-03	0.02
10 Plastic	0.04	-0.01	7.87	-0.06		0.12	-0.01	-5.01E-04
11 NonMtMnr	-0.03	0.02	6.47	0.01		0.04	0.04	0.04
12 Steel	-0.28	-0.03	0.56	-0.07	-1.55	0.19	-0.04	-0.02
13 NonfMtl	0.03	-0.28	-1.31	-0.30	13.09	-0.17	-0.28	-0.27
14 MetalPr	0.01	0.02	3.87	-0.02		0.14	0.03	0.04
15 MchPrcls	-0.03	0.01	4.00	-0.05		0.17	9.72E-03	0.02
16 ElecMch	-0.16	-0.01	5.53	-0.11		0.18	-0.04	-0.02
17 TrnspEq	4.77E-03	-0.12	5.96	-0.29		0.18	-0.16	-0.15
18 OtherMfg	0.01	4.43E-03	9.55	-0.05	2.44	0.16	1.27E-03	0.01
19 Service	0.31	0.02	-0.12	-0.10	2.68	0.12	0.01	0.02

It is apparent from these results that Indonesian trade policy, and tariff removal in particular, can induce significant changes in the composition of domestic production, which can in turn be expected to influence the level and composition of domestic effluent emissions. Tables 4.3 and 4.4 provide percentage changes in pollution emissions and pollution intensities (emissions per unit of output) resulting from Indonesian liberalization. In addition to the effluents listed in Table 3.2, an index developed by Wheeler (1992) is also included. The AHTL index, defined in Section 2 above, is an average of many effluents with weights representing their human health risk.

Table 4.3: Emission Levels by Destination of Supply[a]
(percentage changes)

	Experiment 1				*Experiment 2*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-1.45	-1.72	-1.93	-1.62	1.91	6.23	9.34	4.54
SO2	-2.06	-1.74	-2.23	-1.99	1.99	6.33	9.18	4.63
NO2	-1.23	-1.72	-.91	-1.28	.56	6.15	8.99	3.11
FINP	-.19	-1.48	.33	-.20	-1.06	5.83	6.52	-.50
LEAD	-2.18	-1.79	-2.58	-2.13	2.54	6.02	8.84	4.95
VOC	.26	-1.54	.40	.10	.07	6.26	9.47	1.62
CO	-2.67	-1.30	.57	-1.97	-.03	8.64	12.34	3.23
BOD	-.28	-1.43	2.95	-.14	-.61	8.14	11.78	1.05
SS	-3.55	-1.22	.11	-2.61	.58	9.93	15.56	4.36
TOX	-.43	-1.58	3.13	-.14	.30	6.73	12.27	2.71
METAL	-1.03	-1.32	-.92	-1.06	.33	8.98	11.96	2.46
AHTL	-.67	-1.67	1.88	-.47	.80	6.39	11.50	3.48
Japan	*Domestic*	*Indon*	*ROW*	*Total*	*Domestic*	*Indon*	*ROW*	*Total*
SUSP	.03	4.07	.05	.03	-.09	2.47	-.07	-.09
SO2	.04	3.20	.04	.04	-.10	1.63	-.08	-.10
NO2	.02	4.52	.03	.02	-.03	3.08	-.04	-.02
FINP	.01	6.46	.08	.02	.01	4.71	-.09	.01
LEAD	.06	2.10	.07	.07	-.10	.77	-.06	-.09
VOC	.00	4.32	.03	.01	-.01	2.84	-.07	-.01
CO	.05	2.13	.07	.05	-.07	.74	-.09	-.07
BOD	.00	2.39	.01	.00	-.02	1.26	-.07	-.02
SS	.04	2.30	.06	.05	-.11	.79	-.15	-.11
TOX	.02	2.76	.05	.03	-.03	1.71	-.06	-.03
METAL	.04	2.54	.07	.05	-.06	1.03	-.10	-.06
AHTL	.02	2.28	.05	.03	-.02	1.57	-.06	-.02

[a] See Table 3.2 for the definition of pollutants.

In most cases, the direction of change in pollution levels (Table 4.3) depends on the foreign exchange regime. In particular, the fixed exchange rate policy forestalls Indonesia's export growth, leading to a reduction in pollution. By contrast, Japanese pollution rises largely because of increased production for export to Indonesia. The reductions in levels of almost all effluent categories for Indonesia is intuitively appealing, but it is not reasonable to expect the government to sustain a trade policy which stifles export growth.

Experiment 2 is a more sustainable policy scenario, but which comes with the burden of increased domestic pollution. As one would expect, in the absence of new technologies economic growth entails increased emission levels. This is inevitable when growth occurs with constant technology and output composition. What these results reveal is that, even when extensive compositional shifts occur in response to trade liberalization, effluent levels will still rise in Indonesia. Thus, the policy challenge is how to mitigate this new pollution.

Table 4.4: Emission Intensities by Destination of Supply[a]
(percentage changes)

	Experiment 1				*Experiment 2*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-2.17	-.18	-1.82	-2.14	1.97	.19	1.01	3.57
SO2	-2.78	-.20	-2.11	-2.51	2.05	.28	.87	3.67
NO2	-1.96	-.19	-.79	-1.81	.62	.12	.69	2.16
FINP	-.92	.05	.44	-.73	-1.00	-.19	-1.59	-1.42
LEAD	-2.90	-.25	-2.47	-2.65	2.61	.00	.55	3.98
VOC	-.48	.00	.51	-.44	.13	.21	1.13	.68
CO	-3.39	.24	.69	-2.49	.03	2.46	3.79	2.28
BOD	-1.01	.11	3.06	-.67	-.55	1.99	3.27	.12
SS	-4.26	.32	.23	-3.13	.65	3.68	6.76	3.40
TOX	-1.17	-.05	3.25	-.67	.36	.66	3.72	1.76
METAL	-1.76	.22	-.81	-1.59	.40	2.78	3.44	1.52
AHTL	-1.40	-.13	1.99	-1.00	.87	.34	3.01	2.53
Japan	*Domestic*	*Indon*	*ROW*	*Total*	*Domestic*	*Indon*	*ROW*	*Total*
SUSP	.03	-1.08	-.04	.02	-.09	-.97	.05	-.08
SO2	.03	-1.91	-.05	.03	-.10	-1.79	.05	-.09
NO2	.01	-.66	-.05	.01	-.03	-.39	.09	-.02
FINP	.01	1.19	-.01	.01	.01	1.18	.04	.01
LEAD	.06	-2.95	-.01	.06	-.09	-2.62	.06	-.09
VOC	.00	-.85	-.05	-.01	-.01	-.62	.05	.00
CO	.05	-2.92	-.02	.04	-.07	-2.65	.04	-.06
BOD	.00	-2.68	-.07	-.01	-.02	-2.15	.05	-.02
SS	.04	-2.76	-.03	.03	-.11	-2.60	-.02	-.10
TOX	.02	-2.33	-.04	.02	-.02	-1.72	.06	-.02
METAL	.04	-2.53	-.02	.03	-.06	-2.37	.03	-.05
AHTL	.02	-2.79	-.04	.02	-.02	-1.84	.07	-.01

[a] See Table 3.2 for the definition of pollutants.

While it might be reasonable to associate economic expansion with growth in total pollution levels, one might reasonably ask if shifts in output composition can lead to lower pollution intensities. Although this is quite possible in theory, given the diversity of sectoral effluent intensities it would not result from Indonesian tariff liberalization (see Table 4.4). Indeed, the results for experiment 2 in Table 4.4 indicate that in the absence of new technology tariff liberalization will increase the emission intensities for almost all major pollution categories. The only exceptions are fine particulate (FINP) and biochemical oxygen demand (BOD, water pollution), whose intensities fall with the output of the cement and pulp and paper industries, respectively. For Indonesia, these results only amplify the policy challenge of addressing the environmental consequences of trade-based economic growth.

Discussion in section 2 focused on the links between pollution and bilateral trade, and the results of Tables 4.3 and 4.4 suggest some interesting and relatively positive conclusions in this regard. First of all, it is reasonable to conclude that the historical asymmetry in the effluent content of trade was not a result of the existing pattern of Indonesian protection. This is apparent since the asymmetry only intensifies with the removal of Indonesian tariffs. Effluent levels rise with bilateral trade in both directions, but Indonesian effluent intensities for exports to Japan generally rise while the latter's intensities fall for bilateral exports. A second important bilateral conclusion is that, while emission intensities for Indonesian exports to Japan rise, they rise less than the pollution intensities of Indonesian exports to the ROW. Thus increased exports to Japan actually have a lower environmental cost at the margin than exports to the ROW. Finally, in most of the major effluent categories, including the acute human toxicity index (AHTL) of all effluents, production for export to Japan is cleaner than average production for the domestic market and almost eight times cleaner than average economy wide production. Annex Tables A.3.1-A.3.3 present the results of two components of experiment 2, piecemeal Indonesian tariff liberalization with respect to Japan and the rest of the world.

Having identified a policy problem, the apparent positive correlation between trade liberalization and effluent intensity, the next three simulations are designed to examine how the problem might be mitigated. The correlation between growth and pollution of course implies a difficult tradeoff between quantitative and qualitative aspects of living standards, and these experiments are intended to give a general idea about the economic costs which would be occasioned by the use of a variety of economic instruments to mitigate domestic pollution. Of the many kinds of policy simulations which the CGE model can carry out, only a small subset are presented here. However, they do give reliable indications about the individual significance and interactions between two important instruments, tariffs and effluent taxes.

Experiment 3 poses the following question: What set of import tariffs would minimize the acute human toxic effluent index AHTL, per unit of real GDP? An experiment which simply minimized AHTL depressed the economy to an unacceptable degree, while an experiment to maximize Real GDP simply set tariffs to zero as one would expect.[17] Even when minimizing effluents per unit of output, the optimal tariffs became untenably large, so in experiment 3 an upper bound of 100 per cent is placed on all tariffs. Most tariffs indeed reached this level, and the result was a drop in imports (Table 4.5) of 14.21 per cent and in real GDP of 2.85 per cent. On the other hand, the toxicity index of economy wide effluents fell by over three times the drop in GDP (9.73 per cent), indicating that a relatively steep tradeoff between real income and pollution. No attempt has been made, however, to put a dollar value on the reduced pollution which would permit more direct comparisons. This is an important direction for future research, since rigorous economic accounting of environmental costs and benefits is essential for comprehensive integration of economic and environmental policies.[18]

Table 4.5: Aggregate Results for Tax and Trade Policies to Reduce Effluents
(percentage changes)

Indonesia	*Exp 3*	*Exp 4*	*Exp 5*
Real GDP	-2.85	-2.95	-2.52
Employment	-4.36	-4.53	-1.93
Labor Income	-4.98	-6.93	-5.16
Capital Income	-7.00	-8.16	-6.62
EV Income	-2.23	-2.57	-2.21
Imports	-14.21	-5.90	-.66
Exports	-14.72	-7.14	-2.73
Govt Budget[a]	108 (4.98)	133 (6.09)	106 (4.90)
Exch Rate	-11.09	9.91	19.09
AHTL	-9.73	-10.00	-10.00

Experiment 3: Tariffs (<100%) which minimize AHTL/real GDP
Experiment 4: Effluent taxes which reduce AHTL by 10%.
Experiment 5: Taxes from Experiment 6 with complete tariff removal.

[a]Figures in parentheses are per cent government revenue in real GDP.

From the results for experiment 3 in Table 4.6, it is apparent that most of the reduction in Indonesian pollution is coming from exports. But this is partly because trade taxes are being used as the economic instrument, raising the real exchange rate and making exports less competitive. It is also because, as was emphasized in section 2, Indonesian exports are much more effluent-intensive than production for the domestic market. It is especially significant that these tax instruments have succeeded in reducing effluent intensities (Table 4.7), since this is the key to the nonlinear relationship between GDP and pollution reductions. Thus it is apparent that, despite negative environmental conclusions about trade liberalization, changes in the composition of production can effect significant reductions in pollution levels and intensities.

Table 4.6: Emission Levels by Destination of Supply
(percentage changes)

	Experiment 3				*Experiment 4*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-6.63	-13.32	-18.69	-10.80	-9.92	-13.87	-18.24	-12.61
SO2	-8.58	-13.66	-18.96	-12.04	-10.50	-14.03	-19.02	-13.14
NO2	-5.76	-13.08	-18.28	-9.34	-7.49	-13.80	-15.95	-10.20
FINP	.16	-12.50	-13.70	-.87	-4.49	-12.21	-7.11	-4.85
LEAD	-8.02	-12.73	-17.88	-11.54	-11.69	-13.87	-19.41	-13.94
VOC	-2.42	-13.41	-18.35	-5.10	-4.31	-13.21	-12.08	-5.97
CO	-10.93	-21.04	-25.99	-14.82	-6.16	-14.80	-16.46	-9.12
BOD	-3.90	-19.41	-23.60	-6.68	-3.24	-14.78	-13.72	-5.00
SS	-15.36	-25.02	-34.70	-19.70	-8.35	-15.94	-23.26	-11.73
TOX	-5.15	-14.96	-21.86	-8.63	-5.54	-13.85	-15.30	-7.93
METAL	-6.46	-22.28	-26.79	-10.27	-5.47	-15.10	-17.62	-7.77
AHTL	-5.99	-13.85	-20.83	-9.73	-6.66	-13.82	-16.45	-9.49

	Experiment 5			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-11.38	-13.86	-16.94	-13.13
SO2	-12.02	-14.00	-18.58	-13.83
NO2	-8.51	-13.84	-13.14	-10.38
FINP	-6.08	-11.77	-2.09	-6.07
LEAD	-13.52	-14.11	-19.74	-14.95
VOC	-4.73	-12.76	-6.79	-5.73
CO	-7.07	-12.34	-9.93	-8.38
BOD	-3.96	-13.05	-8.30	-5.06
SS	-9.59	-12.72	-18.36	-11.28
TOX	-6.03	-13.20	-9.23	-7.44
METAL	-6.11	-12.53	-13.32	-7.57
AHTL	-7.20	-13.58	-11.91	-10.00

Table 4.7: Emission Intensities by Destination of Supply
(percentage changes)

	Experiment 3				*Experiment 4*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-6.44	-.48	-2.82	-8.87	-8.07	-1.92	-16.01	-10.22
SO2	-8.40	-.87	-3.14	-10.13	-8.66	-2.09	-16.81	-10.77
NO2	-5.57	-.20	-2.33	-7.38	-5.59	-1.84	-13.66	-7.74
FINP	.37	.47	3.14	1.28	-2.53	-.03	-4.58	-2.25
LEAD	-7.83	.20	-1.85	-9.63	-9.87	-1.91	-17.21	-11.59
VOC	-2.22	-.59	-2.41	-3.05	-2.34	-1.17	-9.68	-3.39
CO	-10.75	-9.35	-11.55	-12.98	-4.23	-2.97	-14.18	-6.63
BOD	-3.70	-7.47	-8.69	-4.66	-1.25	-2.95	-11.37	-2.40
SS	-15.19	-13.91	-21.95	-17.97	-6.46	-4.28	-21.16	-9.31
TOX	-4.95	-2.36	-6.61	-6.65	-3.60	-1.89	-12.98	-5.41
METAL	-6.26	-10.76	-12.50	-8.33	-3.52	-3.32	-15.37	-5.25
AHTL	-5.80	-1.09	-5.37	-7.77	-4.74	-1.86	-14.17	-7.02

	Experiment 5			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	-9.48	-2.52	-21.03	-11.30
SO2	-10.13	-2.68	-22.60	-12.01
NO2	-6.54	-2.50	-17.42	-8.49
FINP	-4.07	-.15	-6.92	-4.09
LEAD	-11.66	-2.81	-23.70	-13.15
VOC	-2.68	-1.28	-11.38	-3.74
CO	-5.07	-.81	-14.37	-6.45
BOD	-1.90	-1.61	-12.82	-3.06
SS	-7.65	-1.24	-22.38	-9.41
TOX	-4.02	-1.77	-13.70	-5.48
METAL	-4.09	-1.02	-17.60	-5.62
AHTL	-5.21	-2.20	-16.25	-7.20

A neoclassical economist would naturally argue that tariffs are inefficient instruments to control pollution decisions at the producer level. Since we have no technology choice in the present model, it is not possible for individual sectors to substitute between effluents or to finance output-neutral effluent reductions. Thus a direct effluent tax, which would could induce fairly complex technical substitution by firms, here has the effect of a simple output tax. Even in this limited context, it is still useful to compare indirect and trade taxes for their efficacy. Experiment 4 implements a set of taxes on the major air pollutants (SUSP, SO2, NO2, FINP, LEAD, VOC, and CO) which act to reduce AHTL by 10 per cent. Many of the aggregate effects of this (Table 4.5) are quite analogous to the optimal tariff experiment, but other results differ in important ways. Specifically, effluent taxes have a much less repressive effect on trade, bring more revenue to the government, and of course the composition of trade adjustments is significantly different (see Annex Table A.4.1). Again, the effluent reductions are driven mainly by adjustments in export patterns rather than production for the domestic market. Since the tax is now on all output, regardless of destination, it is clear that the environmental benefits are coming from reducing the disparity between effluent intensities between the two types of supply.

The fifth and final experiment seeks to offset the contractionary effects of effluent taxation by combining this with the expansionary effect of tariff liberalization. All tariffs are removed, and effluent taxes are set a levels which reduce AHTL by 10 per cent again. This combination of instruments reduces the output change to about one fourth of the percentage effluent reduction, cuts the overall employment losses by more than half, and more than offsets the lost tariff revenue which would have accrued to the government. Despite this, the overall and constituent effluent adjustments are quite comparable to experiment 4, except that even more pollution savings are obtained from ROW exports. Thus tariff liberalization can still be beneficial and does not preclude effluent reduction, but other economic instruments must be brought into play to achieve the latter.

V. CONCLUSIONS AND EXTENSIONS

The ability of international trade to alter the composition of domestic production activities allows it to exert an important influence on the environment. Historically, export-oriented growth has often been associated with high and unsustainable pollution levels, and countries on this path of development are increasingly aware of the environmental risks. This paper uses data on the economy of Indonesia to appraise the environmental risks of its trade orientation and to evaluate some alternative economic instruments for reducing these risks.

Three principal conclusions emerge from this preliminary research, two rather negative and one positive. First, Indonesia's historical trade orientation has been environmentally asymmetric in the sense that it occasioned significant transfers of pollution services from its trading partners to the domestic economy. Secondly, given current technology, increasingly outward trade orientation by Indonesia is likely to raise both the levels and intensities of major industrial effluents, posing an ever more serious threat to public health. Other things being equal, these effects would be intensified by across-the-board Indonesian tariff reductions. Third, there is considerable scope within the economy for reducing both the level and intensity of domestic pollution under existing technologies. This can apparently be achieved by economic instruments which change the composition of domestic output, including import tariffs and effluent taxes. Such taxes may lead to reductions in real output, but by significantly smaller percentages than the pollution reductions.

Much work remains to be done with the data and analytical resources developed in this research. At least five areas should be given priority. It is important to broaden the simulation model specification to include possibilities for technical substitution. Some account should also be taken of pollution arising from consumption activities, such as vehicular emissions and fertilizer use. Domestic institutions should also be disaggregated so the real incidence of economic and environmental effects can be more clearly understood. It would also be desirable to obtain more country-specific information on pollution intensity and its social and economic costs. Fifth, emissions from agriculture, mining, and service activities need to be incorporated into the present database.

As this family of more extended models is developed, they should be subjected to exhaustive policy experimentation to elucidate the complex environmental role of individual and combined economic instruments. The importance of all this work is to strengthen the empirical foundation for research on the environmental implications of growth policy and the growth implications of environmental policy, two essential steps to secure the basis for sustainable development.

Annex 1: Structural Equations for the Indonesia-Japan CGE Model

I. Country-specific Equations

Emission Levels by Destination of Supply

$$E_h^k = \sum_{i=1}^{n} \varepsilon_{i,h} P_{Si}^k S_i^k \tag{A.1}$$

$k = \{d, b, r\}$, *where* $d =$ *domestic*, $b =$ *bilateral partner, and* $r = ROW$

$h = \{SUSP, SO_2, NO_2, FINP, LEAD, VOC, CO, BOD, SS, TOX, METAL, AHTL\}$

Consumer Behavior

$$C_i = LES_C(P_{Di}, Y) = \gamma_i + \frac{\eta_i}{P_{Di}}\left(Y - \sum_{j=1}^{n} P_{Dj}\gamma_j\right) \tag{A.2}$$

Production Technology

$$S_i = \min\{CES_S(L_{Di}, K_{Di}; \phi_i), V_{1i}/a_{1i}, \ldots, V_{ni}/a_{ni}\} \tag{A.3}$$

$$V_{ij} = a_{ij} S_j \tag{A.4}$$

Factor Demands

$$LD_i / KD_i = \psi(w / r_{Di}; \phi_i) \tag{A.5}$$

$$KD_i = \overline{A}_{KD_i}\left[\sum_{k \in \{d,b,r\}} \theta_i^k \left(KD_i^k\right)^{(\mu_i - 1)/\mu_i}\right]^{\mu_i/(\mu_i - 1)} \tag{A.6}$$

$$KD_i^f / KD_i^d = k_D\left(r_{Di}^f / r_{Di}^d; \mu_i\right), \quad f = b, r \tag{A.7}$$

Factor Supplies

$$LS = LES_L(w, Y) \tag{A.8}$$

$$KS_i = \overline{A}_{KS_i}\left[\sum_{k \in \{d,b,r\}} \upsilon_i^k \left(KS_i^k\right)^{(\lambda_i + 1)/\lambda_i}\right]^{\lambda_i/(\lambda_i + 1)} \tag{A.9}$$

$$KS_i^f / KS_i^d = k_S\left(r_{Si}^f / r_{Si}^d ; \lambda_i\right), \quad f = b, r \tag{A.10}$$

Factor Prices

$$r_{Di} = \sum_{k \in \{d,b,r\}} r_{Di}^k \, KD_i^k \tag{A.11}$$

$$r_{Si} = \sum_{k \in \{d,b,r\}} r_{Si}^k \, KS_i^k \tag{A.12}$$

Commodity Demands, Supplies, and Allocation of Traded Goods

$$D_i = \overline{A}_{D_i} \left[\sum_{k \in \{d,b,r\}} \beta_i^k \left(D_i^k\right)^{(\sigma_i - 1)/\sigma_i} \right]^{\sigma_i/(\sigma_i - 1)} \tag{A.13}$$

$$D_i^f / D_i^d = g_D\left(P_{Di}^f / P_{Di}^d ; \sigma_i\right), \quad f = b, r \tag{A.14}$$

$$S_i = \overline{A}_{S_i} \left[\sum_{k \in \{d,b,r\}} \delta_i^k \left(S_i^k\right)^{(\tau_i + 1)/\tau_i} \right]^{\tau_i/(\tau_i + 1)} \tag{A.15}$$

$$S_i^f / S_i^d = g_S\left(P_{Si}^f / P_{Si}^d ; \tau_i\right), \quad f = b, r \tag{A.16}$$

Composite Domestic Prices

$$P_{Di} \, D_i = \sum_{k \in \{d,b,r\}} P_{Di}^k \, D_i^k \tag{A.17}$$

$$P_{Si} \, S_i = \sum_{k \in \{d,b,r\}} P_{Si}^k \, S_i^k \tag{A.18}$$

Domestic Market Equilibrium

$$D_i = C_i + \sum_{j=1}^n V_{ij} \tag{A.19}$$

$$S_i^d = D_i^d \tag{A.20}$$

$$LS = \sum_{i=1}^n LD_i \tag{A.21}$$

$$\sum_{i=1}^n KS_i^d = \sum_{i=1}^n KD_i^d \tag{A.22}$$

Income and Government Revenue

$$Y = (1-t_L)\sum_{i=1}^{n} w\, LD_i + (1-t_K)\sum_{i=1}^{n} r_{Di}^{d}\, KD_i^{d} + Y_G + \sum_{f\in\{b,r\}}\sum_{i}\left(r_{Si}^{f}\, KS_i^{f} - r_{Di}^{f}\, KD_i^{f}\right) \tag{A.23}$$

$$Y_G = t_L \sum_{i} w\, LD_i + t_K \sum_{i} r_{Di}^{d}\, KD_i^{d} + \sum_{k\in\{d,b,r\}}\sum_{i}\left(t_{Di}^{k}\, P_{Di}^{k}\, D_i^{k} + t_{Si}^{k}\, P_{Si}^{k}\, S_i^{k}\right) \tag{A.24}$$

Balance of Payments

$$\sum_{f\in\{b,r\}} e^{f} B^{f} = \sum_{f\in\{b,r\}} e^{f} \sum_{i}\left(P_{Si}^{f}\, S_i^{f} - P_{Di}^{f}\, D_i^{f}\right) \tag{A.25}$$

Foreign Commodity Prices

$$P_{Di}^{f} = (1+t_{Di}^{f})e^{f}\, PW_{Di}^{f}, \quad f = b,r \tag{A.26}$$

$$P_{Si}^{f} = \left[1/(1+t_{Si}^{f})\right]e^{f}\, PW_{Si}^{f}, \quad f = b,r \tag{A.27}$$

Numéraire

$$\sum_{i} \omega_i P_{Di}^{d} = 1 \tag{A.28}$$

II. Bilateral Equations

Bilateral Trade Flow Equivalence

$$S_i^{b}\,(Indonesia) = D_i^{b}\,(Japan) \tag{A.29}$$

$$S_i^{b}\,(Japan) = D_i^{b}\,(Indonesia) \tag{A.30}$$

Bilateral DFI Stock Equivalence

$$KS_i^{b}\,(Indonesia) = KD_i^{b}\,(Japan) \tag{A.31}$$

$$KS_i^{b}\,(Japan) = KD_i^{b}\,(Indonesia) \tag{A.32}$$

Price Equivalence

$$PS_i^b\,(Indonesia) \;=\; PD_i^b\,(Japan) \qquad \text{(A.33)}$$

$$PS_i^b\,(Japan) \;=\; PD_i^b\,(Indonesia) \qquad \text{(A.34)}$$

$$r_{Si}^b\,(Indonesia) \;=\; r_{Di}^b\,(Japan) \qquad \text{(A.35)}$$

$$r_{Si}^b\,(Japan) \;=\; r_{Di}^b\,(Indonesia) \qquad \text{(A.36)}$$

III. Variable and Parameter Definitions

Price Variables

e^f	Bilateral (f=b) and ROW (f=r) exchange rates (domestic/foreign currency)
P_{Di}^d	Domestic purchaser prices of domestic goods
P_{Di}^f	Domestic purchaser price of imports from region f (f = bilateral partner, ROW)
P_{Si}^d	Domestic producer price in the domestic market
P_{Si}^f	Domestic producer price for exports to region f
P_{Di}	Purchaser price of composite domestic demand
P_{Si}	Producer price of domestic output
PW_{Di}^d	World price of imports from region f
PW_{Si}^d	World price of exports to region f
r_{Di}^d	Domestic rental rate paid on domestic capital
r_{Di}^f	Domestic rental rate paid on capital invested from region f
r_{Si}^d	Domestic rental rate earned on domestic capital
r_{Si}^f	Domestic rental rate earned on capital investe in region f
r_{Di}	Composite rental rate paid on domestic capital stock
r_{Si}	Composite rental rate earned on domestic capital assets
w	Average wage rate

Quantity Variables

C_i	Personal consumption
D_i^d	Domestic demand for domestic goods
D_i^f	Domestic demand for imports from region f
D_i	Composite goods for domestic consumption
E_h^k	Domestic emission levels by destination of supply (domestic market, bilateral country, ROW) for pollutant h
KD_i^d	Domestic demand for domestic capital

KD_i^f	Domestic demand for imported capital (inward direct foreign investment stock) from region *f*
KS_i^d	Domestic supply of domestic capital
KS_i^f	Outward direct foreign investment stock in region *f*
LD_i	Demand for labor
LS	Aggregate labor supply
KS_i^d	Domestic production for domestic use
KS_i^f	Domestic production for export to region *f*
S_i	Gross domestic output
V_{ij}	Demand for intermediate good *i* in sector *j*

Nominal Variables

B^f	Net foreign borrowing from region *f* (may be exogenous)
Y	Nominal domestic income
Y_G	Government income

Structural and Policy Parameters

a_{ij}	Intermediate use coefficients (Leontief technology)
$\varepsilon_{i,h}$	Sectoral effluent intensities of pollutant *h*
γ_i	Subsistence consumption of good *i*
η_i	Marginal budget share for consumption of good *i*
ϕ_i	Elasticity of substitution between labor and capital in domestic production
μ_i	Elasticity of substitution between domestic and imported capital
λ_i	Elasticity of transformation between domestic and exported capital
σ_i	Elasticity of substitution between domestic and imported products
τ_i	Elasticity of transformation between domestic and exported products
$\overline{A}_{KD_i}$	Calibrated intercept parameter for composite capital demand
$\overline{A}_{KS_i}$	Calibrated intercept parameter for composite capital supply
$\overline{A}_{D_i}$	Calibrated intercept parameter for composite product demand
$\overline{A}_{S_i}$	Calibrated intercept parameter for composite product supply
θ_i^k	Base share parameter of capital demand by origin in the composite demand
υ_i^k	Base share parameter of capital supply by destination in the composite demand
β_i^k	Base share parameter of product demand by origin in the composite demand
δ_i^k	Base share parameter of product supply by destination in the composite demand

t_{Di}^{d}	Indirect tax rate on domestic sector production
t_{Di}^{f}	*Ad valorem* tariff rate on imports from region *f*
t_K	Tax rate on capital income
t_L	Tax rate on labor income
t_{Si}^{d}	Producer tax or subsidy on domestic deliveries
t_{Si}^{f}	Tax or subsidy on exports to region *f*
ω_i	Domestic demand shares

Annex 2: Trends in Embodied Trade for Detailed Effluents

Table A.2.1: Trends in Embodied Effluent Trade: Suspended Particulates (SUSPPART)

	1965	1970	1975	1980	1985	1990	Ave
Indonesia							
Exports to							
Japan	10.36	11.26	14.03	10.74	7.82	8.14	10.39
Rest of World	6.37	6.14	12.67	10.31	8.50	6.21	8.37
Imports from							
Japan	2.21	2.27	2.28	1.98	3.01	2.20	2.33
Rest of World	2.34	2.80	2.87	4.32	4.00	3.25	3.26
Effluent Trade Ratio							
Japan	4.69	4.95	6.15	5.42	2.60	3.71	4.59
Rest of the World	2.72	2.19	4.42	2.38	2.13	1.91	2.63
Japan							
Exports to							
Indonesia	2.21	2.80	2.08	1.86	1.84	2.24	2.17
Rest of World	2.00	1.71	1.60	1.66	1.63	1.80	1.73
Imports from							
Indonesia	9.44	10.87	13.57	11.17	8.30	7.65	10.17
Rest of World	4.13	4.12	7.10	7.89	6.36	4.65	5.71
Effluent Trade Ratio							
Indonesia	.23	.26	.15	.17	.22	.29	.22
Rest of the World	.49	.42	.23	.21	.26	.39	.33

Table A.2.2: Trends in Embodied Effluent Trade: Sulphur Dioxide (SO2)

	1965	1970	1975	1980	1985	1990	Ave
Indonesia							
Exports to							
Japan	11.98	11.82	15.89	12.77	10.44	9.83	12.12
Rest of World	7.32	6.56	14.37	11.99	10.19	6.86	9.55
Imports from							
Japan	1.83	1.54	1.50	1.22	1.77	1.06	1.49
Rest of World	2.09	2.31	2.34	4.28	3.80	2.93	2.96
Effluent Trade Ratio							
Japan	6.56	7.70	10.59	10.46	5.90	9.27	8.41
Rest of the World	3.50	2.84	6.13	2.80	2.68	2.34	3.38
Japan							
Exports to							
Indonesia	1.87	2.43	1.51	1.24	1.19	1.03	1.54
Rest of World	1.56	1.26	1.10	1.04	.90	.95	1.14
Imports from							
Indonesia	10.85	11.20	15.26	13.06	10.95	9.31	11.77
Rest of World	4.31	4.11	7.81	8.93	7.30	4.81	6.21
Effluent Trade Ratio							
Indonesia	.17	.22	.10	.09	.11	.11	.13
Rest of the World	.36	.31	.14	.12	.12	.20	.21

Table A.2.3: Trends in Embodied Effluent Trade: Nitrogen Dioxide (NO2)

Indonesia	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*Ave*
Exports to							
Japan	3.56	3.94	4.80	4.31	3.83	3.70	4.02
Rest of World	2.32	2.30	4.37	3.97	3.62	3.09	3.28
Imports from							
Japan	2.29	1.72	1.65	1.32	2.01	1.07	1.68
Rest of World	2.61	2.21	2.15	2.44	2.32	1.92	2.28
Effluent Trade Ratio							
Japan	1.55	2.29	2.91	3.26	1.91	3.45	2.56
Rest of the World	.89	1.04	2.03	1.62	1.56	1.61	1.46
Japan							
Exports to							
Indonesia	2.58	2.58	1.66	1.29	1.22	1.09	1.74
Rest of World	2.16	1.62	1.25	1.14	.97	.96	1.35
Imports from							
Indonesia	3.29	3.82	4.65	4.34	3.96	3.61	3.95
Rest of World	2.67	2.29	3.16	3.38	2.99	2.43	2.82
Effluent Trade Ratio							
Indonesia	.78	.68	.36	.30	.31	.30	.45
Rest of the World	.81	.71	.39	.34	.32	.39	.49

Table A.2.4: Trends in Embodied Effluent Trade: Fine Particulates (FINEPART)

Indonesia	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*Ave*
Exports to							
Japan	.39	.42	.45	.45	.46	.65	.47
Rest of World	.42	.43	.44	.53	.56	1.10	.58
Imports from							
Japan	2.49	2.42	2.41	1.54	3.86	1.07	2.30
Rest of World	2.15	2.19	2.19	1.51	1.89	1.15	1.85
Effluent Trade Ratio							
Japan	.16	.17	.19	.30	.12	.61	.26
Rest of the World	.20	.20	.20	.35	.30	.95	.37
Japan							
Exports to							
Indonesia	2.74	2.78	2.03	1.52	1.36	1.06	1.91
Rest of World	2.90	2.03	1.62	1.70	1.55	1.42	1.87
Imports from							
Indonesia	.38	.42	.45	.45	.47	.74	.48
Rest of World	1.29	1.25	1.19	1.12	1.22	2.16	1.37
Effluent Trade Ratio							
Indonesia	7.19	6.69	4.56	3.35	2.90	1.43	4.35
Rest of the World	2.25	1.62	1.36	1.53	1.27	.66	1.45

Table A.2.5: Trends in Embodied Effluent Trade: LEAD

Indonesia	1965	1970	1975	1980	1985	1990	Ave
Exports to							
Japan	33.24	32.66	44.03	32.58	23.52	23.37	31.56
Rest of World	20.55	18.74	39.64	31.15	25.03	15.76	25.15
Imports from							
Japan	2.02	2.53	2.59	2.51	2.92	2.32	2.48
Rest of World	2.71	4.27	4.50	9.98	8.14	6.29	5.98
Effluent Trade Ratio							
Japan	16.47	12.91	16.98	12.99	8.06	10.09	12.92
Rest of the World	7.59	4.39	8.81	3.12	3.07	2.51	4.91
Japan							
Exports to							
Indonesia	1.72	2.89	2.56	2.37	2.47	2.29	2.38
Rest of World	1.98	2.02	2.28	1.97	1.79	1.86	1.99
Imports from							
Indonesia	30.33	30.71	42.15	33.84	25.02	21.51	30.59
Rest of World	10.82	10.34	20.54	22.90	17.88	10.64	15.52
Effluent Trade Ratio							
Indonesia	.06	.09	.06	.07	.10	.11	.08
Rest of the World	.18	.20	.11	.09	.10	.18	.14

Table A.2.6: Trends in Embodied Effluent Trade: Volatile Organic Compounds (VOC)

Indonesia	1965	1970	1975	1980	1985	1990	Ave
Exports to							
Japan	2.39	2.77	3.08	3.22	3.20	3.09	2.96
Rest of World	1.62	1.59	2.81	2.83	2.71	2.46	2.34
Imports from							
Japan	3.55	3.33	3.30	3.48	3.29	3.40	3.39
Rest of World	3.32	3.00	2.95	3.04	3.27	3.09	3.11
Effluent Trade Ratio							
Japan	.67	.83	.93	.93	.97	.91	.87
Rest of the World	.49	.53	.95	.93	.83	.80	.75
Japan							
Exports to							
Indonesia	3.42	3.46	3.64	3.45	3.32	3.47	3.46
Rest of World	2.83	3.11	3.26	3.43	3.49	3.47	3.27
Imports from							
Indonesia	2.10	2.76	3.02	3.18	3.26	3.07	2.90
Rest of World	1.68	1.80	2.16	2.45	2.35	2.27	2.12
Effluent Trade Ratio							
Indonesia	1.63	1.25	1.21	1.08	1.02	1.13	1.22
Rest of the World	1.68	1.73	1.51	1.40	1.49	1.53	1.56

Table A.2.7: Trends in Embodied Effluent Trade: Carbon Monoxide (CO)

	1965	1970	1975	1980	1985	1990	Ave
Indonesia							
Exports to							
Japan	.93	2.12	1.69	2.20	2.57	2.57	2.02
Rest of World	.99	1.79	1.51	1.91	2.06	2.24	1.75
Imports from							
Japan	1.49	1.73	1.76	1.57	1.69	1.15	1.56
Rest of World	1.42	1.55	1.57	1.74	1.84	1.64	1.63
Effluent Trade Ratio							
Japan	.62	1.23	.96	1.41	1.52	2.24	1.33
Rest of the World	.70	1.15	.96	1.10	1.12	1.37	1.07
Japan							
Exports to							
Indonesia	1.50	2.48	1.78	1.57	1.48	1.05	1.65
Rest of World	1.60	1.44	1.41	1.18	.89	.83	1.23
Imports from							
Indonesia	1.15	2.16	1.77	2.13	2.58	2.67	2.08
Rest of World	2.46	2.83	2.01	2.21	2.09	2.02	2.27
Effluent Trade Ratio							
Indonesia	1.31	1.15	1.01	.74	.57	.39	.86
Rest of the World	.65	.51	.70	.53	.43	.41	.54

Table A.2.8: Trends in Embodied Effluent Trade: Biochemical Oxygen Demand (BOD)

	1965	1970	1975	1980	1985	1990	Ave
Indonesia							
Exports to							
Japan	.66	.63	.71	.57	.58	.55	.62
Rest of World	.91	.94	.85	.80	.88	.68	.84
Imports from							
Japan	.20	.27	.28	.55	.19	.14	.27
Rest of World	.95	1.55	1.64	1.75	1.01	.75	1.28
Effluent Trade Ratio							
Japan	3.21	2.35	2.57	1.04	3.01	4.01	2.70
Rest of the World	.96	.60	.52	.45	.87	.91	.72
Japan							
Exports to							
Indonesia	.30	1.24	.25	.47	.21	.15	.44
Rest of World	.23	.32	.17	.19	.12	.12	.19
Imports from							
Indonesia	.72	.66	.72	.59	.61	.54	.64
Rest of World	2.15	1.58	1.66	1.28	1.22	1.07	1.49
Effluent Trade Ratio							
Indonesia	.42	1.87	.35	.79	.35	.27	.68
Rest of the World	.11	.20	.10	.15	.10	.11	.13

Table A.2.9: Trends in Embodied Effluent Trade: Suspended Solids (SS)

Indonesia	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*Ave*
Exports to							
Japan	.37	.54	.71	.62	1.09	.98	.72
Rest of World	.49	.76	.78	.93	1.12	.95	.84
Imports from							
Japan	1.85	1.63	1.60	1.63	1.43	.80	1.49
Rest of World	1.38	1.59	1.62	1.66	1.91	1.60	1.63
Effluent Trade Ratio							
Japan	.20	.33	.44	.38	.76	1.22	.56
Rest of the World	.36	.48	.48	.56	.59	.60	.51
Japan							
Exports to							
Indonesia	1.64	1.78	1.85	1.42	1.37	.93	1.50
Rest of World	1.32	1.28	1.19	1.19	.75	.66	1.06
Imports from							
Indonesia	.44	.57	.80	.63	1.16	1.03	.77
Rest of World	1.98	2.48	1.49	1.72	1.68	2.01	1.89
Effluent Trade Ratio							
Indonesia	3.74	3.12	2.32	2.26	1.18	.90	2.25
Rest of the World	.67	.52	.80	.69	.45	.33	.57

Table A.2.10: Trends in Embodied Effluent Trade: Bioaccumulative Metals

Indonesia	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*Ave*
Exports to							
Japan	1.35	1.73	1.95	1.61	1.79	1.91	1.72
Rest of World	1.59	2.29	1.81	1.74	1.71	1.62	1.79
Imports from							
Japan	3.91	4.51	4.58	4.82	4.95	4.40	4.53
Rest of World	3.27	3.61	3.66	3.67	4.09	4.04	3.72
Effluent Trade Ratio							
Japan	.34	.38	.42	.33	.36	.43	.38
Rest of the World	.49	.63	.49	.47	.42	.40	.48
Japan							
Exports to							
Indonesia	3.66	4.23	4.51	4.49	4.60	4.53	4.34
Rest of World	3.78	4.04	4.16	4.19	3.97	4.03	4.03
Imports from							
Indonesia	1.58	1.59	1.97	1.63	1.86	1.92	1.76
Rest of World	3.47	4.31	2.72	2.83	2.79	3.22	3.22
Effluent Trade Ratio							
Indonesia	2.31	2.66	2.29	2.76	2.48	2.36	2.48
Rest of the World	1.09	.94	1.53	1.48	1.42	1.25	1.29

Annex 3: Piecemeal Tariff Liberalization by Indonesia

Table A.3.1: Aggregate Results of Piecemeal Tariff Liberalization
(percentage changes)

Indonesia	*Exp A1*	*Exp A2*
Real GDP	0.14	0.90
Employment	0.14	2.19
Labor Income	0.17	2.34
Capital Income	0.58	2.83
EV Income	-0.38	0.94
Imports	-0.37	7.48
Exports	1.92	5.54
BOP		
Exch Rate	1.25	4.34

Experiment A1: Removal of Indonesian tariffs on Japanese goods.
Experiment A2: Removal of Indonesian tariffs on ROW goods.

Table A.3.2: Emission Levels by Destination of Supply
(percentage changes)

	Experiment A1				*Experiment A2*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	.71	1.89	2.64	1.41	1.29	4.64	7.05	3.33
SO2	.88	1.92	2.67	1.53	1.22	4.71	6.87	3.32
NO2	.28	1.87	2.35	.95	.30	4.58	6.92	2.28
FINP	-.50	1.74	1.43	-.34	-.66	4.36	5.24	-.24
LEAD	1.02	1.85	2.67	1.63	1.68	4.48	6.58	3.58
VOC	-.08	1.86	2.21	.34	.09	4.68	7.46	1.28
CO	.32	2.36	2.82	1.02	-.35	6.47	9.62	2.25
BOD	-.10	2.28	2.34	.29	-.58	6.07	9.44	.73
SS	.76	2.66	3.72	1.52	-.15	7.42	11.87	2.90
TOX	.06	1.98	2.40	.63	.20	5.03	9.94	2.10
METAL	.09	2.44	3.02	.65	.21	6.71	9.09	1.82
AHTL	.26	1.92	2.46	.91	.54	4.76	9.19	2.65

Table A.3.3: Emission Intensities by Destination of Supply
(percentage changes)

	Experiment A1				*Experiment A2*			
Indonesia	*Domestic*	*Japan*	*ROW*	*Total*	*Domestic*	*Japan*	*ROW*	*Total*
SUSP	.90	.08	.61	1.31	1.24	.13	.55	2.51
SO2	1.07	.11	.64	1.43	1.18	.20	.39	2.51
NO2	.47	.06	.32	.85	.25	.08	.43	1.48
FINP	-.31	-.07	-.57	-.44	-.71	-.14	-1.15	-1.02
LEAD	1.21	.04	.63	1.53	1.63	-.02	.11	2.77
VOC	.10	.05	.19	.24	.04	.17	.94	0.48
CO	.50	.54	.78	.93	-.39	1.88	2.97	1.45
BOD	.09	.46	.31	.19	-.63	1.50	2.80	-0.07
SS	.95	.83	1.67	1.42	-.20	2.79	5.08	2.09
TOX	.25	.17	.37	.53	.15	.50	3.27	1.3
METAL	.28	.62	.98	.55	.16	2.11	2.47	1.02
AHTL	.45	.10	.43	.81	.49	.25	2.57	1.84

In experiment A1, all nominal tariffs on Japanese imports are removed, while nominal tariffs on the rest of the world (ROW) imports only are removed in experiment A2. The results of these two simulations are mutually consistent with the general tariff liberalization (experiment 2) to the point of being nearly additive in many aspects, but each reveals important elements of the bilateral trade relationships. For example, unilateral liberalization with respect to Japan actually reduces average Indonesian purchasing power because increased exports to Japan rely on (still expensive) imported intermediates from ROW. Domestic competition for resources by the same export industries also drives up the prices of domestic consumption goods (Dutch Disease).

In terms of pollution, it is difficult to compare the percentage changes in emission levels (Table A.3.2) because of the different magnitudes of the trade relationships. In terms of intensities, however, it is interesting to note that liberalization with respect to Japan induces a significantly smaller rise in most effluent intensities for almost all components of Indonesian supply.

Annex 4: Sectoral Results for Tax and Trade Policies to Reduce Effluents

Table A.4.1: Sectoral Results for Tariffs to minimize AHTL/real GDP

(all figures in percentage changes)

	Supply				*Imports*		*Labor*	*Capital*
Experiment 3	*Total*	*Domestic*	*Japan*	*ROW*	*Japan*	*ROW*	*Demand*	*Demand*
1 AgForF	2.14	3.03	-6.98	-14.70		-55.48	-3.66	3.80
2 Petro	-11.52	-7.92	-12.73	-17.89		8.58	-17.59	-11.21
3 Mining	-13.11	-12.55	-15.36	-20.76	-25.84	24.97	-16.40	-9.93
4 FoodProc	0.96	1.18	-3.86	-6.26	-15.47	-33.55	-4.80	2.58
5 Textile	-7.12	-5.77		-14.13	-9.89	12.81	-11.39	-4.52
6 LumWood	-8.74	-0.80	-14.01	-21.15			-13.55	-6.85
7 PulpPapr	-29.77	-29.66		-31.84	-14.67	29.73	-33.50	-28.35
8 IndChem	-50.96	-39.42		-64.18	-4.62	-14.34	-52.10	-48.39
9 OthChem	-12.1	-11.35		-22.53	-18.81	22.45	-17.48	-11.09
10 Plastic	-4.55	-4.35		-12.13	-2.14	72.30	-10.10	-3.13
11 NonMtMnr	0.89	0.96		-3.74	-10.61	3.42	-4.30	3.11
12 Steel	-9.08	-8.95	-11.15	-13.32	-15.61	39.78	-15.25	-8.68
13 NonfMtl	-33.52	-32.75	-31.68	-37.45	-19.13	20.47	-36.76	-31.86
14 MetalPr	-12.21	-12.21			-18.19	40.25	-16.56	-10.09
15 MchPrcls	-14.5	-13.77		-33.03	-6.55	-20.72	-18.98	-12.70
16 ElecMch	2.54	4.38		-11.38	-7.01	-20.95	-2.82	4.71
17 TrnspEq	6.52	7.23		-16.56	-10.21	-26.05	1.50	9.37
18 OtherMfg	1.72	1.85	-2.77	-3.62	-11.34	-14.82	-2.71	4.83
19 Service	0.16	0.50	-5.04	-10.19	-22.87	-38.69	-3.79	3.66

Table A.4.2: Sectoral Results for Taxes to Reduce Effluents

(all figures in percentage changes)

	Supply				*Imports*		*Labor*	*Capital*
Experiment 4	*Total*	*Domestic*	*Japan*	*ROW*	*Japan*	*ROW*	*Demand*	*Demand*
1 AgForF	5.65	3.62	16.39	41.19		-19.02	-1.67	7.76
2 Petro	-14.37	-12.51	-13.90	-19.50		8.15	-21.53	-14.00
3 Mining	-7.03	-7.19	-6.03	-8.36	-1.16	-4.14	-11.34	-2.83
4 FoodProc	-1.04	-1.27	3.41	6.00	-4.57	-10.79	-7.92	.91
5 Textile	-5.18	-5.55		-3.47	-3.07	-10.82	-10.51	-1.93
6 LumWood	-6.18	-3.66	-6.57	-10.12			-12.21	-3.79
7 PulpPapr	-7.76	-7.64		-10.03	-.44	-1.61	-13.75	-5.47
8 IndChem	-28.76	-24.65		-32.22	-1.17	-3.41	-30.79	-24.15
9 OthChem	1.36	1.08		4.85	-2.23	-7.26	-6.21	2.79
10 Plastic	-4.11	-4.18		-1.60	-3.01	-10.42	-10.91	-2.36
11 NonMtMnr	-7.49	-7.40		-13.64	4.24	23.45	-13.30	-4.98
12 Steel	-1.10	-1.16	.32	.41	-1.41	-8.26	-9.27	-.57
13 NonfMtl	-22.39	-20.60	-21.54	-25.84	1.66	7.12	-27.02	-20.01
14 MetalPr	-2.23	-2.23			-1.39	-5.56	-8.15	.67
15 MchPrcls	-6.59	-6.63		-5.87	-2.50	-8.39	-12.58	-4.19
16 ElecMch	-.99	-1.46		2.17	-2.79	-8.83	-7.31	1.59
17 TrnspEq	-1.29	-1.46		3.74	-3.43	-9.61	-6.96	1.96
18 OtherMfg	-4.46	-4.53	-1.47	-1.94	-3.10	-11.17	-9.54	-.85
19 Service	-2.44	-2.77	2.87	6.42	-5.50	-10.16	-7.14	1.77

Table A.4.3: Sectoral Results for Tariff Liberalization with Effluent Taxes

(all figures in percentage changes)

	Supply				*Imports*			
Experiment 5	*Total*	*Domestic*	*Japan*	*ROW*	*Japan*	*ROW*	*Lab Dem*	*Cap Dem*
1 AgForF	7.74	4.16	25.67	67.76		-16.89	1.83	9.43
2 Petro	-15.33	-14.26	-14.15	-19.85		13.93	-20.95	-15.04
3 Mining	-6.34	-6.99	-3.15	-4.42	-1.05	-3.51	-9.77	-3.02
4 FoodProc	-1.13	-1.58	6.82	11.97	-0.31	-0.80	-6.57	0.40
5 Textile	-0.11	-1.97		8.01	4.61	17.71	-4.55	2.58
6 LumWood	-0.86	-3.06	1.24	2.10			-5.90	1.13
7 PulpPapr	-19.96	-20.35		-13.09	2.92	10.29	-24.07	-18.4
8 IndChem	4.52	-0.38		8.11	-0.42	-0.87	2.17	9.8
9 OthChem	2.70	1.87		12.44	-1.02	-3.28	-3.38	3.84
10 Plastic	-3.17	-3.45		5.94	3.06	11.03	-8.61	-1.79
11 NonMtMnr	-11.83	-11.75		-17.37	12.34	80.81	-16.22	-9.96
12 Steel	-3.72	-3.90	0.62	0.75	-1.10	-6.51	-10.03	-3.31
13 NonfMtl	-19.68	-20.97	-17.73	-21.38	1.28	5.52	-23.47	-17.75
14 MetalPr	-8.81	-8.81			1.67	6.66	-13.18	-6.69
15 MchPrcls	3.09	2.26		18.74	0.68	2.04	-2.13	5.18
16 ElecMch	0.42	-1.89		14.39	1.64	4.96	-4.65	2.47
17 TrnspEq	-2.35	-3.13		18.18	1.27	2.83	-6.79	0.17
18 OtherMfg	-3.93	-4.16	3.50	4.87	4.59	17.91	-7.96	-1.09
19 Service	-2.18	-2.86	7.02	15.75	-7.05	-12.86	-5.90	1.13

BIBLIOGRAPHICAL REFERENCES

Anderson, Kym and Richard Blackhurst, eds. (1992), *The Greening of World Trade Issues*, University of Michigan Press, Ann Arbor.

Barde, Jean-Phillippe (1993), "Economic Instruments in Environmental Policy: Lessons from OECD Experience and Relevance to Economies in Transition," paper presented at the Workshop on Managing the Environment with Rapid Industrialization: Lessons from the East Asian Experience, Hanoi.

Corbo, V. (1985), "Reforms and Macroeconomic Adjustments in Chile During 1974-1984," *World Development*, August, 893-916.

Cropper, Maureen L., and Wallace E. Oates (1992), "Environmental Economics: A Survey," *Journal of Economic Literature*, XXX, 675-740, June.

Grossman, G.M., and A.B. Krueger (1992), "Environmental Aspects of a North American Free Trade Agreement," Working Paper No. 644, CEPR, April.

Dean, J.M. (1992), "Trade and the Environment: A Survey of the Literature," in Low, P., ed., *International Trade and the Environment*, Discussion Paper No. 159, The World Bank, Washington, DC.

Institute of Developing Economies (1991), *International Input-Output Table: Indonesia-Japan, 1985*, Statistical Data Series No. 57, IDE, Tokyo.

Lee, Hiro, and David Roland-Holst (1993), "Cooperation or Confrontation in US-Japan Trade? Some General Equilibrium Estimates," Irvine Economics Paper No. 92-93-08, University of California, Irvine, March.

Low, P. (1992), **International Trade and the Environment**, Discussion Paper No. 159, The World Bank, Washington, DC.

Martin, Paul, David Wheeler, Mala Hettige, and Ralph Stengren (1991), "The Industrial Pollution Projection System: Concept, Initial Development, and Critical Assessment," Mimeo, The World Bank, Washington, DC.

O'Connor, David (1992), "Measuring the Costs of Environmental Damage: A Review of Methodological Approaches with an Application to Bangkok, Thailand," Mimeo, OECD Development Centre, Paris.

O'Connor, David (1993), "The Use of Economic Instruments in Environmental Management: The Experience of East Asia," in *Economic Instruments for Environmental Management in Developing Countries*, OECD, Paris.

Radetzki, M. (1992), "Economic Growth and the Environment," in P. Low (ed.), *International Trade and Development*, Discussion Paper No. 159, The World Bank, Washington, DC.

Roland-Holst, David (1992), *Stabilization and Structural Adjustment in Indonesia: An Intertemporal General Equilibrium Analysis,* Technical Paper No. 83, OECD Development Centre, Paris.

Roland-Holst, David, and Jaime de Melo (1993), "Trade Reform and Industry Structure: A General Equilibrium Analysis of Chile," Mimeo, OECD Development Centre, Paris.

ten Kate, Adriaan (1993), "Industrial Development and the Environment in Mexico," Working Paper 1125, Policy Research Department, The World Bank, Washington, DC.

US Department of Commerce, Bureau of Census (1988), *Manufacturer's Pollution Abatement Capital Expenditures and Operations Costs*, US Government Printing Office, Washington, DC.

Wheeler, David (1992), "The Economics of Industrial Pollution Control," Industry Series Paper No. 60, Industry and Energy Department, The World Bank, Washington, DC.

World Bank (1992), *Development and the Environment: World Bank Development Report, 1992*, The World Bank, Washington, DC.

NOTES

[1] See e.g. Grossman and Krueger (1992) and Radetzki (1992).

[2] See, e.g. Wheeler (1992).

[3] Such detailed emission rates are at the moment only available for US manufacturing sectors, obliging us to apply them to both Japan and Indonesia.

[4] In the light of differing environmental standards in the two countries, the disparity is likely to be greater than the indexes would indicate. Japan's effluent controls are more stringent than those of the US, and thus the compositional index for the former is likely to overstate Japanese effluent levels. Likewise, Indonesia's environmental controls are weaker than the reference country, so its actual effluent levels are probably underestimated by E.

[5] As explained in Section 2, the World Bank pollution database actually details a variety of individual pollutants. For each of these, tables measuring historical trends comparable to Table 2.1 are given in Annex II below.

[6] For a general appraisal of this issue, see Cropper and Oates (1992).

[7] Lee and Roland-Holst (1993) treat Japan as a large country so as to affect prices in the ROW market. For the moderate trade flow adjustments for Japan described in this study, however, the small country assumption makes almost no change in the results of simulation experiments.

[8] See IDE (1991).

[9] Total exports as percentages of GDP are 23.0 for Indonesia and 14.9 for Japan.

[10] See Martin et all (1991) and Wheeler (1992).

[11] Of the remaining eleven sectors, other chemicals and plastics are relatively more pollution intensive than the other sectors.

[12] Compare to, e.g. ten Kate (1993).

[13] For a broader discussion of economic instruments for environmental regulation, see O'Connor (1992,1993) and Barde (1993).

[14] Indonesia followed such an adjustment process in the period after its first major oil shocks in the early 1980's. See Roland-Holst (1992) for more details.

[15] This is smaller than the deficits experienced at the height of the oil crisis in the early 1980s. See Roland-Holst (1992).

[16] The most dramatic recent example is probably Chile in the mid-1980s, which was forced to undertake very dramatic structural adjustment in part to overcome the effects of prolonged overvaluation. See de Melo and Roland-Holst (1993) or Corbo (1985) for a summary of this experience.

[17] This optimization is a feature of the GAMS software with which the Indonesia-Japan model is implemented. For other applications see Lee and Roland-Holst (1993).

[18] For a survey of this kind of environmental valuation, see O'Connor (1992).