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Abstract

Traded commodities embody an environmental service, namely the amount of pollution emitted domestically when goods are produced for export. Japan's extensive economic ties with its Asian Pacific trading partners necessitate special consideration of trade and environment linkages. The data presented in this paper indicate that bilateral trade with Japan has resulted in substantial net transfers of effluent loads during the period 1981-95. To remedy environmental inequality of this kind, we recommend the promotion of technology transfer from Japan to developing countries through foreign direct investment and development assistance. In a related context, results in the Appendix show how coordinating multilateral trade liberalization with cost-effective environmental policy can achieve the twin objectives of higher national income and environmental quality improvement.

Keywords: Pollution transfers, trade and environment, emissions embodied in trade (EET), net embodied effluent content of traded goods (NEET), Japan

JEL Classification Codes: F13, F18, F21

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I. Introduction

Greater environmental awareness has altered our perceptions of economic activity in general and international trade in particular. Trade relations are now routinely scrutinized for their environmental implications, particularly when trading partners are at different levels of development. Most commonly, these considerations have arisen in the contexts of standards for multilateral trade agreements and secondary criteria for foreign direct investment and international lending. A vast analytical and empirical literature has arisen around these issues, and they have emerged as an important component of global policy dialogue (e.g., Anderson, 1992, 1996; Bhagwati and Srinivasan, 1996; Low, 1992).

This paper elucidates another environmental dimension of trade, one that is by no means new but upon which we cast new light. By looking at an old environmental problem in a new way, we hope to stimulate more constructive policy solutions. In particular, we propose a new collaborative basis for foreign direct investment (FDI) and official development assistance (ODA) that can confer greater benefits on both the origin and destination countries.

When exporters ship their goods abroad, they also ship an embodied environmental service, namely retention of the pollution caused by manufacturing their products. Conversely, an importing country can defer domestic pollution to the exporter. Thus a dual perspective on trade flows emerges: every traded good corresponds to an embodied pollution service. As in the case of embodied factor services, this dualism opens up a large area for theoretical work on implicit and explicit environmental markets, resource, effluent, and environmental damage cost convergence, but this is not the focus of the present paper.

Using detailed trade statistics, we use this new perspective to examine the environmental implications of Japan's bilateral trade. Not surprisingly, significant asymmetries emerge in the pollution content of this country's imports and exports, particularly with respect to large natural resource/energy exporters. While this does not appear to be the result of any deliberate policy, Japanese consumption is much more pollution-intensive than its production, the main reason being imbalances in the effluent content of its imports and exports. Ultimately, then, Japanese consumers are contributing much more to global pollution than their environmental conditions at home would indicate.

While Japanese consumption (particularly intermediate use) patterns bear significant responsibility for these imbalances, so does the advanced state of the economy and its industry, and herein lies a means to redress bilateral pollution imbalances. Japan's developing-country trading partners generally have more pollution-intensive exports and domestic production for two reasons. Firstly, their economies are at an earlier stage of development, and primary and industrial activities represent a larger share of GDP than in OECD countries. Secondly, their technology is likely to be more pollution-intensive, and external markets are simply leveraging these environmentally inferior techniques to the detriment of everyone.

The more advanced countries generally, like Japan in the present discussion, can make an important contribution to global pollution levels and pollution inequality. They can do this by promoting economic development generally and technology transfer in particular. The former will inexorably shift the composition of GDP towards tertiary activities, while the latter will achieve flatter pollution trajectories for industrial expansion. More importantly, the role advanced countries play in this process can be beneficial to themselves as well as to the emerging economies. Countries like Japan can promote technology transfer in both FDI and ODA policy, securing new markets for greener technologies while facilitating overseas development and new investment opportunities.[1] In this way, redressing bilateral pollution imbalances becomes a collaborative, win-win basis for development and international lending/investment policy.

In Section II, we provide an overview of historical bilateral trade patterns for Japan. This information is then combined with pollution data to elucidate the underlying trade in pollution services. With this empirical information, Section III then discusses how Japan can more effectively coordinate its development assistance and foreign investment policies to achieve the dual objectives of economic expansion and environmental mitigation. Section IV is devoted to conclusions and discussion of extensions to this methodology. The Appendix provides general equilibrium results of the effects of multilateral trade liberalization and cost-effective environmental policy on welfare and environmental quality.

II. International Trade in Pollution Services

In the context of international trade, linkages between economic activity and the environment become more complex. This is especially the case when trade in goods and embodied pollution services are seen as dual to each other. Conventional notions of national welfare can be overturned, for example. A trade surplus might correspond to domestic pollution retention on behalf of millions of foreign consumers, while a deficit

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[1] Under a somewhat different context, Hayami (2000) proposes that developed countries should provide financial assistance to developing countries which implement anti-pollution policies. Having both found that developing countries' participation in achieving a given CO_2 abatement target would lead to global efficiency gains and substantial reductions in abatement costs for the industrialized countries, the OECD (1995) and Coppel and Lee (1996) also recommend transfer payments to developing countries to encourage participation.

might arise from imports of environmentally risky goods produced elsewhere.[2] Thus simple mercantilist notions of export promotion seem environmentally retrograde while excessive import dependence might be promoted by green interests. Of course these ideas are still subject to the usual fallacies, both in terms of inconsistent behavioral aggregation and negative environmental externalities.

Although many economic activities occasion some negative environmental consequences through the uses of exhaustible resources and/or emissions of pollution, the net effect of trade on the domestic environment depends upon the composition of trade and the pollution intensity of the goods under consideration. Thus a country can have a trade surplus or deficit and, depending upon the composition of imports and exports, a surplus or deficit in services arising from domestically retained pollution or other environmental degradation. In this context, a winning country would be one that sustains a trade surplus and a pollution service deficit, accumulating net income from abroad while deferring more pollution to its trading partners that it retains at home. As we shall see in this section, Japan is just such a country.

To better understand the situation of Japan in this context, it is useful to review detailed patterns of its bilateral trade. Table 1 summarizes Japan's trade flows, by sector and trading partner, over the period 1981-1995. Trade is disaggregated among seven sectors and eleven individual and aggregated trading partners. All figures are expressed in constant, 1990 U.S. dollars. The patterns that emerge here are well known to empirical trade economists and regional experts, and do not require much elaboration. Suffice to emphasize that, during this period, Japan was a very successful export-oriented economy. Japan and most of the partners considered here are relatively diversified, and patterns of

[2] Examples of the former are mining, forestry, and other primary products. The latter would include, for example, Swiss imports of French nuclear energy.

comparative advantage are evident in persistent sectoral deficits with respect to some partners. Despite this, however, Japan sustained growing surpluses in high value-added products, and the result has been consistent aggregate surpluses and prodigious long-term wealth accumulation.

< Insert Table 1 here >

To examine the environmental implications of this trade pattern, we estimate the pollution attendant upon production of the imports and exports represented in Table 1. More specifically, coefficients for effluent production per unit of output were obtained from the Industrial Pollution Projection System (IPPS) database developed and maintained by the World Bank.[3] These were in turn applied to the import and export data to determine induced pollution in the country of origin.

Let $\varepsilon_{r,i,h}$, $X_{r,i}$, and $M_{r,s,i}$ denote country *r*'s sectoral effluent intensities of pollutant *h*, its exports of commodity *i*, and its imports of commodity *i* from country *s*, respectively. Then the net embodied effluent content of traded commodities (NEET) in country *r* is given by

$$NEET_{r,i,h} = \varepsilon_{r,i,h} X_{r,i} - \sum_s \varepsilon_{s,i,h} M_{r,s,i}$$

Because of the data constraint, we relied exclusively on pollution coefficients for the United States, thereby assuming that Japan and all its trading partners were using the same production technologies, i.e.,

$$\varepsilon_{r,i,h} = \varepsilon_{US,i,h} \quad \forall r$$

The pollution coefficients in question are given in Table 2.

< Insert Table 2 here >

[3] See Hettige et al. (1994).

While this approach simplified the present estimations, the likely result is that environmental asymmetries have been underestimated. This is to be expected because many Japanese technologies are significantly less pollution-intensive than those of its developing-country trading partners. While such an approach cannot yield the most precise quantitative results, the qualitative support for our conclusions would in most cases be even stronger if country-specific pollution coefficients were used.

Given the history of Japan's bilateral trade and the conservative parameter estimates we have obtained, what are the induced patterns of trade in embodied effluents or pollution services? These are summarized in Table 3, confining discussion to the latter time interval (1991-95) since the earlier periods indicate a monotone process of trade expansion with relatively stable composition since 1981. The sectors and trading partners are the same, and all figures are expressed as average annual emissions, in tons of each of seven pollutants.

< Insert Table 3 here >

The patterns of embodied effluent trade, depending as they do on the composition of trade and the pollution-intensity of individual activities, are quite complex and not amenable to easy generalization. For example, all four combinations of surplus and deficit for the two types of trade are in evidence. Japan has a trade surplus with the United States and industrial Europe, but a pollution deficit. This is the win-win scenario alluded to above, environmental mercantilism, where a country accumulates net foreign assets while its trading partners accumulate net environmental degradation.

With respect to Canada, Australia, and New Zealand, a different pattern emerges. Japan has a deficit in commodity trade with this group for the period 1991-95. At the same time, however, they also have a deficit in pollution services. The reason for this is that, despite significant exports of manufactured goods, imports of natural resources from these three countries are much more pollution-intensive.[4] Thus these trading partners, at the national level at least, are renting their environmental assets in exchange for Japanese savings inflows.

With respect to China, Japan evinces a trade surplus in both goods and pollution services. This is largely because of China's current heavy dependence on heavy industry and capital-goods imports. Unlike other Asian trading partners, China provides relatively little to Japan in the way of pollution-intensive natural resources. Recently, Japan has increased imports of Chinese light industrial products, but these are relatively low pollution activities. In this way, Japan is renting its environmental assets while it is accumulating direct investment stocks in China. This result, however, is one that might well be contradicted in two ways. Firstly, the use of U.S. coefficients for China probably underestimated the pollution-intensity of its exports and this could reverse the balances in Table 3. Secondly, it is reasonable to expect that Chinese exports to Japan will shift to more heavy industry over time, and thus greater pollution-intensity, again reversing the bilateral balance of trade in embodied effluents.

The situation for Korea, Taiwan, and Singapore appears analogous to China at first sight, but different forces are at work here. All three of these countries are quite advanced, and their exports to Japan are less pollution-intensive than natural resources emanating from developing countries. Thus these three appear to be enjoying a net transfer of pollution to Japan, at the expense of individual trade deficits. The former estimate, however, could be reversed if export industries in any of the three were sufficiently dirtier than their counterparts in the United States.

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[4] Natural resources consist of non-energy resources, such as metal ores, gravel and quarry, and mineral mining.

Indonesia and Other ASEAN economies (Malaysia, Thailand, and the Philippines) represent an especially important group.[5] From the perspective of commodity trade, the two trading partners differ, i.e., Indonesia enjoys a trade surplus with Japan while Other ASEAN has a bilateral deficit. On the other hand, both countries are creating vastly more pollution at home on behalf of Japanese consumers than arises in Japanese production for exports to these countries. The reason for this is not difficult to ascertain – despite significant demand for Japanese manufactures in both regions, exports by them of natural resources are much more pollution-intensive. We shall have more to say about these important trading partners in the next section.

The last two trading partners represented are the Middle East and a Rest-of-World composite residual group. The former consists, from a Japanese trade perspective, mainly of energy exporters and this leads to predictable outcomes in both contexts. Japan is exceptionally import dependent in energy, and this leads to big trade deficits but also to a lot of deferred domestic pollution problems. The Rest-of-World group consists mainly of primary-dependent developing countries, and its balances behave accordingly – commodity surplus and pollution service deficit for Japan.

Perhaps most telling among the estimates presented are the world totals. Here we see the win-win strategy of environmental mercantilism in high relief. Japan's legendary trade surplus is clearly in evidence, yielding equally legendary net capital outflows to the rest of the world. The corresponding deficit in pollution service trade is not so well known, but it is an inevitable consequence of the existing patterns of specialization. The figures at the bottom of Table 3 are particularly arresting in their absolute magnitudes. According to these estimates, Japanese consumption annually induces net emissions of several hundred

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[5] Because of many missing values in their commodity trade data, Brunei, Laos, Myanmar, and Vietnam are not included in Other ASEAN.

thousand tons of toxic pollutants in other countries. In light of these results, it is reasonable to ask if there are incentive-compatible policies that could mitigate these effects.

III. A Collaborative Agenda for Japanese Foreign Direct Investment

How does today's global trade regime deal with environmental inequality of the type observed above? It is most obviously dealt by market forces, but these are as imperfect as many domestic markets for environmental amenities and commons. It is sufficiently difficult to achieve market valuation of these goods and services even in the most advanced economies, so there is little hope in the near future for implicit international market coordination that might equalize domestic resource costs.[6]

Another approach has been more interventionist, the stipulation of explicit environmental standards or conditionality in trade agreements.[7] While this approach gives clear voice to environmental interests, it is not congruent with conventional understanding of market forces and is likely to lead to greater inefficiency and unforeseen welfare costs.[8] Indeed, most environmental side agreements have exerted their primary market influence via induced rent-seeking and other distortionary effects. We are concerned that this ad hoc approach to the environmental incidence of economic activity ignores several essential

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[6] If domestic markets for environmental resources were more complete, one might envisage links between trade in goods and domestic relative prices of their embodied resources, as with embodied labor in Stolper-Samuelson theory.

[7] Esty (1994) provides a detailed assessment of trade and environment disputes.

[8] Anderson (1992) shows that even if a country has comparative advantage in the production of pollution-intensive goods, free trade would still raise welfare unambiguously, so long as an optimal pollution tax is introduced. Devising such a tax may not be a simple matter, however, but Beghin, Roland-Holst, and van der Mensbrugghe (1997) show how simpler, piecemeal measures can achieve most of the desired benefits.

realities. One of these is economic hierarchy, which is essentially the sequence of individual economies in a historical continuum of economic development.

The situation portrayed in the previous section for Indonesia, Other ASEAN economies, and probably China (given more accurate data) represents a dilemma familiar to most developing countries. When embarking on the road to modernization, one must often barter resources, and even environmental amenities, in exchange for the imported implements of industrialization and modern consumerism. To ignore these facts in multilateral policy dialogue is not only paternalistic, but it threatens to impose debilitating distortions on already struggling economies.

While such a growth-environment tradeoff might seem an inevitable result of international economic hierarchy, the extent of environmental damage it occasions is by no means inevitable. Although most developing countries want to experience industrialization, there is no need to experience the same environmental damage that occurred in the last two centuries of Western industrialization. Better technologies can reduce the rate of environmental degradation along any given growth path, and new patterns of industrialization (i.e. information technology) may be greener than their precursors.

Better technologies are also marketable exports for the more advanced countries, and herein lies the potential for a market-based, incentive compatible reconciliation of growth and environmental objectives. Ultimately, it is the responsibility of the developing countries to adopt cleaner technology, but this will contribute to increased efficiency and greater environmental sustainability. Thus it should not be difficult to make a case for trade and investment in these more advanced techniques and, given the kind of environmental inequities observed above, it is reasonable to expect countries like Japan to take the lead in this regard.

We suggest two ways for pollution debtors, like Japan, to facilitate global environmental mitigation. The first is simple export promotion, with special emphasis on innovative sectors that are leaders in producing clean technology. The second is more indirect, but probably more important in the long run. In dollar terms, Japan is now the world's largest player in ODA and one of the leaders in FDI. Both activities have an important influence on recipient-country technology adoption, and the Japanese government can advance its more innovative sectors by promoting technology transfer in both contexts. In the long run, this will not only enhance the Japan's stature as a trading partner, but promote innovation and exports.[9]

IV. Conclusions and Extensions

When seen from the perspective of trade in embodied pollution services, a new relationship emerges between market forces and global environmental conditions. Depending upon their domestic technologies and patterns of import and export concentration, countries can be net importers or exporters of pollution services. Examination of detailed trade data, with reference to the pollution intensity of production for the tradables, reveals an elaborate and quite asymmetric system of induced pollution transfers.

In this paper, we have examined the effluent content of Japan's bilateral trade and find it to be a significant debtor country in terms of global pollution. Our estimates

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[9] Formally, this can be modeled by treating emissions per unit of output endogenously; e.g.,

$$\varepsilon_{r,i,h} = f(XK_{J,r,i}, FDI_{J,r,i}, ODA_{J,r,i}), \quad \frac{\partial f(\cdot)}{\partial XK_{J,r,i}} < 0, \frac{\partial f(\cdot)}{\partial FDI_{J,r,i}} < 0, \frac{\partial f(\cdot)}{\partial ODA_{J,r,i}} < 0$$

where $XK_{J,r,i}$, $FDI_{J,r,i}$, and $ODA_{J,r,i}$ are Japan's capital-goods exports, foreign direct investment, and official development assistance, respectively, to sector *i* of its developing-country trading partner *r*.

indicate that, despite its perennial trade surplus, Japanese consumers confer net transfers of thousands of tons of toxic pollutants onto the country's trading partners. This is especially the case for developing and developed natural resource exporters, including countries as different as Indonesia and the United States. Japan has made significant progress with domestic environmental improvement over the last few decades, but our estimates indicate that its net consumption habits are still imposing heavy environmental burdens elsewhere in the world.

Thus Japan and other environmental debtor nations have a special responsibility to foster pollution mitigation internationally, and there may be no better way to do this than to promote technology transfer within the framework of their (extensive) FDI and ODA programs. Such an approach, much less ad hoc than negotiated environmental standards, would improve economic welfare in both recipient and donor countries, while setting a progressive example for collaborative reconciliation of growth and environmental objectives.

There are four main directions in which we would like to see this work extended. First, we believe this a very rich area for theoretical research. The environmental content of trade has only begun to be understood, and many of the tools used to understand other implicit trade (e.g. factor content) remain to be applied and could be quite enlightening. Beyond this, the subtle interplay of commodity, resource, and "environmental" markets at both the domestic and international level is only just now being examined seriously and is very inviting. Problems of incomplete markets are difficult enough in the domestic context, but their implications for multilateral trade and comparative advantage are far more complex. Finally, more rigorous comparative domestic environmental analysis may ultimately yield the tools needed for a better understanding of global commons.

A second important area for more work is on environmental data. To more clearly delineate patterns of global environmental inequality and to ultimately measure the opportunity cost of more homogeneous technologies, country-specific emissions data are essential. Fortunately, the Economics of Industrial Pollution Control Project at the World Bank, which produced the emission data used in this paper, has also obtained estimates for a few other countries, and this database is growing gradually. It would be useful for any country to more clearly understand the environmental dimension of its bilateral trade relations.

Third, it would be useful to move our empirical approach beyond static share tabulations to a more sophisticated simulation framework. Such an approach, typified by calibrated general equilibrium (CGE) models, would enable us to appraise the costs and benefits of alternative policy responses to the issues raised here. Preliminary results from a ten-country CGE model are reported in the Appendix, but we have not yet incorporated several important features into the model.

Finally, an idea of the type put forth here will ultimately be of limited interest unless it is incorporated into the domestic and international policy agenda. By fostering a new way of looking at the environmental incidence of trade, we hope to stimulate policy dialogue. By advocating linkage between FDI, ODA, and technology transfer, we hope to facilitate a collaborative approach to reconciling two modern aspirations, economic growth and a better environment.

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Appendix: General Equilibrium Estimates of the Impact of Trade and Tax Policies on Welfare and the Environment in the Pacific Basin

A ten-country calibrated general equilibrium (CGE) model for the Pacific Basin economies is used to simulate the effects of trade liberalization and effluent taxes on welfare and the environment.[10] It details ten production sectors in each country and completely endogenous trade flows between them. We are particularly interested in the impact of a shift in trade and/or tax regime on the composition of output and the resulting change in emissions of each pollutant.

Ad valorem tax rates on production (or supply), t_{S_i}, are the sum of ad valorem indirect taxes, t_{X_i}, and ad valorem effluent taxes:

$$t_{S_i} = t_{X_i} + \sum_h \tau_{i,h} \varepsilon_{i,h} ,$$

where $\tau_{i,h}$ are excise taxes on emissions (\$/ton of pollutant *h*). Sectoral emission levels by pollutant and destination of supply are computed as

$$EMI_{i,h}^k = \varepsilon_{i,h} P_{S_i}^k S_i^k ,$$

where $P_{S_i}^k$ and S_i^k are producer prices and supplies of output by destination (*k* consists of the domestic market, nine Pacific Basin trading partners, and the rest of the world).

The model is first used to assess the linkage between trade and the environment by removing tariffs of ten Pacific Basin (PAC-10) economies on imports from all sources (experiment 1). Table A.1 summarizes the main results. Multilateral tariff liberalization

[10] See Lee and Roland-Holst (1995, 1997b) for a complete set of equations describing the model. Since we used the Institute of Developing Economies' ten-country input-output table (IDE, 1992) as the principal data source, the present model does not include Canada, Australia and New Zealand, EU-12, or the Middle East. It should be also noted that Hong Kong is excluded from China as its input-output table is not provided in IDE (1992). Furthermore, foreign direct investment and technology transfer are not explicitly modeled here.

would bring about welfare gains in all PAC-10 countries, measured by Hicksian equivalent variations (EV). China, Singapore, Malaysia, and Thailand experience welfare gains of more than one percent while Japan, the United States, Korea, Taiwan, and Indonesia experience relatively small gains.[11]

< Insert Table A.1 here >

The effects of tariff liberalization on emission levels depend upon the extent of shifts in the composition of PAC-10's sectoral trade and output resulting from changes in relative prices (a composition effect), as well as the extent of increase in aggregate output (a scale effect).[12] Large variations in these two effects across countries lead to large differences in the resulting changes in emission levels. Overall, increases in emissions are relatively large on most of the pollutants in Singapore and Malaysia largely because of the substantial expansion of output in at least one pollution-intensive industry. Specifically, the energy and mineral sector (mostly refined petroleum) in Singapore and metal and chemical and paper sectors in Malaysia expand their production significantly. Across pollutants, the increase in emissions of total suspended solids (TSS) are relatively large in Malaysia (13.5%), the Philippines (10.7%), and Thailand (5.1%), which is strongly associated with a sharp increase in output of the metal sector.

In Japan emissions of the two water pollutants (BOD: biochemical oxygen demand and TSS) increase slightly, whereas emissions of five air pollutants (particulates, SO_2, NO_2, CO, and VOC: volatile organic compounds) all decrease. Emissions of every

[11] While the United States incurs a small loss in real GDP (0.06 percent), it is more than offset by an improvement in its terms of trade, resulting in a 0.1 percent gain in welfare.

[12] Another important factor is a "technical" effect in abatement; i.e., a reduction of pollution achieved by changing the input and factor mix to produce the same good (Copeland and Taylor, 1994), which will be incorporated in a later version. A limitation of the present model 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.

pollutant decline in the United States because the expanding sectors (i.e., agriculture, food products, transport equipment, and services) are all relatively clean while some of the declining sectors (i.e., chemicals and paper, metal) are relatively dirty. In China emissions of all seven pollutants increase modestly.

Table A.2 summarizes absolute changes in the effluent content of Japanese exports and imports resulting from experiment 1 (i.e., multilateral tariff liberalization). The results indicate a pattern in which the effluent content of Japanese exports is significantly lower than that of its imports in trade with China and ASEAN countries. In spite of using the same emission intensity for each pollutant in all countries, the size of net embodied effluent trade is quite large in Japan's trade with Indonesia, Malaysia, China, and Singapore.[13] By contrast, Japanese exports embody more effluent loads than its imports from Korea and Taiwan in all pollution categories. For all pollutants except TSS, the amount of pollution emitted from goods produced in Japan that are exported is less than that emitted from goods produced in the trade partners' territory that are exported to Japan (the last column of Table A.2).

< Insert Table A.2 here >

For a number of East Asian countries the effects of trade liberalization on emission levels lead to the policy challenge of addressing the environmental consequences of trade-based economic growth. In the second experiment, a uniform effluent tax is levied in each country with the exception of the United States to mitigate a particular pollutant to achieve a given abatement target. We employ a uniform effluent tax because it is more cost-

[13] Since the U.S. effluent coefficients are applied to all countries, differing levels of technology and environmental regulations between Japan and its trading partners do not affect our results. If country-specific data were available, the results would have yielded even larger asymmetries. There are significant technological disparities across countries in a variety of industrial activities, and environmental regulations in Japan and the United States are more stringent than in other economies.

effective than other forms of taxes (Lee and Roland-Holst, 1997a,b).[14] Under this scheme each sector would abate emissions until the marginal abatement cost is equal to the uniform tax rate. In each country, we selected the pollutant that showed the largest percentage increase in emissions induced by tariff liberalization. In addition, the abatement target is chosen to just offset the magnitude of increase in emissions. Accordingly, the targets are set as follows: 1%, 4%, 6%, 11%, and 14% reductions in TSS emissions for Japan, Korea, Thailand, the Philippines, and Malaysia, respectively; 2%, 4%, and 10% reductions in NO_2 for China, Indonesia, and Singapore, respectively; and 1% reduction in VOC for Taiwan.

The results of achieving the curtailment targets by uniform effluent taxes are presented in Table A.3. Emissions for the selected pollutant are reduced by the chosen target in each country. Since abatement of one emission necessitates output reductions in several dirty industries, emissions of other pollutants also tend to decrease.[15] Real GDP and the welfare level generally decline, but there are some exceptions.[16] First, while Singapore incurs a 0.6 percent loss in real GDP, its terms of trade improves sufficiently to result in a 0.6 percent gain in welfare. Second, Malaysia's real GDP increases slightly despite the imposition of effluent tax because a large output contraction in the metal sector is more than offset by output expansion in other manufacturing sectors.

< Insert Table A.3 here >

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[14] A system of tradable emission permits is an alternative cost-effective instrument to a uniform tax, but may be more difficult to implement in developing countries.

[15] The only exception is BOD in Malaysia.

[16] The present model does not incorporate the benefits of reduced pollution in the utility function or EV calculation, but their inclusion should increase the social welfare level for a small effluent tax.

In the final experiment, the same uniform tax scheme implemented in the second experiment is combined with multilateral tariff liberalization. This experiment is conducted to illustrate a critical point that the combination of trade liberalization and a cost-effective emission abatement instrument can lead to both an improvement in welfare and a reduction in pollution. The results are presented in Table A.4.

< Insert Table A.4 here >

The combination of tax and trade policies leads to a welfare gain in every country. In Malaysia, Korea, and Taiwan, however, setting abatement target for one pollutant was not adequate to reduce some other pollutants sufficiently to offset pollution generated by trade liberalization. For other countries, the benefits of tariff removal are greater than the cost of cutting pollution by the magnitude which more than counterbalances pollution brought about by tariff removals.

Table 1 Japanese Bilateral Trade Flows by Sector and Trading Partner
(Annual Averages, Billions of 1990 U.S. Dollars)

	Japanese Exports			*Japanese Imports*			*Net Trade*		
Trading Partner	1981-85	1986-90	1991-95	1981-85	1986-90	1991-95	1981-85	1986-90	1991-95
United States									
Agriculture and Food	364	386	321	5,646	8,832	12,645	-5,282	-8,445	-12,324
Primary Products	71	118	168	4,345	6,644	7,009	-4,274	-6,525	-6,842
Energy	45	101	173	1,746	1,933	1,656	-1,701	-1,832	-1,483
Chemicals and Paper	1,374	2,501	4,108	3,855	5,693	6,736	-2,481	-3,192	-2,628
Primary Metals and Mineral	4,948	4,008	3,173	909	1,677	2,112	4,039	2,331	1,062
Machinery and Transport Eq	44,051	72,893	77,012	5,978	11,287	20,238	38,072	61,607	56,775
Light Industry	7,035	10,613	12,421	3,047	6,200	9,024	3,988	4,414	3,398
Total	57,887	90,621	97,376	25,525	42,264	59,420	32,362	48,357	37,956
Canada, Australia and NZ									
Agriculture and Food	96	94	82	2,604	3,643	4,883	-2,508	-3,549	-4,800
Primary Products	100	73	50	4,230	6,480	7,185	-4,130	-6,407	-7,136
Energy	5	9	10	2,682	4,863	6,794	-2,676	-4,854	-6,784
Chemicals and Paper	464	580	649	784	1,340	1,513	-320	-761	-864
Primary Metals and Mineral	961	796	649	936	1,793	1,876	25	-997	-1,226
Machinery and Transport Eq	8,156	10,810	10,943	137	328	734	8,019	10,482	10,209
Light Industry	1,494	1,745	1,716	233	1,302	1,478	1,260	443	238
Total	11,276	14,106	14,101	11,606	19,748	24,464	-331	-5,642	-10,363
EU-12									
Agriculture and Food	170	181	125	1,101	2,519	3,767	-932	-2,338	-3,642
Primary Products	137	197	241	324	689	856	-186	-492	-615
Energy	56	35	61	39	200	113	17	-165	-53
Chemicals and Paper	980	2,316	3,894	1,962	4,291	6,098	-982	-1,975	-2,204
Primary Metals and Mineral	596	781	981	733	1,789	2,237	-138	-1,009	-1,256
Machinery and Transport Eq	17,062	33,824	41,582	2,302	7,077	11,820	14,761	26,747	29,762
Light Industry	4,192	7,286	8,790	3,326	7,811	8,981	866	-525	-191
Total	23,192	44,620	55,674	9,787	24,376	33,873	13,406	20,243	21,801
China (including Hong Kong)									
Agriculture and Food	189	289	490	741	1,837	3,542	-552	-1,547	-3,052
Primary Products	268	300	561	665	1,362	1,420	-397	-1,062	-859
Energy	20	84	450	2,163	2,547	2,540	-2,142	-2,463	-2,090
Chemicals and Paper	1,191	1,832	3,385	253	516	757	938	1,316	2,628
Primary Metals and Mineral	3,391	3,356	4,025	216	583	1,437	3,175	2,773	2,588
Machinery and Transport Eq	6,458	9,531	19,461	88	475	2,872	6,370	9,056	16,589
Light Industry	3,035	4,214	7,153	1,771	4,418	12,591	1,264	-204	-5,439
Total	14,552	19,605	35,525	5,897	11,737	25,158	8,656	7,868	10,366
Korea									
Agriculture and Food	97	42	144	760	1,538	1,471	-663	-1,496	-1,327
Primary Products	192	329	375	116	328	369	77	2	6
Energy	103	266	554	275	557	724	-172	-291	-170
Chemicals and Paper	1,009	2,028	3,143	170	362	562	840	1,666	2,581
Primary Metals and Mineral	1,257	1,971	2,488	629	1,620	2,159	628	351	328
Machinery and Transport Eq	3,341	8,288	11,089	391	1,601	3,594	2,949	6,687	7,495
Light Industry	1,219	2,095	3,201	1,688	4,375	4,571	-469	-2,280	-1,371
Total	7,219	15,020	20,993	4,028	10,381	13,451	3,191	4,639	7,542

Source: United Naion's Trade Analysis and Reporting System (TARS).
The light industry includes textiles, clothing, footwear, leather, rubber, wood, furniture, and miscellaneous manufactures.

Table 1 (continued)

Trading Partner	*Japanese Exports* 1981-85	1986-90	1991-95	*Japanese Imports* 1981-85	1986-90	1991-95	*Net Trade* 1981-85	1986-90	1991-95
Taiwan									
Agriculture and Food	122	256	260	969	2,234	2,848	-847	-1,978	-2,588
Primary Products	142	280	289	199	411	405	-57	-131	-116
Energy	55	101	318	48	71	22	6	30	295
Chemicals and Paper	710	1,646	3,108	134	274	352	575	1,372	2,756
Primary Metals and Mineral	1,053	1,913	2,794	179	490	807	874	1,423	1,987
Machinery and Transport Eq	3,181	7,414	11,669	378	1,548	3,251	2,803	5,866	8,418
Light Industry	777	1,570	2,894	1,217	2,906	3,006	-440	-1,336	-112
Total	6,040	13,180	21,331	3,125	7,935	10,691	2,915	5,245	10,640
Singapore									
Agriculture and Food	72	70	106	37	109	218	34	-39	-112
Primary Products	18	27	47	36	97	110	-18	-70	-63
Energy	9	45	137	925	1,391	999	-916	-1,346	-862
Chemicals and Paper	284	489	985	86	193	207	198	296	778
Primary Metals and Mineral	821	797	1,242	10	42	44	810	754	1,199
Machinery and Transport Eq	3,101	5,477	10,821	168	505	2,299	2,934	4,972	8,522
Light Industry	817	1,028	2,040	127	331	556	690	697	1,484
Total	5,123	7,933	15,378	1,390	2,670	4,431	3,732	5,263	10,947
Indonesia									
Agriculture and Food	33	13	17	357	680	1,121	-325	-667	-1,104
Primary Products	65	55	135	663	917	1,195	-598	-862	-1,060
Energy	18	14	25	7,228	7,915	8,534	-7,210	-7,901	-8,509
Chemicals and Paper	419	417	764	10	36	109	409	380	655
Primary Metals and Mineral	770	500	690	254	443	418	516	57	272
Machinery and Transport Eq	2,390	2,180	4,148	1	28	246	2,389	2,152	3,903
Light Industry	337	331	624	78	897	2,314	260	-566	-1,690
Total	4,032	3,509	6,404	8,591	10,916	13,937	-4,559	-7,406	-7,533
Other ASEAN									
Agriculture and Food	81	125	170	1,077	2,013	3,394	-996	-1,887	-3,225
Primary Products	85	112	195	2,315	3,434	3,225	-2,230	-3,322	-3,029
Energy	44	64	156	1,185	2,166	2,632	-1,142	-2,103	-2,476
Chemicals and Paper	687	1,003	2,227	120	218	433	567	784	1,795
Primary Metals and Mineral	1,260	1,586	3,243	478	547	610	782	1,039	2,633
Machinery and Transport Eq	4,548	6,661	17,945	142	632	4,546	4,406	6,029	13,398
Light Industry	669	975	2,531	324	908	3,132	345	67	-602
Total	7,374	10,526	26,467	5,642	9,918	17,972	1,732	608	8,495
Middle East									
Agriculture and Food	157	45	41	12	30	40	145	15	1
Primary Products	73	28	40	497	832	638	-424	-804	-599
Energy	13	36	3	21,312	19,899	26,035	-21,299	-19,863	-26,033
Chemicals and Paper	245	189	214	40	298	242	204	-110	-28
Primary Metals and Mineral	2,235	791	712	98	164	218	2,137	627	494
Machinery and Transport Eq	9,033	4,392	5,513	1	2	2	9,032	4,391	5,511
Light Industry	2,496	1,524	1,339	39	94	116	2,457	1,429	1,223
Total	14,252	7,005	7,862	21,998	21,319	27,292	-7,746	-14,314	-19,431

Table 1 (continued)

	Japanese Exports			*Japanese Imports*			*Net Trade*		
Trading Partner	1981-85	1986-90	1991-95	1981-85	1986-90	1991-95	1981-85	1986-90	1991-95
Rest of World									
Agriculture and Food	477	462	462	3,837	6,673	9,277	-3,360	-6,211	-8,815
Primary Products	466	536	519	4,385	5,867	6,478	-3,919	-5,331	-5,959
Energy	251	257	471	7,599	8,183	9,415	-7,347	-7,926	-8,944
Chemicals and Paper	1,995	3,212	4,862	1,185	2,359	2,825	811	852	2,037
Primary Metals and Mineral	5,607	5,069	4,944	3,470	6,708	8,806	2,137	-1,640	-3,862
Machinery and Transport Eq	26,120	32,107	41,871	1,093	2,912	5,544	25,027	29,195	36,327
Light Industry	4,687	5,535	7,121	3,927	7,401	7,539	760	-1,866	-418
Total	39,603	47,178	60,249	25,495	40,103	49,884	14,108	7,075	10,365
World Total									
Agriculture and Food	1,856	1,963	2,217	17,141	30,106	43,206	-15,285	-28,143	-40,990
Primary Products	1,618	2,055	2,619	17,774	27,060	28,891	-16,156	-25,004	-26,272
Energy	620	1,013	2,359	45,202	49,727	59,467	-44,583	-48,714	-57,108
Chemicals and Paper	9,358	16,211	27,341	8,600	15,582	19,834	759	629	7,507
Primary Metals and Mineral	22,898	21,566	24,942	7,913	15,857	20,723	14,985	5,710	4,218
Machinery and Transport Eq	127,440	193,577	252,056	10,678	26,393	55,146	116,762	167,185	196,910
Light Industry	26,759	36,918	49,828	15,777	36,644	53,307	10,982	274	-3,479
Total	190,550	273,304	361,361	123,085	201,368	280,575	67,465	71,936	80,786

Table 2 Emission Intensities by Pollutant, United States, 1987 (tons/1987 US$ million)

	Air pollutants [a]					*Water pollutants* [b]	
	PARTIC	SO_2	NO_2	CO	VOC	BOD	TSS
Agriculture and Food	0.24281	0.32129	0.29261	0.07208	0.11175	0.33366	0.10842
Primary Products	2.61546	10.55967	2.68603	7.13949	0.66216	0.44891	26.78224
Energy	2.05221	7.54428	4.56010	3.69167	2.24194	0.04055	0.61213
Chemicals and Paper	0.48170	2.77550	1.86379	3.06792	1.37799	0.81846	2.73960
Primary Metals and Mineral	2.59047	9.42033	3.04412	8.04100	0.74154	0.27984	46.88446
Machinery and Transport Eq	0.03700	0.17896	0.11435	0.19065	0.33084	0.00424	0.03343
Light Industry	0.39069	0.31197	0.45374	0.58395	0.73265	0.01957	0.66588

[a]Air pollutants: particulates (PARTIC), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and volatile organic compounds (VOC).

[b]Water pollutants: biochemical oxygen demand (BOD), total suspended solids (TSS)

Source: World Bank/PRDEI, Industrial Pollution Projections System data (compiled by Mala Hettige, David Shaman, David Wheeler, and Dave Witzel).

Table 3 Japanese Bilateral Trade in Pollution Services by Sector and Trading Partner
(Annual Averages for 1991-95)

	Net Japanese Pollution Retention, in Thousands of Tons of Effluent						
	PARTIC	SO_2	NO_2	CO	VOC	BOD	TSS
United States							
Agriculture and Food	-2,993	-3,960	-3,606	-888	-1,377	-4,112	-1,336
Primary Products	-17,895	-72,249	-18,378	-48,848	-4,530	-3,071	-183,243
Energy	-3,044	-11,189	-6,763	-5,475	-3,325	-60	-908
Chemicals and Paper	-1,266	-7,295	-4,898	-8,063	-3,622	-2,151	-7,200
Primary Metals and Mineral	2,750	10,002	3,232	8,537	787	297	49,778
Machinery and Transport Eq	2,100	10,160	6,492	10,824	18,783	241	1,898
Light Industry	1,327	1,060	1,542	1,984	2,489	66	2,262
Total	-19,019	-73,471	-22,380	-41,930	9,205	-8,791	-138,749
Canada, Australia and NZ							
Agriculture and Food	-1,011	-1,338	-1,218	-300	-465	-1,389	-451
Primary Products	-18,663	-75,350	-19,167	-50,945	-4,725	-3,203	-191,108
Energy	-13,922	-51,181	-30,936	-25,044	-15,209	-275	-4,153
Chemicals and Paper	-416	-2,394	-1,605	-2,647	-1,184	-710	-2,378
Primary Metals and Mineral	-2,961	-13,481	-3,132	-9,589	-863	-604	-48,544
Machinery and Transport Eq	417	1,573	1,134	1,902	3,949	34	381
Light Industry	103	71	106	156	190	4	208
Total	-36,453	-142,100	-54,818	-86,467	-18,308	-6,144	-246,046
EU-12							
Agriculture and Food	-937	-1,240	-1,129	-278	-431	-1,287	-418
Primary Products	-1,609	-6,495	-1,652	-4,391	-407	-276	-16,472
Energy	-108	-398	-241	-195	-118	-2	-32
Chemicals and Paper	-1,045	-5,795	-3,680	-6,475	-2,482	-2,138	-7,170
Primary Metals and Mineral	-3,085	-12,103	-3,744	-10,744	-973	-374	-63,090
Machinery and Transport Eq	1,103	5,081	3,643	6,231	10,343	130	1,291
Light Industry	-65	-62	-87	-95	-125	-4	-91
Total	-5,747	-21,012	-6,890	-15,947	5,807	-3,951	-85,984
China (including Hong Kong)							
Agriculture and Food	-330	-436	-397	-98	-152	-453	-147
Primary Products	-2,248	-9,075	-2,308	-6,135	-569	-386	-23,016
Energy	-4,289	-15,767	-9,530	-7,715	-4,686	-85	-1,279
Chemicals and Paper	1,240	6,772	4,205	7,598	2,721	2,693	9,038
Primary Metals and Mineral	8,531	20,139	9,172	14,818	1,558	285	88,311
Machinery and Transport Eq	537	3,283	2,146	3,675	4,741	92	702
Light Industry	-681	-1,655	-2,098	-783	-1,699	-99	-3,833
Total	2,762	3,261	1,190	11,359	1,914	2,047	69,776
Korea							
Agriculture and Food	-296	-392	-357	-88	-136	-407	-132
Primary Products	15	60	15	41	4	3	152
Energy	-349	-1,283	-775	-628	-381	-7	-104
Chemicals and Paper	1,211	6,529	3,969	7,354	2,464	2,769	9,298
Primary Metals and Mineral	814	2,813	1,088	3,007	273	47	19,307
Machinery and Transport Eq	264	1,454	845	1,388	2,232	35	207
Light Industry	-218	-430	-555	-273	-500	-26	-790
Total	1,441	8,752	4,229	10,801	3,956	2,414	27,939

See notes on Table 2.

Table 3 (continued)

	Net Japanese Pollution Retention, in Thousands of Tons of Effluent						
	PARTIC	SO_2	NO_2	CO	VOC	BOD	TSS
Taiwan							
Agriculture and Food	-552	-731	-665	-164	-254	-759	-247
Primary Products	-304	-1,228	-312	-830	-77	-52	-3,115
Energy	606	2,229	1,347	1,091	662	12	181
Chemicals and Paper	1,295	6,999	4,273	7,876	2,677	2,930	9,839
Primary Metals and Mineral	4,910	17,600	6,404	17,896	1,624	369	112,430
Machinery and Transport Eq	275	1,692	1,045	1,764	2,356	45	307
Light Industry	-20	-33	-43	-27	-45	-2	-94
Total	6,209	26,528	12,048	27,606	6,943	2,544	119,301
Singapore							
Agriculture and Food	-25	-33	-30	-7	-12	-35	-11
Primary Products	-164	-663	-169	-448	-42	-28	-1,681
Energy	-1,768	-6,500	-3,929	-3,181	-1,932	-35	-527
Chemicals and Paper	366	1,979	1,210	2,226	760	825	2,769
Primary Metals and Mineral	2,551	14,264	2,729	10,312	894	715	51,150
Machinery and Transport Eq	260	1,897	1,004	1,646	1,988	49	208
Light Industry	309	298	410	444	685	18	3,232
Total	1,529	11,241	1,225	10,991	2,342	1,508	55,139
Indonesia							
Agriculture and Food	-171	-226	-206	-51	-79	-235	-76
Primary Products	-2,772	-11,191	-2,847	-7,567	-702	-476	-28,385
Energy	-17,462	-64,194	-38,802	-31,412	-19,077	-345	-5,209
Chemicals and Paper	306	1,625	964	1,838	569	737	2,476
Primary Metals and Mineral	867	2,482	849	1,449	151	81	7,131
Machinery and Transport Eq	137	738	459	768	1,202	18	132
Light Industry	-581	-575	-808	-848	-1,105	-36	-439
Total	-19,676	-71,341	-40,390	-35,823	-19,040	-256	-24,371
Other ASEAN							
Agriculture and Food	-623	-824	-750	-185	-287	-856	-278
Primary Products	-7,923	-31,989	-8,137	-21,628	-2,006	-1,360	-81,133
Energy	-5,081	-18,678	-11,290	-9,140	-5,551	-100	-1,515
Chemicals and Paper	844	4,575	2,806	5,145	1,773	1,890	6,346
Primary Metals and Mineral	8,786	21,422	9,038	13,924	1,491	436	77,371
Machinery and Transport Eq	445	2,712	1,591	2,648	3,723	69	416
Light Industry	-150	-181	-247	-211	-307	-11	-467
Total	-3,702	-22,963	-6,988	-9,447	-1,163	69	739
Middle East							
Agriculture and Food	. .	. .	. .	. .	. .	. .	. .
Primary Products	-1,565	-6,320	-1,608	-4,273	-396	-269	-16,030
Energy	-53,424	-196,397	-118,711	-96,104	-58,364	-1,056	-15,935
Chemicals and Paper	-13	-72	-44	-80	-29	-29	-96
Primary Metals and Mineral	1,570	4,060	1,682	2,954	303	81	17,099
Machinery and Transport Eq	213	771	786	1,419	2,270	24	393
Light Industry	269	411	545	363	560	25	347
Total	-52,951	-197,547	-117,350	-95,721	-55,656	-1,223	-14,223

Table 3 (continued)

	Net Japanese Pollution Retention, in Thousands of Tons of Effluent						
	PARTIC	SO_2	NO_2	CO	VOC	BOD	TSS
Rest of World							
Agriculture and Food	-1,632	-2,160	-1,967	-484	-751	-2,243	-729
Primary Products	-15,585	-62,924	-16,006	-42,544	-3,946	-2,675	-159,593
Energy	-18,356	-67,479	-40,787	-33,020	-20,053	-363	-5,475
Chemicals and Paper	965	5,327	3,363	5,958	2,244	2,006	6,729
Primary Metals and Mineral	-10,420	-36,614	-11,674	-28,872	-2,707	-1,156	-162,793
Machinery and Transport Eq	1,299	6,428	4,564	7,838	12,097	171	1,624
Light Industry	-95	-128	-171	-130	-198	-8	-298
Total	-43,824	-157,550	-62,679	-91,254	-13,314	-4,268	-320,535
World Total							
Agriculture and Food	-8,569	-11,339	-10,327	-2,544	-3,944	-11,775	-3,826
Primary Products	-68,713	-277,423	-70,567	-187,569	-17,396	-11,794	-703,622
Energy	-117,197	-430,838	-260,418	-210,824	-128,033	-2,316	-34,958
Chemicals and Paper	3,486	18,250	10,561	20,730	5,891	8,822	29,650
Primary Metals and Mineral	14,314	30,584	15,644	23,693	2,539	177	148,150
Machinery and Transport Eq	7,050	35,789	23,709	40,104	63,685	907	7,558
Light Industry	198	-1,225	-1,407	578	-55	-72	35
Total	-169,431	-636,202	-292,804	-315,831	-77,313	-16,051	-557,012

Table A.1 Results of Multilateral Tariff Liberalization (percentage changes)

	Japan	U.S.	China	Korea	Taiwan	Singapore	Malaysia	Thailand	Indonesia	Philippines
Welfare (EV)	0.32	0.10	1.28	0.11	0.37	1.37	1.05	1.31	0.21	0.95
Real GDP	0.18	-0.06	1.66	1.30	1.76	0.57	2.19	1.63	0.68	1.98
Terms of Trade	3.08	1.51	-9.35	-6.22	-2.73	1.76	-3.75	-2.94	-2.80	-5.85
Emissions										
PARTIC	-0.49	-0.17	1.81	1.15	0.67	9.59	4.08	0.04	3.14	0.34
SO_2	-0.35	-0.16	1.81	1.59	-0.19	9.32	5.42	-0.21	3.28	1.32
NO_2	-0.59	-0.17	1.83	1.39	0.64	9.62	4.53	-0.41	3.32	-0.18
CO	0.00	-0.18	1.42	1.65	-0.32	7.87	6.91	0.48	2.59	2.63
VOC	-0.19	-0.15	1.44	1.60	0.99	8.79	4.72	-0.57	2.90	-0.13
BOD	0.08	-0.09	0.87	-0.12	0.59	2.39	4.44	2.78	-0.50	-0.76
TSS	0.46	-0.35	1.30	3.26	-1.29	2.21	13.47	5.09	-0.71	10.67
Sectoral Output										
Agriculture	-1.40	0.23	1.39	-2.51	-1.05	-2.19	1.51	0.43	-0.42	-0.67
Energy and Minerals	-3.14	0.00	3.79	0.12	-3.23	11.53	3.47	-3.17	4.51	-1.80
Food Products	-0.28	0.10	1.74	-0.75	-1.01	0.50	0.62	4.38	-0.62	-0.17
Textiles and Apparel	-0.29	-4.91	2.31	15.91	11.58	5.88	3.91	2.29	1.98	14.60
Chemicals and Paper	0.22	-0.10	0.26	-0.86	1.47	0.99	6.71	0.03	-1.29	-4.34
Metal	0.55	-0.42	1.35	3.86	-1.67	-1.28	18.09	7.77	-3.31	14.66
Machinery	1.20	-0.16	-0.17	4.18	8.44	2.51	14.83	4.82	-1.63	38.26
Transport Equipment	1.61	0.16	-2.54	8.66	-3.13	-0.43	-4.78	-4.29	-5.33	-4.69
Other Manufac.	0.67	-0.73	0.42	0.78	6.44	1.95	-5.87	-0.30	-3.96	0.64
Services	0.12	0.01	1.81	0.37	0.15	-0.54	0.36	1.42	0.03	2.31

Table A.2 Changes in the Effluent Content of Japanese Exports and Imports resulting from Multilateral Tariff Liberalization (Thousands of Tons of Pollutant)

	Trading Partner									
Pollutant	U.S.	China	Korea	Taiwan	Singapore	Malaysia	Thailand	Indonesia	Philippines	Total
A. Absolute changes in effluent content of Japanese exports by trading partner										
PARTIC	298	161	201	138	8	32	30	51	16	935
SO_2	870	566	906	652	34	127	127	191	71	3,544
NO_2	399	321	462	273	13	57	64	88	42	1,719
CO	723	511	912	655	33	120	123	184	64	3,325
VOC	511	375	334	229	12	67	66	76	30	1,700
BOD	36	79	139	73	2	12	18	20	14	393
TSS	2,724	944	2,690	2,639	136	432	375	672	118	10,730
B. Absolute changes in effluent content of Japanese imports by trading partner										
PARTIC	227	510	145	79	190	269	40	1,169	82	2,711
SO_2	769	1,869	563	190	702	1,078	152	4,353	418	10,094
NO_2	451	1,108	311	131	411	578	86	2,520	151	5,747
CO	632	1,022	400	133	353	680	143	2,236	386	5,985
VOC	322	555	169	79	201	293	54	1,228	78	2,979
BOD	193	81	44	54	8	38	43	47	19	527
TSS	1,440	1,086	1,379	288	153	1,382	396	1,427	1,882	9,433
C. Net embodied effluent trade (A - B)										
PARTIC	71	-349	56	59	-182	-237	-10	-1,118	-66	-1,776
SO_2	101	-1,303	343	462	-668	-951	-25	-4,162	-347	-6,550
NO_2	-52	-787	151	142	-398	-521	-22	-2,432	-109	-4,028
CO	91	-511	512	522	-320	-560	-20	-2,052	-322	-2,660
VOC	189	-180	165	150	-189	-226	12	-1,152	-48	-1,279
BOD	-157	-2	95	19	-6	-26	-25	-27	-5	-134
TSS	1,284	-142	1,311	2,351	-17	-950	-21	-755	-1,764	1,297

See notes on Table 2.

Table A.3 Results of Effluent Taxes (percentage changes)

	Japan	U.S.	China	Korea	Taiwan	Singapore	Malaysia	Thailand	Indonesia	Philippines
Welfare (EV)	-0.06	0.00	-0.83	-0.07	-0.17	0.60	-0.34	-0.16	-0.03	-0.29
Real GDP	-0.08	0.01	-0.92	-0.09	-0.19	-0.60	0.02	-0.07	-0.90	-0.57
Terms of Trade	-0.07	-0.20	0.98	0.07	0.02	2.21	-1.61	-0.78	5.68	1.78
Emissions										
PARTIC	-0.27	0.07	-1.93	-0.99	-0.94	-9.93	-1.40	-0.41	-3.84	-2.94
SO_2	-0.43	0.08	-2.09	-1.53	-0.92	-9.71	-2.28	-0.93	-4.02	-4.20
NO_2	-0.19	0.06	-2.00	-0.69	-1.07	-10.00	-0.92	-0.28	-4.00	-2.82
CO	-0.56	0.08	-2.07	-2.04	-0.71	-8.23	-3.55	-1.73	-3.65	-5.38
VOC	-0.19	0.05	-1.94	-0.64	-1.00	-9.04	-0.72	-0.29	-3.80	-2.75
BOD	-0.17	0.02	-1.46	-0.28	-0.63	-2.53	0.03	-0.12	-0.68	-0.82
TSS	-1.00	0.14	-2.03	-4.00	-0.12	-2.35	-14.00	-6.00	-1.51	-11.00
Sectoral Output										
Agriculture	0.04	-0.04	-0.24	0.37	0.04	0.59	1.00	0.16	0.50	0.04
Energy and Minerals	0.34	0.08	-2.75	-0.12	-2.50	-12.03	-0.31	0.28	-4.84	-2.93
Food Products	-0.01	-0.01	-0.55	0.15	-0.06	0.36	0.49	0.19	0.27	0.04
Textiles and Apparel	0.08	-0.05	-0.70	1.17	-0.14	0.57	2.13	0.28	-0.10	1.42
Chemicals and Paper	-0.03	0.01	-1.82	0.28	-0.95	-1.41	1.38	0.06	-1.30	-0.68
Metal	-1.12	0.17	-2.04	-4.61	0.06	1.32	-21.10	-8.56	0.19	-13.45
Machinery	-0.29	0.01	-1.35	-0.94	-0.08	0.52	1.24	-0.26	0.63	-4.75
Transport Equipment	-0.23	0.01	-1.18	-1.17	-0.79	1.17	0.35	-0.50	0.15	-0.77
Other Manufac.	-0.05	0.01	-1.37	-0.05	-0.48	0.06	0.42	0.01	-0.55	-0.49
Services	-0.02	0.00	-0.90	0.02	0.05	0.00	-0.01	-0.07	-0.06	-0.31

Note: For each country except the United States, a uniform effluent tax is levied to achieve a given abatement target: Japan – 1% in TSS, China – 2% in NO_2, Korea – 4% in TSS, Taiwan – 1% in VOC, Singapore – 10% in NO_2, Malaysia – 14% in TSS, Thailand – 6% in TSS, Indonesia – 4% in NO_2, and the Philippines – 11% in TSS.

Table A.4 Results of Effluent Taxes and Multilateral Tariff Liberalization (percentage changes)

	Japan	U.S.	China	Korea	Taiwan	Singapore	Malaysia	Thailand	Indonesia	Philippines
Welfare (EV)	0.26	0.10	0.50	0.07	0.26	2.31	0.73	1.16	0.21	0.70
Real GDP	0.11	-0.05	0.78	1.26	1.71	-0.19	2.32	1.58	-0.18	1.35
Terms of Trade	2.99	1.33	-8.63	-6.28	-2.97	4.74	-5.55	-3.77	2.17	-4.05
Emissions										
PARTIC	-0.75	-0.11	-0.13	0.46	0.49	-3.62	2.16	-0.29	-0.67	-3.30
SO_2	-0.79	-0.09	-0.27	0.51	-0.30	-3.62	2.41	-1.05	-0.71	-3.96
NO_2	-0.78	-0.11	-0.18	0.93	0.39	-3.67	3.26	-0.61	-0.65	-3.63
CO	-0.58	-0.11	-0.60	0.19	-0.32	-3.14	2.38	-1.16	-1.00	-4.21
VOC	-0.38	-0.10	-0.49	1.18	0.75	-3.22	3.78	-0.78	-0.86	-3.49
BOD	-0.09	-0.07	-0.52	-0.30	0.44	-0.92	4.73	2.69	-1.11	-1.73
TSS	-0.56	-0.23	-0.62	0.34	-0.89	-1.36	-4.36	-0.82	-2.06	-3.65
Sectoral Output										
Agriculture	-1.35	0.19	1.22	-2.25	-1.10	-1.33	2.81	0.60	0.12	-0.58
Energy and Minerals	-2.80	0.08	0.77	0.09	-4.03	-4.51	2.76	-2.76	-0.37	-5.30
Food Products	-0.28	0.10	1.27	-0.64	-1.08	1.09	1.29	4.59	-0.33	-0.08
Textiles and Apparel	-0.19	-4.96	1.72	17.01	11.55	6.66	6.62	2.61	1.99	16.89
Chemicals and Paper	0.19	-0.09	-1.49	-0.60	1.20	-0.74	9.01	0.13	-2.43	-4.98
Metal	-0.59	-0.27	-0.56	0.45	-1.15	-0.26	-9.32	-0.83	-2.84	-3.42
Machinery	0.92	-0.16	-1.41	3.51	8.40	3.21	16.69	4.66	-0.87	31.09
Transport Equipment	1.38	0.17	-3.59	7.71	-3.44	1.13	-4.30	-4.70	-5.10	-5.32
Other Manufac.	0.62	-0.72	-0.87	0.77	6.33	2.14	-5.26	-0.28	-4.42	0.24
Services	0.11	0.01	0.98	0.40	0.18	-0.55	0.41	1.36	0.02	2.06