Workshop 3: Pollution havens and pollution halos

IN SEARCH OF POLLUTION HAVENS?
DIRTY INDUSTRY IN THE WORLD ECONOMY, 1960-1995

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Abstract

The last three decades have witnessed rapid economic development, particularly in countries which have pursued relatively open economic policies. Rising environmental awareness in the 1960s also led to a rapid tightening of pollution regulation in the industrial economies. According to the 'pollution havens' hypothesis, the result should have been more rapid growth of dirty industries in unregulated economies which were open to international trade.

Using data for the period 1960-1995, the authors find that the displacement of pollution to developing countries has not been a major phenomenon for several reasons. Tendencies toward formation of pollution havens have been self-limiting, because economic growth has generated countervailing effects through increases in regulation, technical expertise, and investment in cleaner production. In practice, the authors argue that pollution havens have apparently been as transient as low-wage havens.

Acknowledgments

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1. Introduction

During the past three decades, many poor countries have experienced rapid economic development after adopting liberal economic policies. In manufacturing sectors such as apparel assembly, a 'cascading' pattern of growth has accompanied this global movement toward openness. Production has accelerated in progressively poorer countries, as wage increases in rapidly-developing open economies have changed the pattern of comparative advantage. Downward migration of garment assembly has reflected its continuing labour-intensity: Low unit labour costs in poor economies have been sufficient to offset the potential for automated production in higher-wage countries.[1] We might therefore characterise the world garment story as a continuous (and self-defeating) search for 'low wage havens' by apparel manufacturers. From the perspective of development economics, this has been salutary: Exports of garments and other light assembly goods have provided the first rung on the ladder of rapid income growth and skills development for millions of poor workers.

Although they are critical factors, relative wages and labour skills are not the only determinants of locational advantage. Other long-recognised factors include the quality and local price of available energy and raw materials, agglomeration economies, etc.[2] More recently, attention has turned to the possible impact of differences in environmental regulation. In the OECD economies, stricter regulation means polluters pay more – for pollution control equipment, conversion to cleaner processes, or penalties for unacceptable emissions. This regulatory gap between developed and developing countries could, in principle, produce 'pollution havens' analogous to 'low wage havens.' Pollution-intensive industries (i.e., those with low elasticities of substitution between use of the environment and other productive factors) might join labour-intensive industries in the migration from the OECD countries to open developing economies, if the latter remained unregulated and environmental pricing were a significant determinant of comparative advantage.

Have 'pollution havens' in fact emerged? In this paper, we examine the record using international information on industrial production, trade and environmental regulation for the period 1960 - 1995. The paper is organised as follows. In Section 2, we use recent results on the relationship between regulation and development to argue that 'pollution havens' must be as transient as 'low wage havens:' In the worst case, we would expect to see pollution-intensive sectors follow the 'cascading' international growth pattern of garment production. Section 3 draws on several empirical approaches to identify industry sectors which are clearly among the most pollution-intensive. Focusing on these sectors, the rest of the paper examines the evidence on shifts in pollution-intensive production from the OECD to developing economies. Section 4 focuses on the OECD, giving particular attention to the Japanese case. Section 5 considers the experience of developing Asia and Latin America, while Section 6 provides a summary and conclusions.

2. Development, Regulation and 'Pollution Havens'

'Low wage havens' are transient because incomes and wages increase continuously with development. Similarly, recent evidence suggests that 'pollution havens,' if they exist, may be transient because environmental regulation also increases with development. Dasgupta, et. al. (1996) document the striking correlation between national income per capita and the strictness of environmental regulation. Recent studies of regional income and regulation in China (Wang and Wheeler, 1996; Dasgupta and Wheeler, 1997) and Indonesia (Pargal and Wheeler, 1996) find similar relationships.

Regulation of industrial pollution increases with economic development for two main reasons. First, the demand for environmental quality rises with income, both for aesthetic reasons and because the

1 For a detailed discussion, see Mody and Wheeler (1990)

2 See Wheeler and Mody (1992)

valuation of pollution damage increases. Secondly, more developed economies have (on average) more highly-developed public institutions and are more capable of enforcing desirable environmental norms[3]. If the income elasticity of regulation is greater than one, then developing countries will not retain a comparative advantage in dirty production. However, the interplay of relative prices and agglomeration economies might lead to a garment-style 'cascading' pattern of growth, in which rapid growth of dirty sectors is visible during transitional periods when regulation lags behind the growth of output and income.

3. Defining Dirty Industries

To test for pollution havens, we need a clearly-defined set of 'dirty' industries. A conventional approach in the literature has been to identify pollution-intensive sectors as those which have incurred high levels of abatement expenditure per unit of output in the US and other OECD economies (Robison (1988), Tobey (1990), Mani (1996)). By this criterion, five sectors emerge as leading candidates for 'dirty industry' status: Iron and Steel, Non-Ferrous Metals, Industrial Chemicals, Pulp and Paper, and Non-Metallic Mineral Products.[4] Another, more direct, approach is to select sectors which rank high on actual emissions intensity (emissions per unit of output). To determine high-ranking sectors by this criterion, we have used detailed emissions intensities by medium for US manufacturing at the 3-digit Standard Industrial Classification (SIC) level, computed by the World Bank in collaboration with the US EPA and the US Census Bureau (Hettige, et. al., 1995). We have computed average sectoral rankings for conventional air pollutants, water pollutants, and heavy metals, with results displayed in Table 1.

Table 1. Ranking of Pollution-Intensive Industries

Rank	Air	Water	Metals	Overall
1	371 Iron and Steel	371 Iron and Steel	372 Non-Ferrous Metals	371 Iron and Steel
2	372 Non-Ferrous Metals	372 Non-Ferrous Metals	371 Iron and Steel	372 Non-Ferrous Metals
3	369 Non-Metallic Min. Prd.	341 Pulp and Paper	351 Industrial Chemicals	351 Industrial Chemicals
4	354 Misc. Petroleum, Coal Prd.	390 Miscellaneous Manufacturing	323 Leather Products	353 Petroleum Refineries
5	341 Pulp and Paper	351 Industrial Chemicals	361 Pottery	369 Non-Metallic Min Prd.
6	353 Petroleum Refineries	352 Other Chemicals	381 Metal Products	341 Pulp and Paper
7	351 Industrial Chemicals	313 Beverages	355 Rubber Products	352 Other Chemicals
8	352 Other Chemicals	311 Food Products	383 Electrical Products	355 Rubber Products
9	331 Wood Products	355 Rubber Products	382 Machinery	323 Leather Products
10	362 Glass Products	353 Petroleum Refineries	369 Non-Metallic Min. Prd.	381 Metal Products

[3] This is confirmed in a recent study by Hettige, Mani, and Wheeler (1998)

[4] Petroleum has been excluded because a very few countries are actually involved in its production.

Again, five of the six sectors with highest overall ranks are Iron and Steel, Non-Ferrous Metals, Industrial Chemicals, Pulp and Paper, and Non-Metallic Mineral Products. We have therefore selected them as the 'dirty sectors' for this analysis. If there is a significant pollution havens story, it should emerge in their international development history since 1960. However, since this is a comparative advantage story, we need to be sure that it is not confounded by changes in relative prices of factors other than 'environment' in which dirty industries may also be intensive.

In fact, it is quite reasonable to suppose that pollution-intensive industries *are* intensive in other inputs, particularly bulk raw materials, energy and land. Pollutants are waste residuals – harmful by-products of industrial processes which are not profitable to recycle or resell at existing prices (including the price of pollution). The volume of such residuals is, almost tautologically, largest in weight-reducing industries which transform bulk raw materials into primary inputs for industrial production. Such industries should be land intensive, because some bulk material inventories must be stored on-site. They should also be energy-intensive, because transformation processes generally involve the application of high temperature, pressure, and /or mechanical force to raw material inputs. We are agnostic about their capital- and labour-intensity, but these factors are also clearly important for the comparative advantage story.

To test for differential intensities, we have identified the five 'cleanest' sectors using the same pollution-intensity rankings employed for Table 1. They are SIC sectors 321 (Textiles), 382 (Non-Electrical Machinery), 383 (Electrical Machinery), 384 (Transport Equipment), and 385 (Instruments). Using available data from Japan, we have computed energy, land and labour intensities for the five cleanest and dirtiest sectors and compared the results.

The results for energy intensity, displayed in Figure 1, are very clear: The five dirty sectors are about three times more energy intensive than the five clean sectors, and there is striking uniformity within the two groups. Although there is more within-group variation, the result is basically the same for land intensity (Figure 2): It is about three times higher in the dirty sectors. Capital intensity is also substantially higher in the dirty sectors, with an average ratio around 2:1 for capital/output (Figure 3) and investment/output (Figure 4). Labour intensity shows considerable variation within groups, but the clean sectors are about 40% more labour intensive on average (Figure 5).

To summarise, our evidence suggests that dirty industries are relatively intensive in capital, energy and land; their clean counterparts are relatively intensive in labour, although the difference is not as striking. Clearly, the pollution havens hypothesis cannot be tested using information on environmental regulation alone. Shifts in pollution-intensive production might also be explained by differences in the relative prices of these other inputs. In the following section, we take a careful look at the relative price story for Japan.

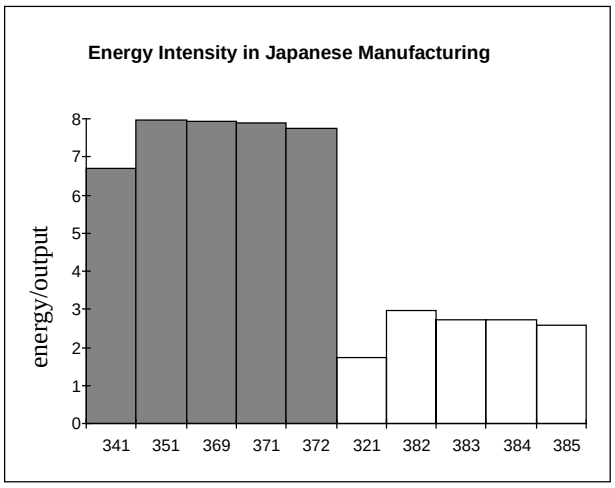
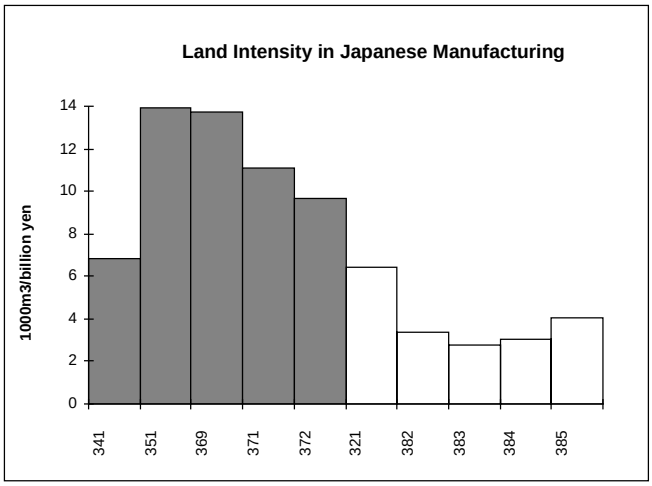


Figure 1



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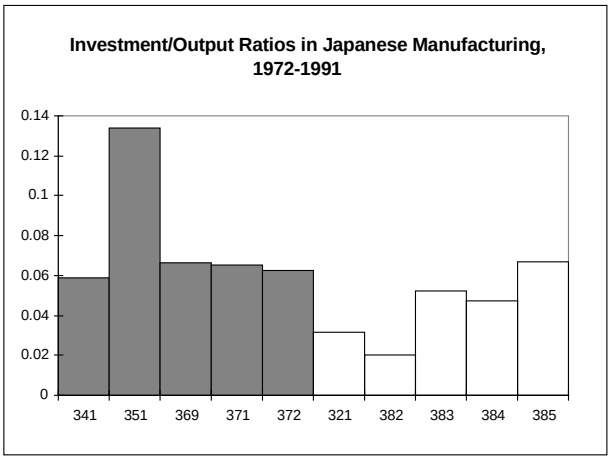

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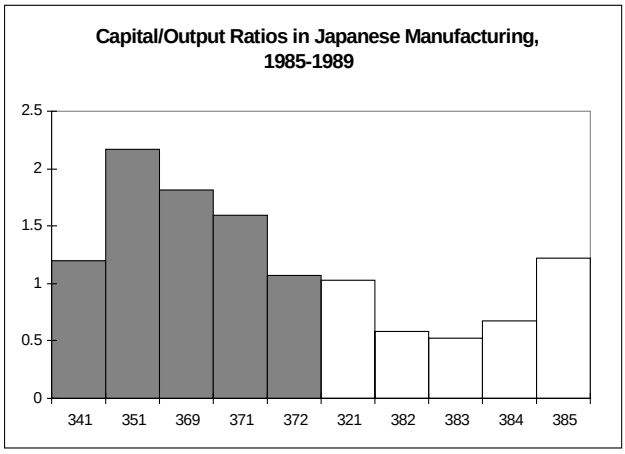

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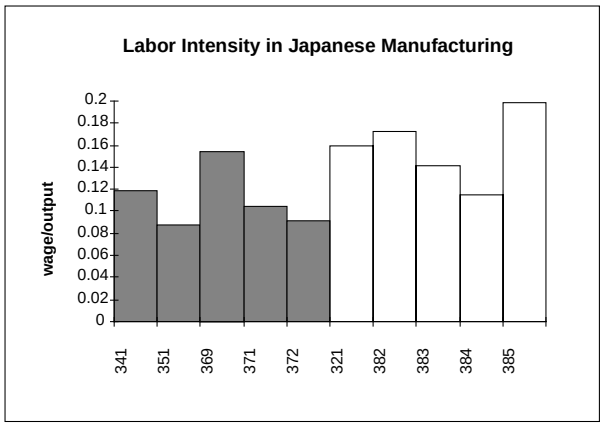


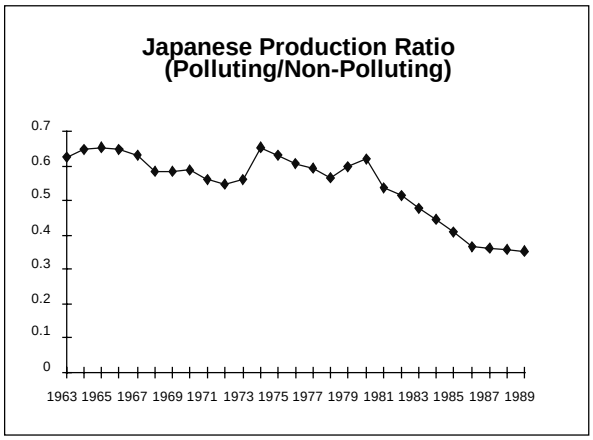
Figure 5

4. Pollution-Intensive Production in the OECD

4.1 The Japanese Story

4.1.1 The Relative Decline of Pollution-Intensive Sectors

During the past three and one-half decades, Japan has gone through major changes in economic and environmental conditions. As Figures 6 and 7 suggest, these changes have had significant consequences for pollution-intensive industry in Japan. Whether compared to the five cleanest sectors (Figure 6) or Japanese manufacturing as a whole (Figure 7), the share of our five dirtiest sectors trended strongly downward during the period 1963-1993. As a proportion of clean-sector production, dirty-sector output dropped from nearly 70% in 1963 to about 30% in the mid-1990's. As a proportion of total manufacturing production, dirty-sector output dropped from about 25% in the early 1960's to about 15% in the mid-1990's. Both series show clear breaks in trend during the two periods of rapid energy price escalation, 1973-74 and 1978-80. Since the dirty sectors have relatively high energy intensity, the short-run response to the energy price increases was a 'pass-through' to customers and temporary escalation of output value relative to the value of sectors with lower energy intensity. After each break, however, the downward trend quickly reasserted itself. What explains this decline? Obvious candidates are price changes for factors in which the pollution-intensive sectors are highly intensive: Energy, land and environment.



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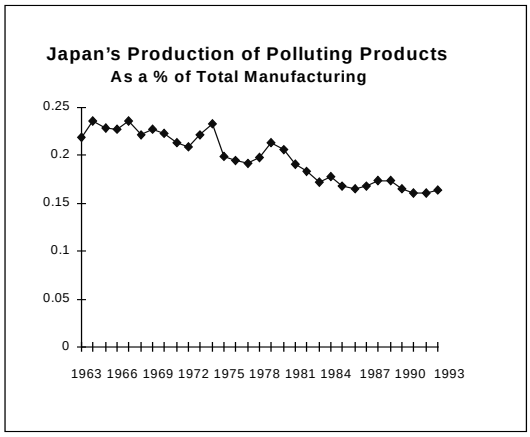


Figure 7

4.1.2 Energy and Land Prices

Energy prices escalated sharply in 1973, and this increase may well explain part of the decline in the share of pollution-intensive production in the 1970's. However, relative energy prices were not increasing during the 1960's and 1980's -- periods when Japan's dirty industry share was also declining.

As Figure 8 shows, the past three decades have also witnessed a rapid escalation of land prices in Japan. However, the decline in dirty-sector share began slackening in the 1980's, at precisely the time when land prices began escalating sharply. Land price increases may therefore have played some role, but it seems unlikely that they were a decisive factor.

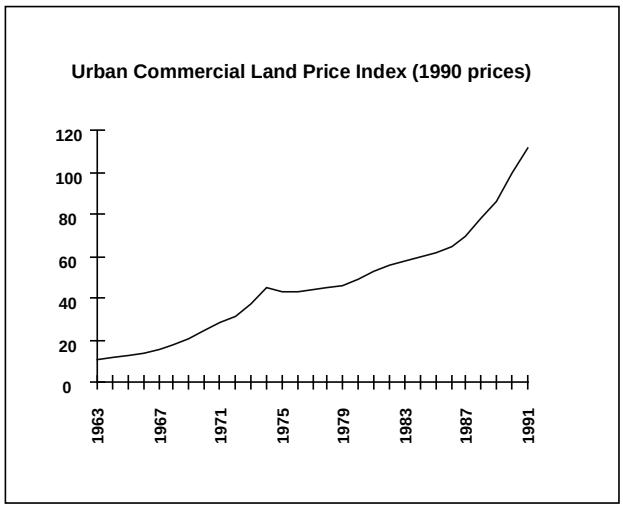
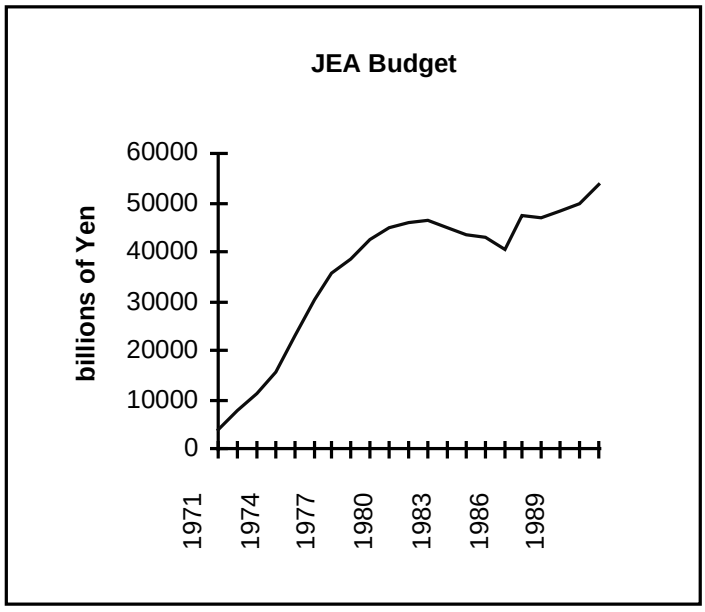


Figure 8

4.1.3 The Timing and Impact of Environmental Regulation

Does the timing of stricter environmental regulation in Japan jibe with the pattern of relative decline in pollution-intensive production? Cities like Tokyo, Osaka, and Kyoto enacted some pollution control measures by the mid-1950's, and Japan's first water quality preservation law was enacted in 1958. However, strong opposition from growth- and industry-oriented national ministries hampered the national movement toward stricter regulation until the late 1960's. From 1967 to 1970, regulations covering industrial air and water emissions were enacted in rapid succession. The Japanese Environmental Agency (JEA) was set up in 1971 and, as Figure 9 shows, its activities grew very rapidly during the 1970's.

As JEA's regulatory activity increased, Japanese industry went through a period of rapid adjustment to new environmental norms. Figure 10 shows that the mid-1970's witnessed a surge of investment in pollution control by Japanese industry. Thus, it is plausible to suppose that tightened regulation had an impact on the relative fortune of pollution-intensive production in Japan during in the 1970's and early '80's. However, tightened regulation cannot explain the decline of pollution-intensive production in the 1960's.



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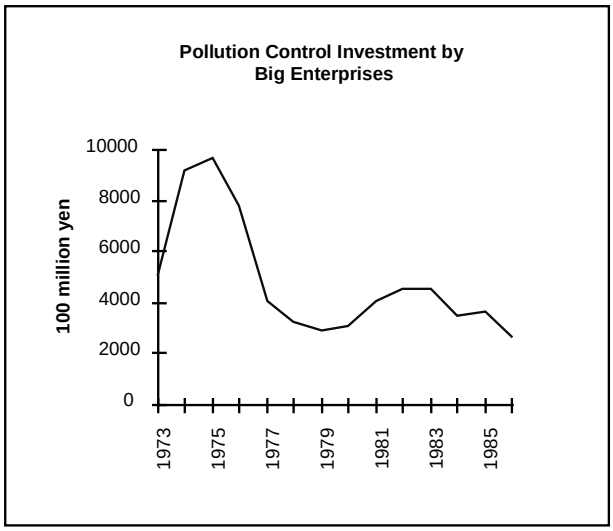
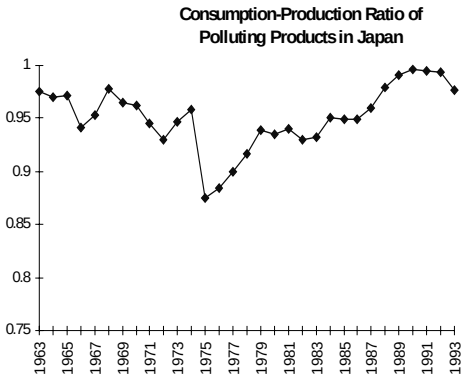


Figure 10

4.1.4 Income Growth

Figures 6 and 7 suggest a consistent pattern of decline in the share of dirty industry from the sixties to the nineties, despite large interim changes in the prices of energy, land and environment. During this entire period, of course, Japanese income per capita increased rapidly. Our five dirty sectors are 'basic' industries, whose domestic demand elasticity falls as income increases. Thus, income growth alone may explain a significant part of their relative decline.



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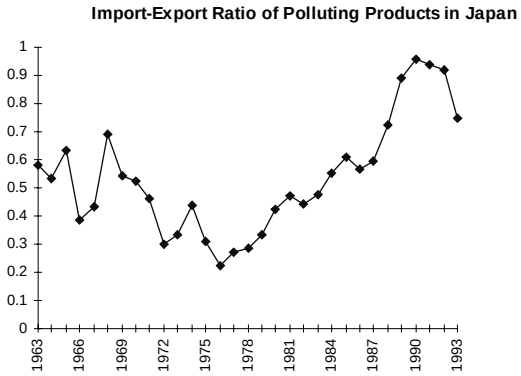


Figure 12

Figures 11 and 12 tell an intriguing story in this context. During the 'pre-environmental' period of rapid growth, from 1963 to the mid-1970's, declining trends in both consumption/production and import/export ratios are consistent with the income-elasticity hypothesis. However, in the mid-1970's both ratios reversed course: Production of polluting products slowed relative to consumption, and imports increased much more rapidly than exports. Thus, although relative domestic demand for pollution-intensive products undoubtedly continued to decline with income growth after 1975, the evidence suggests that the pure 'income effect' was outweighed by another factor which suddenly retarded the growth of domestic production and exports. In light of the regression results, the most plausible candidate for this role is increased environmental regulation.

4.1.6 Dirty Industry's 'Retreat' from Japan: A Summary Perspective

Many factors can be invoked to explain the relative decline of pollution-intensive industry in Japan since 1963. Although energy and land prices are plausible culprits, our regression analysis suggests that they have not played dominant roles in the story. Lower income elasticities for dirty-sector products have undoubtedly played a role. Indeed, the evidence suggests that they played a dominant role in the 1960's. However, the most striking part of Japan's dirty-sector story is the rapid increase in consumption/production and import/export ratios since 1976, coupled with rapid growth of the JEA and sharp increases in industrial pollution control investments. A plausible inference is that stricter environmental regulation had a significant impact on Japan's comparative advantage in pollution-intensive products. We conclude that regulation probably led to both significant abatement by pollution-intensive industries in Japan, and displacement of some pollution-intensive production to Japan's trading partners.

4.2 Dirty Production in North America and Western Europe

Although we have used the Japanese case to examine the 'environmental transition' in detail, regulation was also increasing rapidly in North America and Western Europe during the same period. Rapidly-rising real wages in the 1960's and energy price hikes in the 1970's were common to all three OECD regions. As in the case of Japan, the growth of environmental regulation imposed substantial abatement costs on industry in North America and Western Europe during the 1970's. However, other conditions were different. Slower income growth after 1970 should have dampened the domestic income elasticity effect and kept the escalation of land prices well below Japanese rates. In the case of North America, three additional factors were operative: Relative to Japan and Western Europe, North America has low settlement density (and land prices), a much greater supply of bulk raw materials, and substantially lower energy prices -- all factors which would enhance comparative advantage in pollution-intensive products. North America also has a skilled labour force capable of rapid adjustment toward cleaner production processes. It is therefore at least possible that the environmental era witnessed displacement of pollution-intensive production from Japan and Western Europe to North America, whose higher abatement expenses would have been compensated by a cost advantage in other factors.

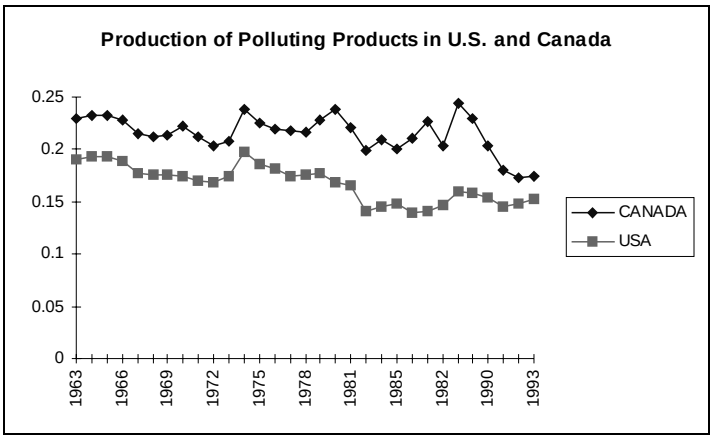
Figures 13-16 tell us what actually happened. In the case of North America, the evidence suggests that the impact of environmental regulation outweighed the potentially-displacing effects of tighter regulation in Japan and Western Europe. From 1963 - 1993, the dirty-sector share of industrial production declined steadily in the US and, more modestly, in Canada. North America's dirty-sector consumption/production ratio shows no trend and fluctuates within a very narrow range; its import/export ratio increases steadily. Thus, despite several possible countervailing factors, the North American experience was actually quite similar to that of Japan.

Western Europe also displays a declining share of dirty-sector production throughout the period, although its dirty-sector import/export ratio has remained approximately constant. Paradoxically, it is the Western European, not North American, consumption/production ratio which exhibits a downward trend well into the 1980's before returning to its 1960's level in the 1990's.

4.3 Summarising the OECD Experience

To summarise briefly, two general patterns are visible in dirty-sector production trends for the OECD economies since 1960. In all three regions, the share of pollution-intensive industries has significantly declined. In two of the regions – Japan and North America – this decline has been accompanied by net displacement of polluting production to trading partners, while approximate trade balance has been preserved in Western Europe.

Part of the decline was probably due to low income elasticity of demand for pollution-intensive products. In all three cases, however, another part is most plausibly attributed to stricter environmental regulation and rising abatement costs. The energy price shock may also have had an impact, but our regression results for Japan cast some doubt on this hypothesis.



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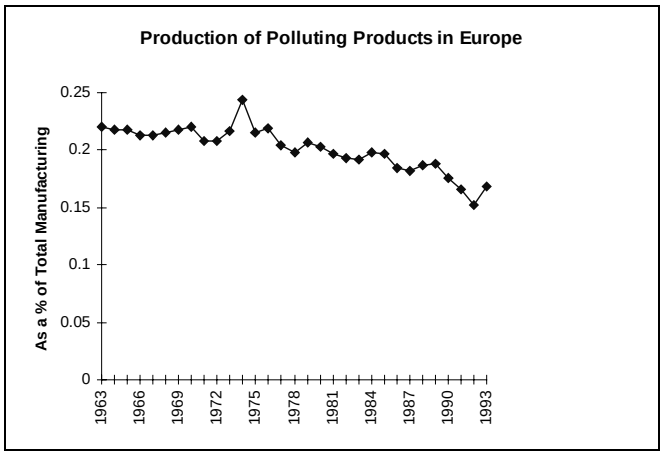

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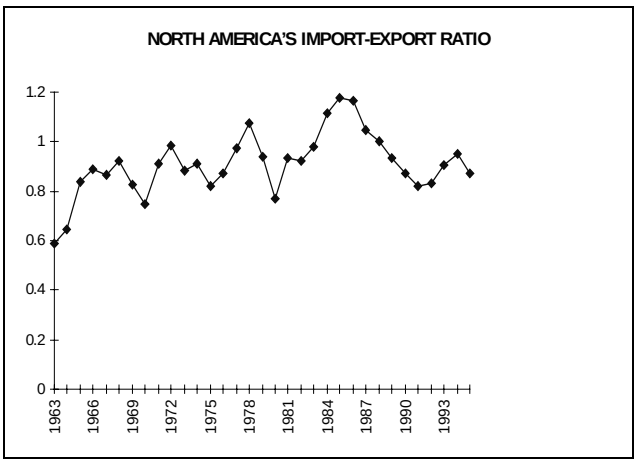

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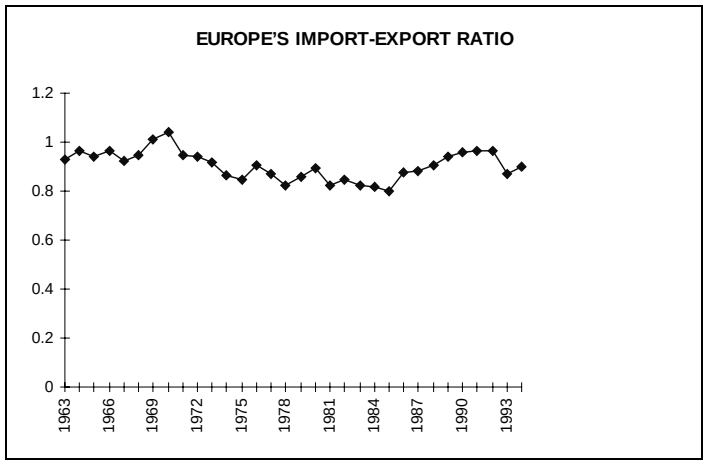

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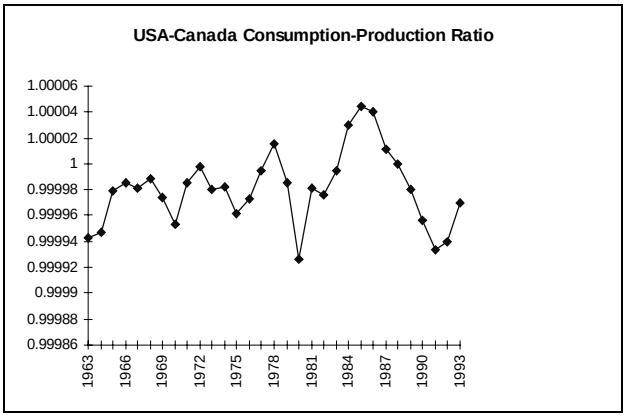

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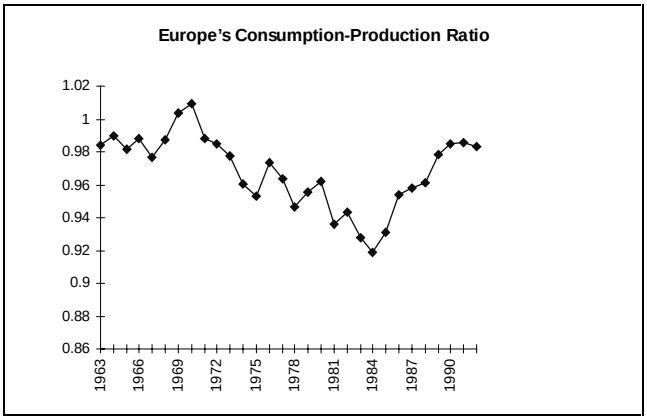
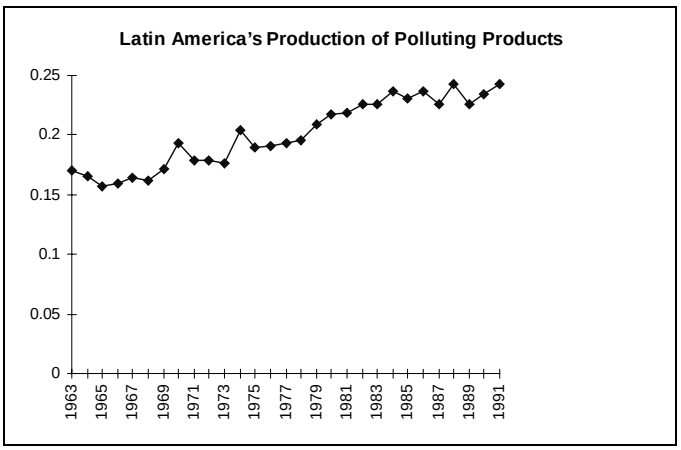


Figure 18

5. Pollution-Intensive Production in Developing Asia and Latin America

5.1 The General Story

The international impact of regulation, income growth and (perhaps) energy price changes are strikingly illustrated by the juxtaposition of OECD trends with Figures 19-22 for Latin America and Asia.[5] For these developing regions, the graphs show a steady upward trend in pollution-intensive production share - a mirror image of the downward trends in North America, Europe and Japan. Superposed on this steady increase are pronounced turning points in Latin American and Asian import/export ratios in the mid-1970's. Latin America exhibits a rising trend beforehand, a steep fall afterwards, and a levelling in the 1980's. The Asian series also exhibits a sudden shift downward in the mid-1970's, but approximate constancy otherwise.



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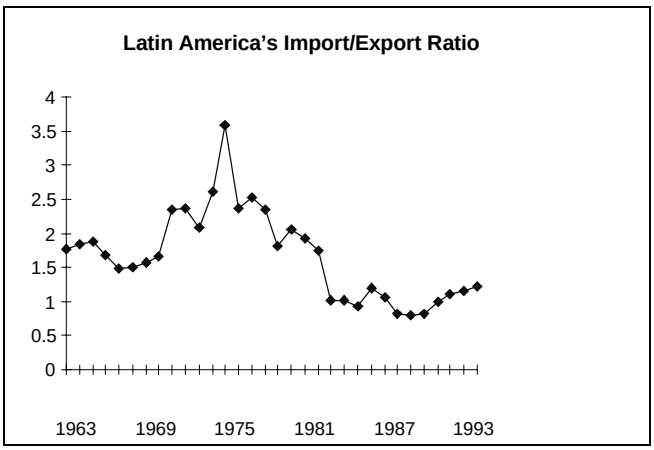

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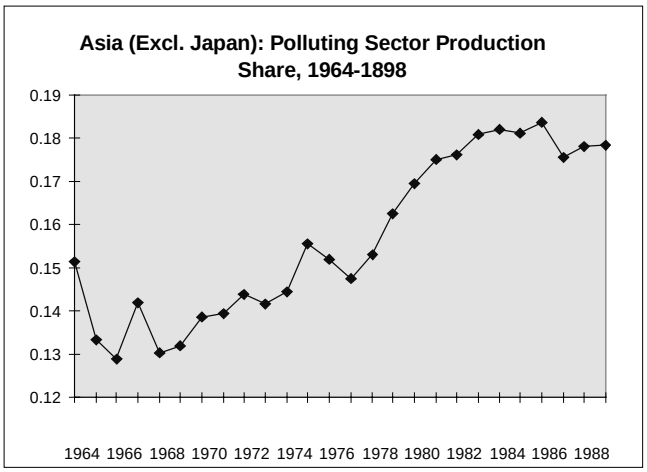

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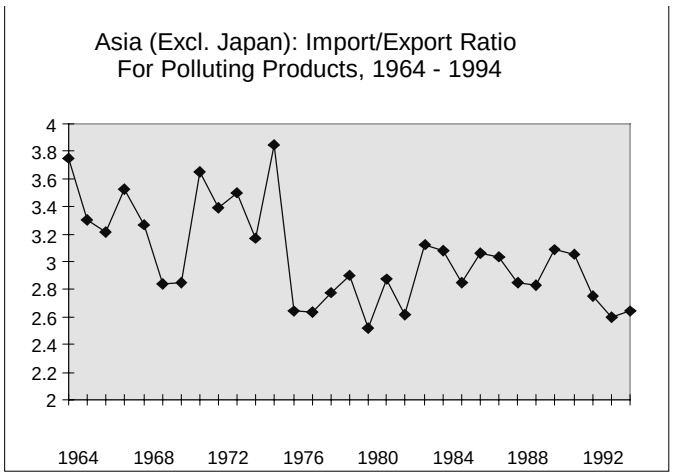

Figure 22

5 We do not have complete data series for all Asian countries for the entire period. Our Asia series in Figure 16 includes data for Korea, Singapore, Pakistan, Philippines and India.

Although other interpretations are doubtless possible, these data are consistent with the following argument: During the 1960's, rapid growth in all regions coincided with relatively weak environmental regulation in the OECD economies and low, stable energy prices world-wide. During this period, domestic income elasticity effects were dominant: Relative demand for pollution-intensive basic products such as metals, chemicals, paper and cement fell in the OECD economies and grew at least as rapidly as domestic production in the poorer nations of Asia and Latin America (apparently more rapidly in the latter).

When the environment/energy shock hit in the mid-1970's, the sudden shift in relative prices changed conditions very significantly at the margin. From a position as net importers of pollution-intensive goods (with imports at three times the level of exports), Latin America and Asia experienced a rapid decline in import/export ratios as weaker regulation and, possibly, lower energy prices altered comparative advantage in dirty-sector production. During this period, changes in relative costs augmented the income elasticity effect: Pollution-intensive production grew faster in the developing regions, and receded more quickly in the industrial economies, than could have been predicted from income change alone.

By the mid-1980's, three mitigating factors had again changed the picture significantly. First, as income growth continued, the more industrialised (and polluted) economies of Latin America and Asia probably experienced some decline in the income elasticity of demand for dirty-sector production. Second, rising consciousness of environmental problems led to enactment and enforcement of stricter environmental regulations in both Latin America and Asia.[6] Third, the energy price gap narrowed as world petroleum prices stabilised and developing countries began abandoning energy subsidies. As a result of these three changes, the share of dirty-sector production stopped increasing and import/export ratios stopped decreasing in both regions. Latin America's import/export ratio stabilised near unity (balanced trade), while Asia remaining a significant net importer of pollution-intensive products.

5.2 Asian Sub-Regions

We turn to Asia for a more detailed analysis of historical trends because its recent growth experience has included rapid transitions in income and economic structure for a number of countries. These raise the possibility of rapid change in locational advantage for pollution-intensive sectors, and in fact the data suggest that such transitions actually occurred. For our analysis, it is convenient to group the Asian economies into three categories (see Table 3):[7] the Newly Industrialising Economies (NIE's -- Hong Kong, Singapore, Korea, Taiwan); Developing East Asia (DEA -- Malaysia, Indonesia, Thailand, Philippines and China); and South Asia (SA -- India, Pakistan, Bangladesh, Sri Lanka).

Tables 2-3 and Figure 23 provide comparative evidence on economic growth, degree of openness (by the Summers-Heston measure[8]) and the timing of environmental regulation during the past three decades. The NIE's were relatively open in 1970, at the beginning of the environmental era and were already experiencing rapid growth; DEA began liberalising significantly and growing rapidly in the 1970's. Stricter enforcement of environmental regulation began in the 1970's in the NIE's and the 1980's in DEA. SA began more rapid growth in the 1980's, but stricter environmental regulation was delayed until the 1990's.

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6 For a detailed analysis, see Wheeler and Mody (1992).

7 Data were not available for the other Asian developing economies.

8 Summers-Heston openness index is defined as (exports + imports)/nominal GDP.

Table 2. Openness and Economic Progress in selected developing countries in Asia and Latin America

	Openness	Economic Progress		
	Degree of openness	Average annual growth of GNP per capita (percent)	People living on less than $1 a day (percent)	Average annual growth of exports (percent)
	1990[a]	1970-1995	1981-95	1980-95
East Asia				
China	25.4	6.9	29.4	12.5
Indonesia	52.6	4.7	14.5	10.6
Korea	62.5	10.0	--	11.6
Malaysia	154.20	4.0	5.6	13.6
Philippines	61.5	0.6	27.5	5.3
Thailand	75.8	5.2	0.1	16.7
South Asia				
Bangladesh	26.9	1.5	--	10.1
India	18.8	2.4	52.5	6.5
Pakistan	35.0	2.9	11.6	9.1
Sri Lanka	67.4	3.2	4.0	11.5
Latin America				
Brazil	12.6	--	28.7	6.3
Chile	65.5	1.8	15.0	7.3
Colombia	35.4	1.9	7.4	8.1
Mexico	32.7	0.9	14.9	13.0
Peru	26.8	1.1	49.4	2.4
Venezuela	59.6	1.1	11.8	1.0

-- Not available.

a. Summers-Heston openness index defined as (exports + imports)/nominal GDP.

Source: World Bank 1997.

Table 3: Initial National Environmental Legislation in Asia

Country	Air	Water	Toxics
Japan	1967	1958	1958
NICs			
Hong Kong			
Singapore	1978	-----	-----
Korea			
Taiwan	1975	-----	
Developing East Asia			
Malaysia	1977	1977	1979
Indonesia	1988	1988	-----
Thailand	1975	1975	1989
China	1985	1985	1989
Philippines			
South Asia			
India	1974	1981	1986
Pakistan	1983	1983	-----
Bangladesh	-----	-----	-----

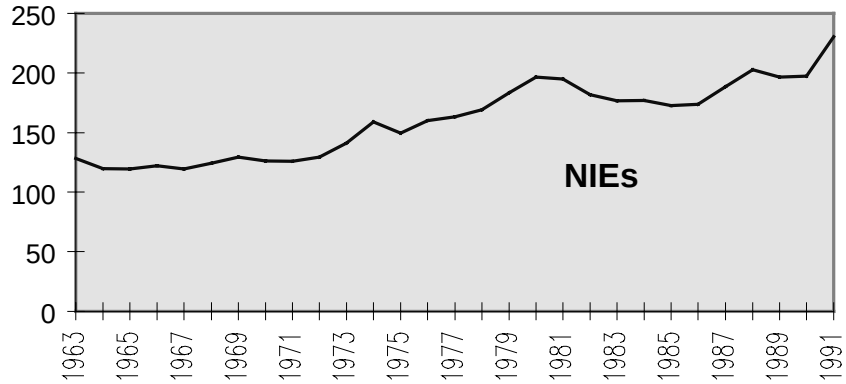
Source: Brandon and Ramankutty (1993)

Across the three regions, the growth experience of pollution-intensive industry seems to reflect these developments in a 'cascading' pattern. Figures 24-30 show changes in dirty-sector production shares and import/export ratios. The dirty-sector share grew in all three regions during the 1970's; it levelled off in the NIE's and DEA, but continued rising in SA. The NIEs' dirty-sector import/export ratio fell sharply during the 1970's. When regulation tightened and the NIEs' ratio levelled off in the early 1980's, it began falling in DEA. As regulation tightened in DEA during the late 1980's, the import/export ratio began falling in SA.

To summarise, for dirty-sector production in Asia we see an adjustment pattern which looks like a 'cascading pollution havens' story. It begins in Japan in the early 1970's, and continues for two decades in the NIE's, DEA and SA. However, in each region it has remained a markedly short story. In the NIE's and DEA, the combined effect of regulation and falling demand elasticity has apparently stabilised the dirty-sector production share, leaving both regions (and SA) as net importers of pollution-intensive products.

The same story is reflected in the historical pattern of consumption/production ratios (Figure 31). Although they have declined for over two decades in both DEA and SA, they remain above one in all three regions. In fact, all the ratios have been very close to one during the entire period. Thus, our 'cascading' dirty-sector production story has been a decidedly marginal affair.

OPENNESS IN ASIA



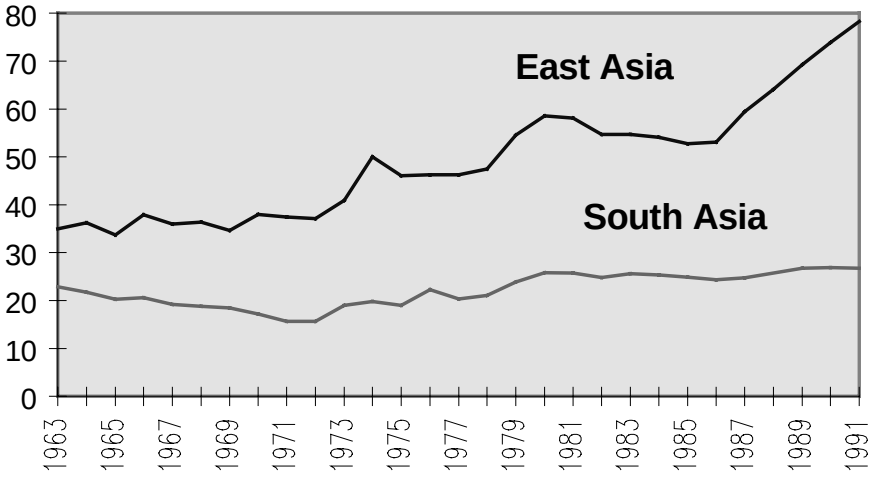


Figure 23

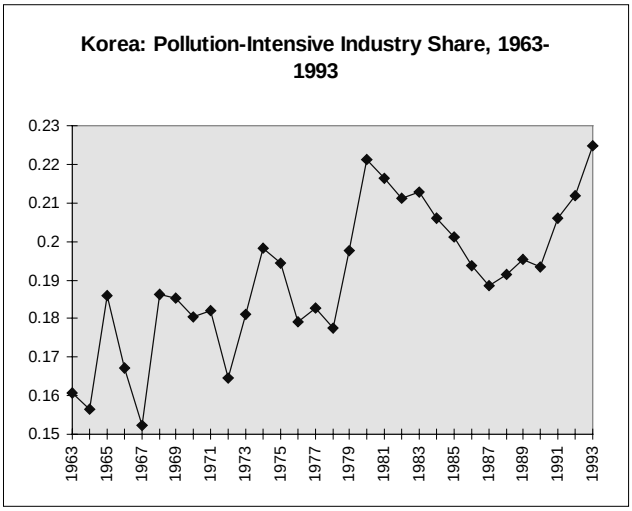


Figure 24

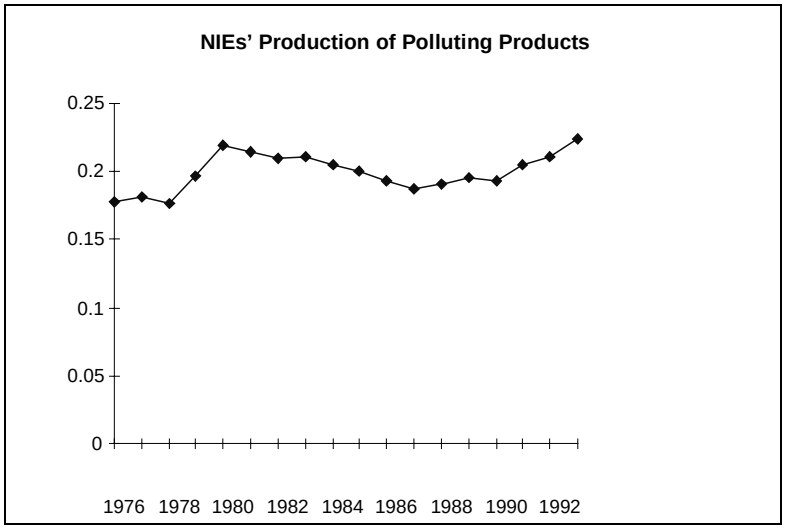


Figure 25

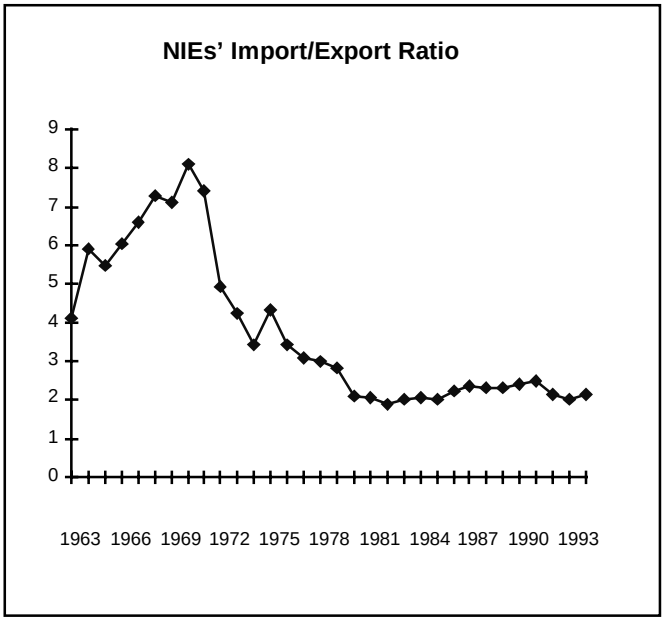


Figure 26

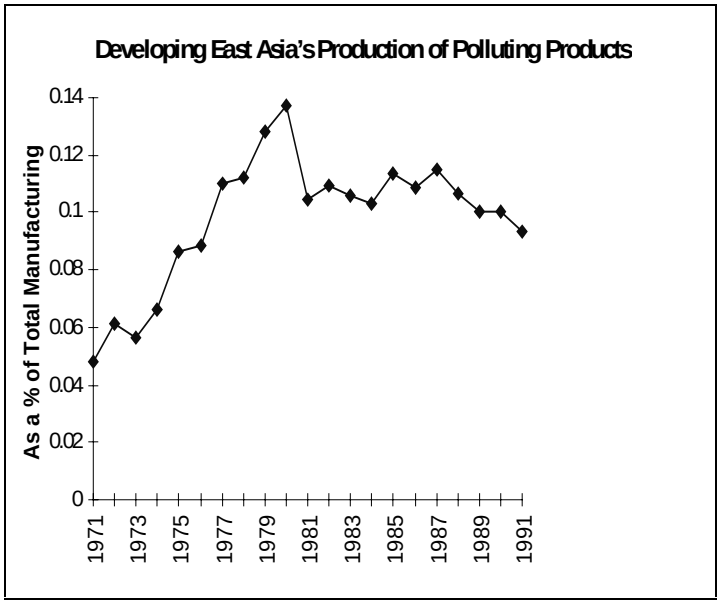


Figure 27

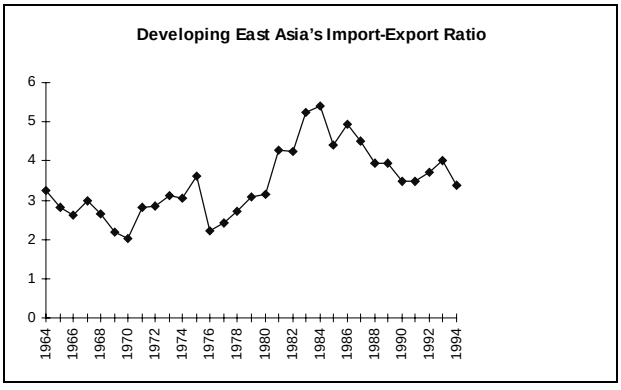


Figure 28

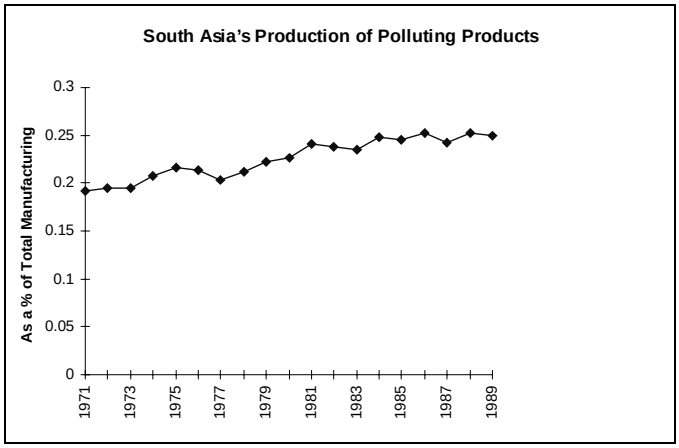


Figure 29

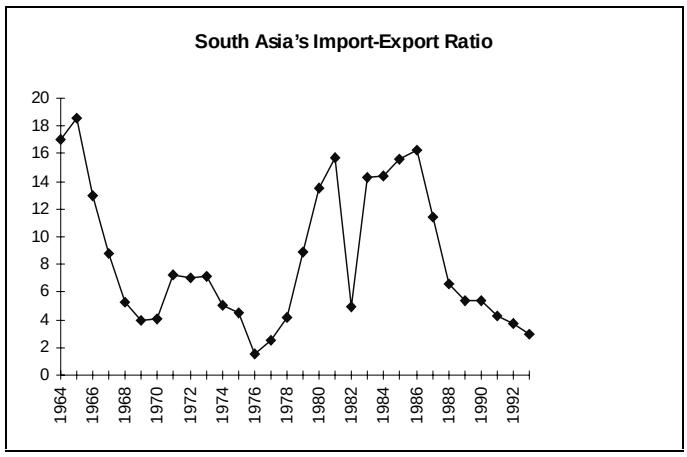


Figure 30

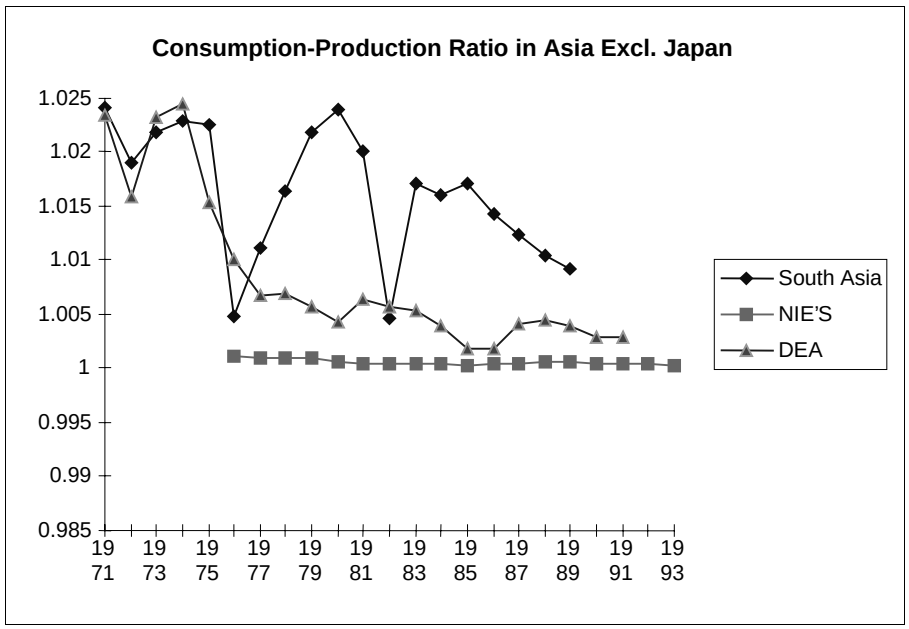


Figure 31

6. Conclusions and Implications

The last three decades have witnessed rapid economic development, particularly in countries which have pursued relatively open economic policies. Rising environmental awareness in the 1960s also led to a rapid tightening of pollution regulation in the industrial economies. This created an international gap in environmental pricing between industrial and developing economies in the 1970s. According to the pollution havens hypothesis, the result should have been more rapid growth of dirty industries in unregulated economies which were open to international trade.

In this paper, we argue that a full understanding of the pollution havens problem requires good evidence about the interactions linking economic development to regulation, industrial location, sectoral pollution intensity, energy and other input prices. Most of the previous studies have focused on the location issue, typically suppressing the other factors by lumping countries into simple 'developed/developing' categories and basing conclusions on sectoral changes evaluated at constant (generally U.S.-based) abatement expenditures. In addition, the locational analyses have typically not considered many of the standard location factors in drawing inferences about the impact of differential regulation and abatement costs.

Although data restrictions have prevented us from incorporating some of the factors mentioned here, our(as we have shown for Japan) results do point to some interesting findings and implications for future research and policy analysis.

Our cross-country analysis has found a pattern of evidence which does seem consistent with the pollution havens story: Pollution-intensive output as a percentage of total manufacturing has fallen consistently in the OECD and risen steadily in the developing world. Moreover, the periods of rapid increase in net exports of pollution-intensive products from developing countries coincided with periods of rapid increase in the cost of pollution abatement in the OECD economies.

However, our evidence also shows that pollution haven effects have not had major significance, for several reasons. First, consumption/production ratios for dirty-sector products in the developing world have remained close to unity throughout the period; most of the dirty-sector development story is strictly domestic. Second, a significant part of the increase in dirty-sector production share in the developing regions seems due to a highly income-elastic demand for basic industrial products. With continued income growth, this elasticity has declined[9]. Third, some portion of the international adjustment has probably been due to the energy price shock and the persistence of energy subsidies in many developing countries. These subsidies have been on the wane for a decade. Finally, environmental regulation increases continuously with income and seems to have played a role in the shift from dirty to cleaner sectors.

Thus, any tendency toward formation of a pollution havens seems to have been self-limiting, because economic growth brings countervailing pressure to bear on polluters through increased regulation, technical expertise, and 'clean sector' production. In practice, pollution havens have apparently been as transient as low-wage havens.

In closing, it is worth asking whether these results are a cause for of optimism or pessimism about the relationship between economic development and environmental quality. The appropriate answer seems to be 'both'. It is comforting to see that industrial pollution levels off or declines in richer countries, because pollution intensity has an elastic response to income growth. In addition, our results suggest that

[9] Dasgupta, et. al. (1995) also find a very strong, monotone increasing relationship between national income per capita and the strictness of environmental regulation.

pollution haven effects have been transient and relatively unimportant. It is clear that no feasible trade policy could 'neutralise' this effect. Cross-country differences in environmental regulation reflect a broad continuum of experience, and the domestic impacts of regulation dwarf international displacement impacts.

However, the evidence suggests that something like a pollution havens effect is real, even if it has been transient for many countries. The results, however, also suggest there will be some countries that lag behind in their efforts to control pollution now and may even take years to catch-up with the rest of the world. This also rises serious issues about continued existence of polluted waterways and lands left behind by itinerant dirty industries, and their legacy will remain for generations.

What, if anything, then should the industrial countries or rest of the world do about this disparity? Our results cast strong doubt on the wisdom of intervention through trade-related measures. The continuous, smooth relationship between income growth and environmental performance shows that developing countries are already making social choices which reflect the calculus of benefits and costs. Countries become less polluted as rising incomes makes a cleaner environment more desirable and affordable. Fortunately, there are progressive alternatives to heavy-handed intervention: The positive alternative to heavy-handed intervention lies in aiding activities to finance pollution control training; the transfer of cost-effective pollution control technologies; and appropriate information systems for regulation and public dissemination of environmental information. At each level of development, such assistance can help developing countries move closer to locally-appropriate levels of pollution control. Ultimately, income growth will be the answer. As developing economies prosper and tighten their regulations, we are confident that the shadow of pollution havens will recede to insignificance.

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