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GROW NOW/CLEAN LATER, OR THE PURSUIT OF SUSTAINABLE DEVELOPMENT?

by

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RÉSUMÉ

En comparant des pays appartenant à deux régions différentes mais qui se sont toutes deux industrialisées rapidement — l'Asie de l'Est et l'Europe de l'Est —, ce document contribue au débat actuel sur les relations entre croissance économique et environnement. Il démontre notamment l'importance de mesures économiquement saines pour favoriser l'utilisation efficiente des ressources. Mais il ressort également de la comparaison de plusieurs pays d'Asie de l'Est que des mesures économiques ne sauraient suffire. En effet, une croissance urbaine et industrielle rapide peut gravement porter atteinte à l'environnement si des politiques environnementales contraignantes et exécutoires ne sont pas adoptées.

Le document traite donc en fait indirectement de la question suivante : quels sont les avantages et les inconvénients d'effectuer tardivement dans le processus de développement les dépenses de préservation de l'environnement, à la manière des économies hautement performantes d'Asie de l'Est ? Il apparaît que les pays qui ont investi très tôt pour améliorer la qualité de l'environnement n'ont pratiquement pas été pénalisés en termes de rythme de croissance. A l'inverse, les pays d'Asie de l'Est qui ont retardé les dépenses environnementales doivent non seulement supporter aujourd'hui les coûts des dégâts accumulés, mais aussi s'apprêter à investir lourdement et à brefs délais dans la protection de l'environnement. Reste à savoir si ces dépenses vont menacer sérieusement les perspectives de croissance. Les derniers venus à la protection de l'environnement bénéficient toutefois d'un avantage : les coûts unitaires de dépollution décroissent généralement dans le temps du fait des progrès techniques.

SUMMARY

This paper is a contribution to the ongoing debate on the relationship between economic growth and the environment. Through a contrast of the experiences of two regional groupings of countries — East Asia and Eastern Europe — that have both experienced rapid industrialisation, it makes clear the importance of sound economic policy in encouraging efficient resource use. At the same, by contrasting the experiences of different East Asian countries, it demonstrates that economic policy is not sufficient. In the absence of reinforcing and enforceable environmental policies, rapid urban and industrial growth can cause severe environmental degradation.

The paper addresses indirectly the question: what are the costs and benefits of delaying environmental expenditures until late in the development process as some of the high performing East Asian economies have done? It finds that those countries which invested early in environmental improvements experienced virtually no trade-off in slower growth. On the other hand, those East Asian countries that postponed environmental investments not only have had to shoulder sizeable cumulative damage costs but must now contemplate high levels of environmental investment for the foreseeable future. Whether these will have a significant adverse effect on their growth prospects remains to be seen. One factor working to the advantage of "late abaters" is that the unit costs of pollution abatement should generally fall over time with technological innovation.

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PREFACE

This paper fills a gap in the literature on the East Asian 'miracle' by examining whether the fast-growing Asian economies have made sustainable use of their environmental resources. Like most other developing countries, those of East Asia have pursued a "growth first" strategy, but unlike most others they have succeeded spectacularly. The very same policies which yielded high growth have also achieved significant poverty reduction and, in some countries, improvements in income distribution as well. The paper argues that, in addition, those policies have been relatively benign for the environment: they have encouraged efficient resource (including energy) use and the adoption of up-to-date and therefore less polluting technologies.

However, rapid growth has created serious environmental pressures of two sorts: first, by virtue of the sheer scale and, in some cases, geographic concentration of industry and related economic activities; second, because generations of environmental problems appear in rapid succession and thus partially overlap. In consequence, those East Asian countries which had hoped simply to grow out of environment problems appear instead to be growing into them. It remains to be seen whether those which delayed decisive environmental measures will be penalised by slower growth in the future. What seems clear from the historical evidence is that those countries which addressed environmental problems early on did not pay a significant price in slower growth.

The present analysis offers some encouragement to those countries that are still at an early stage in their industrial transformation. It indeed shows that early attention to environmental consequences of growth need not imply slow growth. On the contrary, failure to anticipate those consequences and to avoid getting locked into environmentally destructive patterns of development can prove very costly at a later date. As the paper points out, however, the magnitude of environmental damage costs incurred in the High Performing Asian Economies (HPAEs) and in other developing countries is a topic which has only begun to be explored in the literature. Also, the relationship between the cost of environmental improvement, and the type of policy chosen (regulatory or economic instruments or a mixture of both) calls for further research.

Jean Bonvin
President, OECD Development Centre
March 1996

I. THE ENVIRONMENT-GROWTH TRADEOFF: *QUOI DE NEUF?*

This paper explores a neglected aspect of the "East Asian miracle", viz., how the so-called high-performing East Asian economies (HPAEs[1]) made use of their environmental resources in the course of rapid industrial development. The principal policy question the paper seeks to answer is the following: if a government were interested in emulating the East Asian growth strategy today, what might it learn from the East Asian experience about how (or how not) to manage the environment?

The paper is structured as follows. In the remainder of this section, we present the main theoretical arguments about the relationship between growth and the environment, as well as some empirical evidence bearing on that relationship. In section 2, we consider the environmental dimension of the growth process in East Asia, comparing it and contrasting it with the experience of certain OECD countries and Eastern European countries. Evidence on relative pollution intensity and energy intensity is reviewed. Also of interest is whether there is a significant difference in the pattern of environmental resource use between the early East Asian industrialisers (Japan and the four dragons — Hong Kong, Korea, Chinese Taipei, and Singapore) and the later ones (Indonesia, Malaysia and Thailand). Section 3 then briefly reviews estimates of the environmental damage costs incurred by certain of the East Asian economies, and how these relate to actual measured output. Section 4 examines evidence on environmental expenditures in these countries, both actual and projected. Ideally one would like to compare countries in terms of the unit pollution abatement costs associated with different time profiles of abatement, but the available data does not yet permit this. Finally, in section 5, some lessons are distilled for today's and tomorrow's late industrialisers in the region — China, India, Viet Nam and others.

While it is not inaccurate to describe the East Asian strategy as one of "growth first", this is not an adequate description, not least because it does not differentiate it from the strategies pursued by many other developing countries — and, for that matter, by most OECD countries in an earlier era. In short, there are different ways to put growth first, and far too many countries have succeeded neither in growing very fast nor in protecting their environments. The Eastern European and Soviet development model provides one example, about which more will be said momentarily. By the same token, it is possible that a development strategy can both yield high growth and be relatively environmentally benign. The "relatively" needs to be stressed, because high economic growth will almost certainly place stresses on the environment simply by virtue of the expanding scale of economic activities, not to mention their growing concentration in urban-industrial centres. How benign depends on a variety of factors, including economic policies that may affect patterns of structural change and of resource use as well as policies explicitly aimed at environmental protection. It will be argued here that, while the East Asian economies have done quite well in implementing economic policies that encourage less environmentally damaging patterns of development, not all have been effective in the area of environmental policy per se. Thus, while the HPAE industrialisation experience compares favourably, say, to that of Eastern Europe, in terms of avoiding environmental excess, rapid growth has nonetheless created serious environmental stresses to which some countries have responded earlier and more effectively than others.

Earlier analyses of the East Asian growth experience have pointed to the rapid turnover and the recent vintage of their capital stocks as a potential environmental advantage, on the grounds that newer capital equipment is often less polluting than older equipment (see O'Connor 1994). Thus, even without explicit policies to ensure that industries comply with certain emission/effluent standards, the pollution coefficients built into the new equipment installed by expanding industries should ensure relatively low emission/effluent intensities. Even granting this, the effects of the scale of economic activities on pollution levels would still need to be addressed through explicit policies. Pollution loads can increase very rapidly when economies are sustaining growth rates in the range of 10 per cent per year, especially with the high income elasticities of demand for certain polluting products like automobiles. Before governments have been able to come to grips with one set of environmental problems, others loom on the horizon.

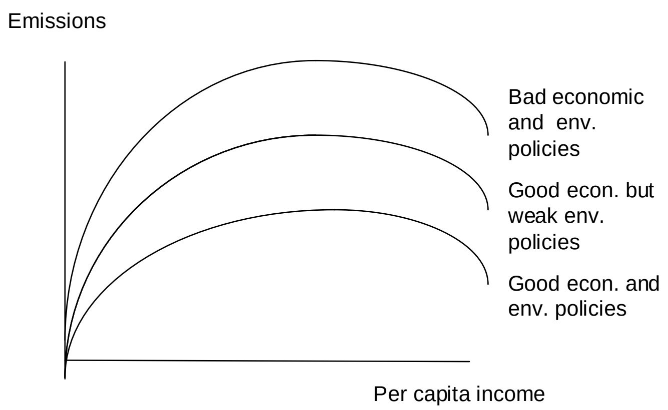
Environmental Indicators and Per Capita Income

The grow now/clean later strategy implies a time profile of pollution in which rising per capita income is accompanied at first by deteriorating environmental quality up to some threshold income beyond which structural change and rising environmental expenditures check and begin to reverse that deterioration. Recent work on the environment-income relationship (see for example Shafik and Bandyopadhyay 1991, Grossman and Krueger 1991, and Grossman 1994) provides some support for this inverted-U-shaped functional relationship, though with notable exceptions[2]. Some environmental measures steadily improve with per capita income (e.g., access to sanitation and safe drinking water) and others begin to show improvement from rather low per capita income levels (like suspended particulates in air). Other indicators show the inverted-U-shaped relationship: an initial deterioration, then a levelling off, followed by gradual improvement [e.g., sulphur dioxide and carbon monoxide levels in air, biological oxygen demand (BOD)[3] /chemical oxygen demand (COD) and faecal coliform in water]. Still others show steady deterioration with rising income (carbon dioxide emissions and per capita waste generation).

No attempt is made in this paper to estimate these pollution-income relationships for the HPAEs, but the trends in environmental quality sketched in the next section (and discussed in more detail in Annex A) appear broadly consistent with the patterns observed in the multi-country studies just cited. From the perspective of the HPAEs, the analysis would seem to suggest that, by virtue of their high growth rates, they have been (or should be) able to move faster than other countries from the upward-sloping portion onto the downward-sloping portion of their inverted-U-shaped pollution curves[4] (see Figure 1). By the same token, their rapid growth implies that pollution levels may rise very quickly in a relatively short time as countries climb the curve. What is not known *a priori* is whether because of either the rate or the pattern of growth the peaks of those curves tend to be higher/lower in the HPAEs than in other countries.

One plausible hypothesis is that the position of the curve is a function of the combination of economic and environmental policies pursued. Figure 1 plots out three possible pollution trajectories, corresponding to three different policy combinations. The highest pollution curve occurs in countries with unsound economic policies (e.g., generous energy and other resource subsidies, policies favouring heavy industries, etc.) and ineffective environmental policies. (Perhaps pre-reform Eastern bloc countries come closest to fitting this description.) The lowest curve occurs in countries with sound economic policies and effective environmental policies. Among the HPAEs, Japan and Singapore come closest to fitting this description; Hong Kong and Malaysia are perhaps not too far behind. The middle curve occurs in those countries which have sound economic but inadequate environmental policies (to varying degrees, the other HPAEs).

Figure 1: Alternative Pollution Trajectories



II. THE ENVIRONMENT IN THE EAST ASIAN "MIRACLE"

The economic results of the East Asian growth strategy are by now well known. Numerous attempts have been made to "explain" this success, most recently by the World Bank in its 1993 *East Asian Miracle* study. While that study discusses the contributions of capital and human resources to East Asian growth, there is no discussion of the contribution of environmental resources. In one sense, the omission may not matter. One might argue that, if per capita income growth of 5.5 per cent a year can be sustained over a quarter of a century, the question of whether that growth is "sustainable" is a moot one. This argument is not entirely persuasive, however. Consider how a policy maker in Thailand or Indonesia (or even Korea or Malaysia) might react to the proposition that by pursuing a certain growth strategy the country could ensure 5 per cent plus per capita GDP growth for a quarter of a century, after which it would need to settle for (near) zero growth. When one considers that, in purchasing power terms, in 1993 Indonesia's per capita income was only about one-eighth that of the United States, Thailand's one-fourth, and Malaysia's one-third, this does not appear a particularly appealing proposition (Table 30 of the *World Development Report 1995*). One question of interest then is whether unusually high growth over the last quarter century has been "bought" at the expense of slower-than-usual growth in the future. Two factors might contribute to a significant slowing of growth: rapidly escalating external costs from accumulated pollution damage and/or rapidly escalating investments in remediation of that damage. Another way of phrasing the question would be to ask whether certain of the East Asian economies may be in danger of running up against environmental "limits to growth" before a convergence to OECD living standards has been accomplished.

There is another way of interpreting the absence of environmental considerations from discussions of the East Asian "miracle". Among the HPAEs, there has been considerable variation in the emphasis given to environmental protection, yet there has been remarkable consistency in economic performance. So, perhaps those countries that chose not to neglect their environment (or to neglect it less) while pursuing rapid growth did not face such a severe tradeoff after all. In short, it could be that the belief held by some HPAE governments that a better environment could only be bought at the expense of slower growth was simply mistaken. Singapore poses the clearest challenge to this belief. Over the last quarter century, the per capita income growth rate in Singapore has been only marginally lower than in Korea and Chinese Taipei[5,6]. Could it be that the supposed growth-environment tradeoff is relatively modest when environmental protection is pursued simultaneously with growth, but more severe when a country postpones environmental investments and thus accumulates problems for eventual clean-up? This is the familiar "an ounce of prevention is worth a pound of cure" adage transformed into a hypothesis about the optimal timing of environmental expenditures. Perhaps, the next decade or two will provide an opportunity to test the "prevention beats cure" hypothesis at the level of national economies via a comparison of the longer-term growth experience of the "early abaters" and the "late abaters".

While certain countries may be able, for political or other reasons, to ignore accumulating environmental problems longer than others, the price of doing so may well be to incur even higher clean-up costs once problems are finally recognised and addressed. The countries of Eastern Europe and the former Soviet Union would seem to provide the clearest illustration of an unsustainable growth strategy, with environmental degradation an important though not the only dimension of that unsustainability. Among the HPAEs, there is little risk of such a catastrophic outcome, in large part because their growth has not been based to nearly the same extent on underpricing of natural resources and the environment[7]. Thus, the incremental environmental damage associated with each percentage point increase in the GDP growth rate has arguably been much less in the HPAEs. Still, by hypothesis, it may make a significant difference to long-term growth prospects whether a country invests in the environment *pari passu* with high growth or whether it postpones that investment until "the morning after" growth.

Scale Effects and Structural Shifts

To frame the discussion of policy choices, it may be helpful to distinguish two aspects of growth's impact on the environment — *scale effects* and *structural shifts*. As the scale of activity expands, an economy consumes absolutely more energy and materials, generating more residuals and thus a larger potential *pollution load*. Yet, scale is not all that matters; growth can be more or less energy-intensive and more or less materials-intensive, hence, more or less pollution-intensive. *Pollution intensity* is in part a function of the structure of the economy (with some sectors generating more pollution per unit of output than others), but it is also a function of the choice of technology within any given sector (since some technologies are "cleaner" than others, and some firms may abate their pollution more than others).

Table 1 provides a broad picture of structural shifts which have occurred in several of the HPAEs over roughly the last quarter century, with several OECD countries included for comparison. The most striking changes have been the steep decline in agriculture's GDP share and the steep rise of industry's. In the case of Indonesia, for instance, industry's GDP share rose 20 percentage points over this period and in Thailand the rise was only slightly less dramatic. For those two countries, the increase in the urban share of the total population was as dramatic, with Thailand's rising from 15.1 to 35 per cent between 1975 and 1994 and Indonesia's rising from 19.4 to 32 per cent over the same period (ADB 1995). In general, rapid industrialisation and urbanisation interact in such a way that rising pollution levels affect a growing number of people. So, it is hardly surprising that cities like Bangkok and Jakarta face serious environmental pressures. The data in Table 1, however, are too broad-brush to know how the pollution-intensities of the HPAEs have evolved; for that, one needs to have more specific data on the sectoral composition of industrial output and the pollution intensities of those sectors.

Table 1: **Sectoral composition of gross domestic product (GDP)**
(percentages)

Country	Agriculture	Industry	Services	Agriculture	Industry	Services	Agriculture	Industry	Services
	1970			1983			1993		
HPAEs									
Chinese Taipei	16	37	48	7	45	48	4	41	56
Korea	25	29	46	14	39	47	7	43	50
Thailand	26	25	49	23	27	50	10	39	51
Indonesia	45	19	36	26	39	35	19	39	42
OECD									
Japan	6	47	47	4	42	55	2	41	57
Germany	3	49	47	2	46	52	1	38	61
Italy	8	41	51	6	40	54	3	32	65
UK	3	45	52	2	32	66	2	33	65

Note: In Hong Kong, services accounted for 79 per cent of GDP in 1993, up from 62 per cent in 1970; in Singapore, services accounted for 62 per cent of GDP in 1993, down from 68 per cent in 1970.

Sources: For Chinese Taipei: *Taiwan Statistical Data Book 1994,* Council for Economic Planning and Development; for other countries: World Bank (1985, 1995), *World Development Reports*, Washington, D.C.

Thus, to analyse the impacts of changing economic scale and structure on the environment, it would be desirable to have industry — and even technology —specific pollution coefficients for a whole range of pollutants. Wheeler and his team working on the World Bank's Industrial Pollution Projection System (IPPS) have been assembling just such a database (see Hettige *et al.*, 1995). Ideally, pollution intensities could be calculated based on actual firm-level emission/effluent data in each country but, barring that, pollution coefficients from one country can be transferred to another.

Changing Pollution Intensities of Industry

Lucas (1992) — using the same database as Hettige *et al.* — reports several pollution intensity indices for 34 sectors (reasonably close to the level of disaggregation in the published industrial statistics of the HPAEs). For examining acute toxicity risk, the ranking based on total releases and transfers of toxic substances[8] per million US dollars of output is used here. (N.B. Other rankings have also been calculated by Hettige *et al.*: e.g., for specific criteria air pollutants and for certain measures of water pollution; these will be referred to later.) The rankings show industrial chemicals (ISIC 3510 and 3511) to pose by far the greatest environmental risks; leather products (3230) and synthetic resins (3513) are the next most pollution-intensive sectors, with pollution intensities roughly half that of basic industrial chemicals. These are followed by plastic products n.e.c. (3560) and non-ferrous metals (3720), with pollution intensities about 30 percent of basic industrial chemicals; paper products (3410) and iron and steel (3710) follow, at between 20-25 percent of basic industrial chemicals' pollution intensity. Among the least pollution-intensive sectors are professional goods (ISIC 3850), beverages (ISIC 3130), office and computing machinery (3825), tobacco (3140), motor vehicles (3843), and food products (3110) — which range in pollution intensity from 0.6 to 2.2 percent of basic industrial chemicals.

In applying these US rankings to other countries' industrial statistics, it is necessary to bear in mind that pollution intensities of any given industry may differ somewhat across countries, depending on the specific processes and process technologies predominating. It was not possible for this paper to put together a complete set of comparable industrial statistics for all the HPAEs. Fortunately, though, the OECD's STAN industrial database contains figures for the Republic of Korea. The total production value and the production share in total manufacturing output of the most pollution-intensive and the least pollution-intensive sectors (mentioned above) were calculated for 1974, 1982 and 1990. The results are summarised in the following table:

Table 2: **Production value (bn. won) and manufacturing shares of 8 most polluting and 6 least polluting industries in the Republic of Korea**

Value of production (share of mfg.)	1974	% change 1974-82	1982	% change 1982-90	1990
8 most polluting industries	1 401	920	14 251	170	38 011
(share of mfg.) (%)	(16)		(21)		(22)
6 least polluting industries	2 497	550	16 220	150	41 591
(share of mfg.) (%)	(29)		(24)		(23)

Notes: 8 most polluting industries: ISIC 3510,3511,3230,3513,3560,3720,3410,3710
6 least polluting industries: ISIC 3850,3130,3825,3140,3843,3110
Production figures are at current prices; thus, in real terms the output growth was probably somewhat slower. It is also possible that some of the increased share of polluting industries from 1974-82 reflects relative price increases caused by rising petroleum and energy prices.

Sources: For pollution intensity indices: Lucas (1992); for industrial data, OECD (1995), *The OECD STAN Database for Industrial Analysis*, Paris.

Especially noteworthy is the significant shift in industrial structure from 1974 to 1982, with the share of highly polluting industries increasing sharply and that of less polluting industries falling. This spans Korea's heavy industry promotion phase, when government policy explicitly encouraged the development of the chemical and steel industries. Since 1982, the pollution structure of Korean industry has remained relatively stable.

Applying a different pollution-intensity index from that used by Lucas, Lu (1992) examines what has happened over the period 1964-89 to the pollution intensity of Chinese Taipei industry, concluding that it rose from 1964 to 1981 before declining slightly through 1989 (though remaining significantly above the mid-1960s level). The broad pattern of change resembles that observed in Korea over roughly the same period. The most important contributor to the changes in pollution-intensity in Chinese Taipei were the rise and (relative) decline of the chemicals and petroleum sector[9]. Also, it is worth bearing in mind that the scale of production of polluting industries continued to increase, albeit at a slower rate during the latter period. To cite just a few examples of major chemical products: from 1973 to 1983, output of man-made fibres grew by approximately 375 per cent, and from 1983 to 1993 by 170 per cent; output of polyvinyl chloride (PVC) rose by 285 per cent and 100 per cent respectively; that of polyethylene by 390 per cent and 95 per cent (Council for Economic Planning and Development 1994).

Besides toxicity-based rankings, industries are also ranked in Hettige *et al.* (1995) by their intensity in other pollutants. An interesting result is the rather high concentration of certain types of pollutants within a handful of industries. In the case of air pollution, for example, the cement, lime and plaster industry (ISIC3692) is by a very wide margin the most important source (in terms of pollutant per million $ output) of SO_2, NO_2 and particulate matter (especially PM10, the fine particulates that cause the greatest health risk). Likewise, in the case of water pollution, the pulp and paper industry (ISIC3411) is by far the most BOD-intensive industry, while iron and steel (ISIC3710) is by far the most intensive in suspended solids (SS). One should bear in mind, however, the distinction between pollution intensity and pollution load. Even if a particular industry happens to be highly pollution intensive, if it is very small it may contribute little to total pollution load. Assuming, however, that certain of these industries are sizeable ones in a particular developing country, then environmental policy may be able to accomplish significant results by focusing on a few priority industries.

A few figures from Korea and Chinese Taipei on these air- and water-polluting industries tend to corroborate the earlier story with regard to toxic pollutants, namely, that the 1970s were a decade of somewhat more rapid growth in polluting industries than the 1980s. Even so, for some polluting industries, slower growth from a larger base translated into a sizeable absolute increase in production volume. For example, in Korea, cement production rose by 175 per cent from 1972 to 1982, and then by 150 per cent in the following decade; in tonnage terms, however, the increase in the latter period was more than double that in the earlier one. Similarly, despite a much reduced growth rate, the tonnage increase in steel ingot production 1982-92 was more than double the increase 1972-82. In Chinese Taipei, cement production (in metric tonnes) rose by 130 per cent 1972-82 but by only 60 per cent 1982-92 (though in tonnage terms the increase was roughly the same in the two periods). As for steel bars, the rate of increase dropped steeply from the earlier to the later period, but in tonnage terms the increase 1982-92 was well over double the 1972-82 increase. The slowdown in the rate of growth of pulp and paper production from the earlier to the later period was of similar magnitude for both Korea and Chinese Taipei (UNESCAP 1995 and Council for Economic Planning and Development 1993).

The principal unknown is what has happened to process technology in these and other polluting industries in the HPAEs over the last two decades. In the case of steel production, the main question is whether there has been a significant shift towards continuous casting and electric-arc furnaces, which represent relatively clean processes compared to basic oxygen steel making. In the case of pulp and paper, the question is the changing weight of thermomechanical wood pulping relative to chemical pulping. While data on technology choice in specific HPAEs are not available, econometric analysis by Wheeler, Huq and Martin (undated) based on data for the steel and pulp and paper industries suggests that there has been a significant shift to cleaner processes over the last two decades, particularly in steel; while this has occurred in developing countries as a group, it has occurred at a significantly faster pace in open economies (which include HPAEs Japan, Korea and Chinese Taipei), than in closed ones.

A recent study (see World Bank 1994a) has examined the changing pollution intensity and pollution load of Indonesian industry. It distinguishes between processing industries and assembly-type industries, calculating the pollution intensities of the two groups with respect to several air and water pollutants. With the exception of volatile organic compounds (an air pollutant) and BOD (a water pollutant), processing industries as a group are significantly more pollution-intensive than assembly-type industries. As processing industries have been growing more slowly than assembly-type industries in recent years, the overall pollution intensity of Indonesian industry has declined since 1970. Yet, over this period, the total pollution load has grown rapidly with the 8-fold increase in industrial output. Moreover, through the next 25 years, pollution loads are projected to rise steeply (in a business-as-usual scenario), with BOD load increasing 10-fold even though BOD-intensity is projected to register the steepest decline. Total loads of other pollutants are projected to rise even more quickly, with sulphur dioxide (SO_2) and suspended particulates in air increasing 13-fold and 15-fold, respectively, and bioaccumulative heavy metals (e.g., lead and mercury) increasing up to 19-fold.

The overall picture which emerges from the preceding discussion is one in which, for the most part, the pollution-intensity of the HPAEs has been declining or at least relatively stable in the last decade to decade-and-a-half. Nevertheless, the rapid growth in the scale of economic activities continues to exert strong pressures on environmental resources. As can be seen from Annex A, however, in the case of some countries and some pollutants, countermeasures have begun to stabilise or even reduce ambient pollution levels.

Energy Consumption Patterns

Since much air pollution results either directly or indirectly from the burning of fossil fuels, energy consumption data can provide at least a rough indication of which countries have potentially serious air pollution problems. Clearly many factors must be taken into account before a close link can be established between energy consumption and air pollution (geographical distribution of power generation and energy use, energy and fuel mix, physical and chemical properties of the fuel, climatic conditions, abatement technologies, etc.). Nevertheless, a comparison of energy consumption patterns in the HPAEs with those in OECD countries and in Eastern Europe is instructive.

Table 3 provides data on growth in commercial energy consumption by several HPAEs over the decade 1971-91. During this period, recall, per capita GNP in the HPAEs as a group (including Hong Kong) was growing by over 5 per cent per annum[10]). With this rapid growth it is not surprising that total energy consumption was also rising rapidly. Note also that those countries which started with the lowest income levels and per capita energy consumption also tended to experience the most rapid growth. Yet, despite rapid growth in energy consumption for a generation, by 1991 only Singapore and Japan (the two countries with the slowest energy demand growth) had per capita consumption higher than Europe's.

Table 3. **Commercial Energy Consumption, 1971-91**

	Total:		Per Capita:		Per constant 1987 $US of GNP:	
	Peta-joules 1991	Percent change since 1971	Giga-joules 1991	Percent change since 1971	Mega-joules 1991	Percent change since 1971
Japan	17384	78	140	52	6	-25
Indonesia	1914	337	10	187	20	24
Korea	3821	254	87	164	21	-35
Malaysia	825	344	45	169	19	14
Singapore	467	145	171	89	16	-46
Thailand	1281	425	23	249	18	28
Asia	80374	238	25	129		
Europe	68507	163	134	142		
World[a]	321430	45	60	...		

Note: [a] 'Europe' includes both OECD Europe and Central and Eastern Europe.

Source: World Resources Institute, *World Resources 94-95*, Oxford University Press, New York, 1994.

Table 4 provides a more detailed comparison of energy consumption for the HPAEs, selected OECD countries and selected Eastern European economies in transition.

The per capita income levels in Chinese Taipei and Korea as of 1992 were very similar (in purchasing power terms) to the income levels in Japan, the UK and Italy in 1973. Chinese Taipei's 1992 energy intensity of GDP was also quite close to the UK's (and Germany's) of two decades earlier. Korea, on the other hand, had an energy intensity of GDP significantly higher than those of the UK and Germany. On a per capita basis, Chinese Taipei and Korea's energy consumption levels in 1992 were between those of Italy and Japan in 1973.

Table 4. **Energy consumption at different levels of real per capita income, selected HPAEs, OECD countries and Eastern European countries**

Country	PPP per capita income (US$)	TPES/ GDP (TOE/ '000 US$)	TPES/ Pop. (TOE/ capita)	PPP per capita income (US$)	TPES/ GDP (TOE/ '000 US$)	TPES/ Pop. (TOE/ capita)	PPP per capita income (US$)	TPES/ GDP (TOE/ '000 US$)	TPES/ Pop. (TOE/ capita)
		1973			1983			1992	
HPAEs									
Chinese Taipei	3 669	0.40	0.85	6 372	0.34	1.62	11 590	0.30	2.60
Korea	2 840	0.43	0.64	4 991	0.47	1.15	10 010	0.39	2.60
Thailand	1 750	0.35	0.22	2 621	0.28	0.27	4 694	0.37	0.63
Indonesia	1 538	0.26	0.07	1 938	0.39	0.18	2 749	0.52	0.34
OECD									
Japan	11 017	0.21	2.98	14 093	0.16	2.81	19 425	0.15	3.64
Germany	13 152	0.30	4.28	15 545	0.26	4.29	19 351	0.20	4.23
France	12 940	0.22	3.39	15 388	0.19	3.39	17 959	0.19	3.99
Italy	10 409	0.19	2.38	13 225	0.15	2.33	16 229	0.14	2.80
UK	11 992	0.31	3.93	13 299	0.25	3.43	15 738	0.23	3.70
Spain	8 739	0.17	1.51	9 601	0.18	1.81	12 498	0.19	2.41
Eastern Europe									
Bulgaria	5 284	...	2.37	6 238	1.68	3.37	4 054	1.18	2.35
FCSR[a]	7 036	...	4.06	8 133	1.49	4.69	6 845	1.40	3.84
Hungary	5 596	...	2.06	6 519	0.91	2.69	5 638	0.87	2.43
Poland	5 334	...	2.69	5 498	2.02	3.17	4 726	1.63	2.49

Notes: TPES = Total primary energy supply (indigenous production + imports - exports - international marine bunkers ± stock changes)
All PPP per capita GDP figures are in 1990 Geary-Khamis Dollars; energy intensities are calculated based on GDP at 1990 prices.
[a] FCSR = Former Czech and Slovak Republic

Sources: For PPP figures: Angus Maddison (1995); for energy figures, IEA/OECD (1993, 1995a and 1995b).

There is a striking difference between the HPAEs and the Eastern European countries in terms of per capita energy consumption. In 1983, the per capita incomes of Chinese Taipei and Korea were roughly on a par with those of Eastern Europe a decade earlier; yet, their per capita energy consumption was only between one-half and three-fourths as high (ignoring the FCSR's exceedingly high figure). A decade later, in 1992, when Chinese Taipei and Korea's per capita incomes were roughly double those of Eastern Europe in 1973, their per capita energy consumption had finally reached Eastern Europe's 1973 levels (again ignoring the FCSR). Equally impressive is the wide gap between the HPAEs (and the OECD countries) on the one hand and the Eastern European countries on the other in terms of the energy intensity of GDP. In 1983, the energy intensity of Eastern European countries' GDP was anywhere from two to six times higher than that of the HPAEs. Clearly, the pattern of development has been dramatically different between the HPAEs and Eastern Europe, at least in terms of energy use.

It is also instructive to compare Thailand and Indonesia's energy use patterns with those of Chinese Taipei and Korea. In 1992, per capita income in Thailand was roughly on a par with that of Korea in 1983. Yet its per capita energy consumption was only about half Korea's of a decade earlier — this despite the fact that the share of industry in Thailand's GDP was the same in 1993 as in Korea in 1983 (see Table 1 above). So, it would appear that Thailand has pursued a somewhat less energy-intensive pattern of industrialisation. Similarly, in the case of Indonesia, per capita income in 1992 was comparable to that of Korea in 1973, but per capita energy consumption was just a little more than half Korea's of two decades earlier. Moreover, Indonesia was even more highly industrialised in 1993 than was Korea in 1973, at least in terms of industry's share in GDP. With regard to the energy intensity of GDP, however, Indonesia's is particularly high, largely as a result of its being a major oil and gas producer (the energy intensity of its GDP was roughly on a par with that of Malaysia, another oil and gas producer, in 1992).

Table 5. **Energy intensity of industry, 1993**

Country	GDP (million $)	Industrial value added (million $)	Energy intensity of industry (TOE/$'000)
Chinese Taipei	214 547	87 964	0.248
Korea	330 831	142 257	0.341
Thailand	124 862	48 696	0.170
Indonesia	144 707	56 436	0.283
Bulgaria	10 369	3 940	1.362
Czech Republic	31 613	12 645	0.929
Hungary	38 099	10 668	0.501
Poland	85 853	33 483	0.623

Note: TOE = tonnes of oil equivalent

Sources: For GDP and industrial value added: World Bank (1995), *World Development Report;* for energy data: IEA/OECD (1995b).

The difference in industrial structure between the HPAEs and the Eastern European countries is made apparent in Table 5, which shows the energy use in the industrial sector per thousand dollars of industrial value added. In the case of the HPAEs, in no instance does energy use per unit of industrial value added exceed one-third tonne of oil equivalent (TOE); in the Eastern European countries, in no case does it fall below one-half TOE and in most cases it is well above that level. Among the HPAEs, Korea clearly has the most energy-intensive industrial structure. Inasmuch as energy intensity is correlated with pollution intensity (notably air pollution intensity), one would expect Korea to have potentially one of the most serious air pollution problems among the HPAEs, at least with respect to stationary sources.

With respect to the potential for mobile source pollution, the picture is somewhat different. Table 6 provides data on per capita consumption of petroleum products for road transport in the HPAEs. Singapore shows the highest per capita consumption, contrary to what one might expect in view of the strong Singaporean government effort to limit private automobile use. (In 1993, its per capita consumption was roughly equal to that of Japan and slightly lower than the average for OECD Europe). On the other hand, Singapore's per capita consumption has remained constant while those of Korea, Thailand and Chinese Taipei have grown rapidly since 1990. Also somewhat surprisingly, Malaysia's per capita consumption has risen by only 12 per cent during this period.

Table 6. **Per capita consumption of petroleum products for road transport, 1990 and 1993 (TOE)**

	1990	1993	% change, 1990-93
Singapore	0.52	0.52	0
Chinese Taipei	0.31	0.40	+29
Korea, Rep.	0.25	0.35	+40
Malaysia	0.26	0.29	+12
Thailand	0.15	0.20	+33
Hong Kong	0.10	0.11	+10
Indonesia	0.05	0.06	+20
Japan	...	0.53	

Note: TOE = tonnes of oil equivalent
Source: For population figures: ADB (1995), World Bank (1995) for Japan; for energy figures: IEA (1993, 1995a and 1995b).

What is Distinctive About East Asian Industrialisation?

There has been no single East Asian path to industrialisation but there are nevertheless some common features. Industrial development has had a strong export-orientation. This has had three salutary environmental effects. First, it has enabled the HPAEs to direct a sizeable share of their high savings towards the purchase of imported capital goods. The OECD countries have been the major source of imported technologies and capital equipment and, since those were usually developed to meet rather strict OECD emission/effluent standards, the importing countries have often acquired relatively clean technologies. This has not always been the case, since on occasion the pollution abatement features of the technology were simply end-of-pipe add-ons without which the equipment could still be operated perfectly well. Unfortunately, not enough is known about the environmental characteristics (pollution intensities) of the capital equipment imported by the HPAEs over the past few decades. One study (Wheeler and Martin 1992) of the pulp and paper industry confirms the hypothesis that the HPAEs and other "open" economies[11] have been quicker to adopt and diffuse cleaner technologies than have "closed" economies.

A second effect of export orientation has been to impose a strict cost discipline on producers in these countries, which has tended to encourage efficiency in energy and materials use. Similarly, the pattern of specialisation which has resulted from trade openness has tended, in most HPAEs, to favour relatively labour-intensive industries, which are often less polluting than capital- and energy-intensive ones. Finally, exporters have had to become sensitive to what appear to be stronger preferences of developed-country consumers in recent years for "green" products.

Thus, in general, economic openness would appear to favour the choice of less-polluting technologies and the growth of relatively low pollution industries, even without explicit environmental policies to encourage such developments. This is just as well since governments of certain HPAEs have exhibited a strong reluctance to impose strict environmental standards thought to diminish the international competitiveness of their domestic industries. At times, governments have even been inclined to assist industries in maintaining competitiveness by subsidising publicly-provided inputs, most notably electricity and other types of energy. While this may have partially negated the positive inducement from international competition to efficient resource use, energy price distortions in the HPAEs have generally not been large by comparison with those in other developing countries or the European economies-in-transition, and they have been decreasing over time. In the case of electricity, for example, in 1993 Chinese Taipei industry paid an average $.077/kWh (equal to the OECD average) and Korean industry $.067; by contrast, Hungarian industry paid $.053, Polish industry $.031 and Russian industry $.01812. Price data for Malaysia, Thailand and Indonesia (see Hammer and Shetty 1995) on various petroleum products and electric power suggest the absence of subsidies in the first two countries (i.e., the consumer price is higher than the producer price) and only a small subsidy in the third. There would still appear to be a price (and perhaps a policy) bias in favour of diesel fuel over gasoline in all three countries (in other words, the ratio of consumer to producer price is lower for diesel than for gasoline — significantly so in Malaysia and Indonesia), whose environmental implications need to be carefully considered.

III. THE COSTS OF ENVIRONMENTAL DEGRADATION

A Brief Overview of Environmental Trends in the HPAEs

With the exception of Japan, for which fairly extensive environmental quality indicators are available in a standardised format[13], it is difficult to piece together a detailed picture of environmental trends in the other HPAEs. Nevertheless, an attempt has been made (and the findings are reported in Annex A.) The main results are summarised here.

First, with respect to Japan, its early post-war development strategy might be considered the prototype of the "grow now/clean later" approach (see Haga and Yano 1992). Following serious pollution incidents, however, in the 1950s and 1960s, and a number of local anti-pollution initiatives, pollution control came to be accorded national priority by the early 1970s. Environmental improvements came fairly swiftly in certain areas (notably in controlling air pollutants like SO_2, carbon monoxide and, to a lesser extent, NO_2). With regard to water pollution, there has been marked progress in reducing human health risks from heavy metals and toxic chemicals but somewhat slower progress in reducing BOD/COD levels. Moreover, the proportion of the population served by waste water treatment plants remains well below the OECD average. The intensive nature of Japan's heavily protected agriculture also makes it among the biggest users of agricultural chemicals, with pesticide consumption per km^2 exceeded only by the Netherlands and nitrogen (from fertilisers and livestock) per km^2 the highest (along with the United Kingdom). Economic growth has brought some increase in the volume of waste generated, but while Japan outperformed every other OECD country (except Turkey) in GDP growth from 1980 to 1992, its growth in per capita municipal waste was among the slowest. Also, per unit of GDP Japan generates the smallest amount of hazardous waste of any OECD country, though in absolute terms its toxic releases are still large. Overall, in terms of its pollution abatement record (and in terms of energy efficiency), Japan ranks among the leaders in the developed world.

The data from the other HPAEs tells a varied story. The city-states of Hong Kong and especially Singapore stand out for having managed to achieve considerable environmental quality improvements. The picture for Korea and Chinese Taipei is more mixed, though on a number of air quality indicators they have made some progress of late. In general, the higher income HPAEs appear to be making greater progress in controlling pollution than the others. This is partly attributable to a shift towards a more mature economic structure, with services and less-polluting industries growing relative to heavy industry. Partly it is due to more vigorous prosecution of environmental policy and larger investments in environmental infrastructure. The late industrialisers — Indonesia, Thailand and to a lesser degree Malaysia — are still faced with mounting environmental problems of several sorts. In short, they are still on the upward-sloping portion of quite a few inverted-U curves, and not far enough down the slope of other curves. Estimated emissions data for a number of air and water pollutants for Indonesia and Thailand (using the World Bank's IPPS data: see

Brandon and Ramankutty 1993) point to significant deterioration[14]. With the exception of BOD, where Indonesia's pollution load has grown very rapidly, the load of all other pollutants has grown far more rapidly in Thailand.

For all the HPAEs, the environmental problems of prosperity are coming to loom larger — automobile pollution, solid waste disposal, hazardous waste generated by new industries. The temporal compression of development has meant, however, that certain "poverty-related" environmental problems have not yet been adequately addressed. For example, in some countries, there is still a large backlog of investments in improved water supply and sanitation. Dealing with overlapping generations of problems could be expected to place sizeable demands on domestic resources for a number of years to come (a point discussed in the next section). Finally, the evidence is mixed on whether the latecomers have learned from the experience of their predecessors and improved on their performance in the environmental field. While in some areas their environmental performance may have benefited from the use of cleaner and more energy-efficient technologies, in other areas their problems seem if anything more serious than those of the earlier industrialisers — e.g., with regard to mobile source pollution and solid waste generation.

Estimating Damage Costs

By now it is generally accepted that standard growth and national income accounting methods can overstate, in some cases significantly, welfare improvements. Inasmuch as there is a growth-environment tradeoff, then — other things equal — one would expect this overstatement to be especially serious for fast-growing economies. What do we know about the magnitude of environmental damages from rapid growth in the HPAEs?

There is a growing body of literature attempting to estimate the economic costs of environmental damage in Asia. Shin *et al.* (1992) is one of the earliest and most wide-ranging contributions. The accumulating evidence suggests that these costs are far from negligible. It should be stressed, however, that while methodologies for economic valuation of environmental impacts are steadily being refined, the data available to be able to apply the methods reliably in developing countries leaves much to be desired and, in this regard, the HPAEs are no exception. Also, even with the best primary data, damage cost (or "benefits") estimates are still subject to a fairly wide margin of uncertainty. In this section we review some damage cost estimates for urban pollution problems in a few HPAEs, providing a rough indication of their size relative to the measured product of the local/regional economy.

This paper does not discuss the literature, pioneered by Repetto *et al.* (1988), which looks at the impact of natural resource degradation on growth. That study of Indonesia's growth from 1971 to 1984 concludes that, while measured GDP grew by 7.1 per cent per annum over that period, *net* domestic product (once adjustments are made for depletion of petroleum, timber and soils) actually grew by only 4.0 per cent. Such resource accounting cannot capture adequately the growth effects of urban and industrial pollution, which manifest themselves not so much through a depreciation of natural capital as through adverse effects on the productivity of human capital and to some degree man-made (or produced) capital.

A study of air and water pollution damage in Jakarta, Indonesia, estimates that the health effects alone may cost the economy \$500 million a year. With regard to air pollution, estimates were made of the incremental morbidity and mortality attributable to elevated ambient concentrations of suspended particulates, lead and nitrogen dioxide. The central value of the estimates (for 1990) was \$220 million (the NO_2 damages were a negligible share). Estimates of the benefits in reduced mortality from improved water quality were in the range of \$285-315 million in 1990 (World Bank 1994a). Since Jakarta accounted for around 14 per cent of Indonesia's non-oil GDP in 1990, the total damage costs amount to roughly 3.5 per cent of Jakarta's domestic product in that year (BPS 1992) — 1.5 per cent in the case of air pollution and between 1.9 and 2.1 per cent in the case of water pollution — which comes to one-half per cent of economy-wide non-oil GDP[15].

The methodology developed in the Jakarta study for estimating air pollution damages (Ostro 1992) has been applied to Malaysia and to Bangkok. The results are summarised here.

In the case of Malaysia (see World Bank 1993b), for reasons of data availability, only two pollutants could be evaluated — suspended particulates and lead. Reducing TSP levels in Kuala Lumpur, Johor, Perak and Pulau Pinang from measured ambient concentrations to the recommended Malaysian guideline ($90\mu/m^3$) would yield an estimated saving from health damages averted of roughly \$560 million. A 90-per cent reduction in lead levels in Kuala Lumpur and Selangor (e.g., through a ban on leaded gasoline) would yield estimated savings of some \$425 million in reduced health damages.

The Bangkok study (World Bank 1994b) considers a larger number of pollutants (suspended particulates, lead, SO_2 and ozone) and yields equally impressive damage cost savings from reduced pollution. The estimated benefits in terms of reduced morbidity and mortality of a 20-per cent improvement in air quality (measured as a 20-per cent reduction in average ambient concentrations of each of the pollutants) are in the range of \$750 to \$3,140 million (at 1989 prices and exchange rate). To get some perspective on these numbers, it is worth noting that the GDP of the Bangkok metropolitan region (BMR) in 1989 was approximately \$31.5 billion (assuming that half of Thailand's overall GDP was generated in BMR; in 1987 the figure was 48.55 per cent, according to the NESDB). Thus, if the actual health damages were at the upper end of the range, the size of the resultant economic losses amount to an extraordinary 10 per cent of 1989 BMR GDP (or 5 per cent of national GDP). Even if the actual damages were at the lower end of the range, the losses would come to 1.2 per cent of national GDP.

The same two studies (World Bank 1993b and 1994b) have sought to estimate the economic costs in Kuala Lumpur and Bangkok respectively of traffic congestion. The Kuala Lumpur study estimates the average time lost per passenger per day in traffic jams at 15 minutes in 1992, which works out to a total wage cost of some $427 million per year (at an average hourly wage of $2.65). The Bangkok study considers what the time and running cost savings would be of a 10-per cent and a 20-per cent reduction in the number of peak hour trips. The cost savings work out to $431 million and $813 million respectively.

A comparison of the health and other damage costs from pollution in Bangkok to those in Jakarta shows the former to be a significantly larger share of national product. The difference is principally a function of the much higher degree of concentration of economic (including industrial) activity in Bangkok than in Jakarta. Such concentration exacerbates pollution and congestion, which in turn adversely impacts a larger proportion of the population and of economic activities. One policy implication is that regional and spatial planning ought to be early priorities in any forward-looking environmental management system.

Less readily quantifiable but potentially important costs of rising pollution and congestion levels in major metropolitan areas of developing Asia are: (i) reduced productivity of private investment and thus potentially the discouragement of foreign direct investment; (ii) tightening restrictions on the location of certain types of industries (e.g., power plants, chemical plants) or environmental facilities (e.g., landfills, incinerators) due to community NIMBY opposition. With regard to the productivity of investment, obvious and direct effects include the higher distribution and, related, inventory costs imposed on businesses by congestion and also the higher travel costs of employees. A less direct but potentially important cost is the declining quality of life in a number of Asian metropolises. As an economy develops, highly educated labour becomes a more and more important productive input. Yet, certain types of professionals increasingly function in a global labour market, and their choice of where to live and work depends not only on monetary rewards but on various dimensions of "quality of life", including environmental quality. So, if a country or city cannot keep its own skilled professionals and/or attract foreign professionals, it will be very difficult to attract investment in those industries which depend on them. It is ironic that not very long ago governments in a number of the HPAEs had strong reservations about tightening environmental regulations for fear of deterring foreign investors.

IV. THE COSTS OF ENVIRONMENTAL IMPROVEMENT

This section examines the actual and projected costs to the HPAEs of maintaining or improving environmental quality. As noted earlier, some environmental indicators show improvement from a low level of per capita income — notably access to safe drinking water and sanitation. By 1988-91, in Indonesia — the HPAE with the lowest per capita income — roughly half the population had access to safe drinking water and 44 per cent had access to sanitation (UNDP 1994). Beyond the basic public infrastructure investments needed to achieve wide water and sanitation coverage, the timing of environmental investments varies across the HPAEs — even to a degree between countries at comparable levels of per capita income. In the case of the four dragons (Korea, Chinese Taipei, Hong Kong and Singapore), for instance, some began relatively early to make sizeable environmental expenditures in an effort to maintain environmental quality in the face of pressures from rapid economic growth; others have begun investing in environmental improvements only belatedly.

Ideally, to know what difference timing makes, we would like to be able to compare the experience of the former group with that of the latter, asking which group has enjoyed the larger net discounted benefits per person. For the former group, abatement costs were incurred early on, but so too were benefits (in reduced damages) enjoyed from an early date. For the latter group, both costs and benefits were postponed. There are several considerations that are relevant to a comparison of the two experiences. First, since health damage costs are measured at prevailing real wages, rising real wages imply that the benefits of averting health damage increase through time. Second, if pollution control technologies are improving over time, then one would expect this to be reflected in declining unit abatement costs. So, other things being equal, the late abater would face lower unit costs and higher marginal benefits.

Are other things equal though? Perhaps not. First, the nature of the costs involved may be different, especially when dealing with certain stock pollutants (e.g., bioaccumulative toxics). Indeed, for such pollutants, it may be useful to differentiate between the familiar abatement cost function, which is normally based on the costs of operating a set of abatement technologies at the plant level, and the "sins of the past" clean-up cost function. This corresponds most closely to the notion of replacement cost in the valuation literature. One reason why the two may differ significantly is that, in the case of clean-up, a sizeable element of costs may involve simply assigning responsibility for shouldering the expense of clean-up (with the attendant fees to lawyers and environmental consultants)[16]. Even beyond these indirect costs, there is reason to suppose that clean-up (or replacement) costs will in general be larger than abatement costs. For, both abatement and clean-up involve removal, treatment and disposal of the waste, but in the latter case the waste is already dispersed in the environment, so recovery is considerably more costly. Moreover, it is apt to be more difficult to recover materials (e.g., heavy metals or chemicals) from dispersed waste for recycling and re-use than it is to recover them at "end of pipe". The Superfund toxic site clean-up effort in the USA is perhaps the clearest illustration of why it makes sense to think in terms of two separate cost functions and to try to avoid getting shunted from the abatement cost onto the clean-up cost curve.

Quite apart from the question of after-the-fact clean-up, the abatement options may differ significantly depending on whether the investments are made up-front or through add-ons to existing plant and equipment. In effect, as long as the capital stock remains to be installed, there is a possibility to install less polluting process technology (technology choice with a clean slate, so to speak). Once polluting capacity has been installed, there are basically three options in response to strengthened environmental standards: to scrap some of it prematurely, partially writing off the investment; to retrofit existing plant and equipment to reduce emissions; to add end-of-pipe treatment technology to neutralise pollutants in (or remove them from) the waste stream. Abatement options involving cleaner process technology are foreclosed, very possibly including some "win-win" options wherein reducing pollution load is instrumental to reducing production costs.

A second reason why other things may not be altogether equal is the inertia of certain systems or, put differently, the long time lag before the structure of certain systems can be significantly modified (so-called "lock-in" effects). This applies particularly to transport systems, but may also apply to other elements of infrastructure involving investments with long lead times. Take for example the related problems of traffic congestion and mobile source air pollution. These problems are in principle easily reversible. If all the automobiles were to be banned from the streets of Bangkok or Jakarta tomorrow, the air quality would improve very quickly. That does not happen because the economic costs would be unacceptably high. Moreover, it would take major long-term investments in redesigning and rebuilding the transport system (not to mention major efforts to change behaviour) in order to reduce significantly dependence on the private automobile. Once committed (if only by default) to a transport policy centred on the automobile, governments can only change course very slowly. Thus, there would seem to be little choice in the short to medium run for residents of these cities but to accommodate themselves to congestion and pollution. Meanwhile, the economic costs continue to mount. Also, inadequate land use planning can result in serious collateral environmental damage which may be difficult to control in the short to medium term. Major shifts in land use patterns normally require sizeable infrastructure investments and involve relatively long lead times. Relocation costs, whether to industry or to people, can also be quite high. Thus, even after government begins to take decisive measures to address such problems (e.g. through improved public transport, enforcement of strict zoning rules, relocation of enterprises to industrial estates serviced with common waste treatment facilities, etc.), it can be many years before the fruits of such measures are evident. In short, *investment costs mount quickly while damage costs decline only slowly*.

A question economic policy makers often ask is whether introducing strict environmental standards early on would dampen private sector investment and thereby slow growth. This seems a misplaced question if one is considering domestic resources in a world of limited international capital mobility, since capital not invested in one industry would still be available for investment elsewhere — presumably in less polluting industries or activities. Naturally, as capital becomes more mobile internationally, one concern is that the domestic effluent standards might lower the rate of return below that obtainable in other countries and cause capital to flow elsewhere. Thus far, though, the empirical evidence does not show large international capital movements responding principally to differential environmental standards. The concern would seem to be largely unfounded, except in a few industries where pollution abatement can constitute a sizeable share of total investment costs.

Pollution Abatement

In the OECD countries, pollution abatement investments (mostly for "end-of-pipe" treatment) averaged about 4 per cent of total investment in the 1970s and early 1980s, when such investments were at or near their peak (OECD 1993). Because of the large production capacity which had already been installed under a more lenient regulatory regime, much of that investment involved "retrofitting" of existing plant and equipment at relatively high cost.

In the case of the HPAEs, sizeable pollution abatement investments can be expected in the next decade. In countries like Korea and Chinese Taipei, which have already built up large industrial and energy generating capacity, there is apt to be need of considerable retrofitting and end-of-pipe treatment. Still, since the bulk of that capacity has been installed since the mid-1970s, and since much of the equipment has been imported from OECD countries, it is possible that a sizeable proportion incorporates some pollution control features already. Industrial and energy installations in countries like Indonesia, Malaysia and Thailand are on average even younger than those in Korea and Chinese Taipei, though little is known about their pollution intensity relative to similar facilities in the latter two countries. Moreover, a very sizeable share of new production capacity built in these Southeast Asian countries over the last decade has been the result of foreign direct investment from Korea and Chinese Taipei as well as Hong Kong and Singapore. Whether (or rather in what proportion) that production capacity incorporates latest available clean production (or abatement) technology versus an earlier generation of more polluting technology is a subject for further research.

Already many of the HPAEs have been raising their levels of public investment in environmental infrastructure and industrial investment in pollution control. This has been in large measure a response to pressures from urban populations experiencing simultaneously large income gains and serious deterioration in environmental quality (O'Connor 1994). Spending levels may well have to rise further, however, if governments are to cope with the accumulated and ongoing growth-induced environmental pressures while at the same time attending to the "unfinished business" of extending access to basic amenities like safe water and sanitation. The pattern is a familiar one. The 1970s were for Japan (as for a number of other OECD countries) a decade of environmental "catch-up", with Japan's pollution control expenditures rising as a share of GDP from 0.79 per cent in 1970 to a peak of 1.73 per cent in 1975 before falling off to roughly 1.5 per cent in the early 1980s[17]. Environmental expenditures in countries like Chinese Taipei and Hong Kong started to turn up steeply towards the end of the 1980s. By 1989, environmental expenditures in Chinese Taipei had reached 1.39 per cent of GDP and, in 1992, they were 1.27 per cent[18]. In other HPAEs (with the exception of Singapore), the share of environmental expenditures in GDP has generally been below one per cent[19]. In the case of Korea, by one estimate, total environmental expenditures (public and private) came to around 0.8 per cent of GDP in the early 1990s (D. Lee 1995). Estimates for Indonesia and Thailand are also well below one per cent of GDP.

It seems entirely plausible that, as a group, the HPAEs might need to spend in the range of 1.0 to 1.5 per cent of GDP on environmental investments over the next decade. Assuming an investment-to-GDP ratio of roughly one-fourth, this would represent between 4 and 6 per cent of total investment. This is not out-of-line with OECD figures, where several countries had pollution control investments in the range of 3-4 per cent of gross fixed capital formation in late 1980s through 1990 (i.e., well after the investment peak). In those HPAEs with a relatively large heavy industry sector, it is possible that, as a share of industrial investment, pollution-control investments may need to increase to even higher levels for some years (as they appear to have done for Chinese Taipei in the early 1990s). According to a 1991 survey of Chinese Taipei industry (see Sung 1995, Table 7), on average industrial enterprises were spending 6.8 per cent of their total investment budget on pollution control measures. The industries with the highest pollution control investment ratios were steel and cement, both at around 12 per cent of total investment. In those two industries, such investments added roughly 4 per cent to their production costs, while the average cost increase for all industries covered by the survey was 3.4 per cent.

While the short-term effect of this increase in environmental expenditures may be to raise incremental capital-output ratios (ICORs) in these economies, in the medium term this should be largely if not wholly offset by the positive effect on the productivity of public and private sector investments, through the mitigation of health and other pollution damages and the alleviation of transport bottlenecks.

Weatherly (1994) has prepared projections of future environmental investment requirements in all the developing member countries (DMCs) of the Asian Development Bank (ADB) through the year 2000 under the assumption of an accelerated environmental investment programme. The projected investments through 2000 for the HPAEs (less Japan) are given by sector in the following table[20]:

The projected investments of Korea are the largest by a wide margin, followed by Indonesia and Chinese Taipei and then Thailand. While it was not possible to verify the plausibility of all these projections from other sources, the Korean figure seems to be in line with government investment plans. In coming years, Korea plans to invest some $7.7 billion in public treatment facilities for waste water, with the overwhelming share of that going to municipal sewage treatment plants ($6.3 billion).

Also, for Chinese Taipei the figure of $10 billion (at present values) is broadly in line with the government's planned environmental budget of $12 billion between 1992 and 1997 (O'Connor 1994, p. 178).

Table 7. **Accelerated Environmental Investment Programme for the HPAEs (less Japan): Net Present Value of Investments, 1991-2000 (at 5% rate of discount) ($ millions)**

	Water Supply	Sanitation	Electric Power	Transportation	Industrial waste	Total
Indonesia	3 959	1 931	1 175	1 829	1 525	10 419
Thailand	1 125	508	2 799	2 571	1 953	8 956
Hong Kong	140	86	985	415	0	1 626
Korea, Rep.	872	511	6 704	3 183	8 007	19 277
Malaysia	570	300	938	830	952	3 590
Singapore	90	57	0	0	757	904
Chinese Taipei	602	359	4 903	1 176	3 223	10 263
Total	7 358	3 752	17 504	10 004	16 417	55 035

Source: Based on Weatherly (1994), Table 1.5.

In per capita terms, the country rankings are somewhat different from the global rankings. Based on 1994 population (ADB 1995), projected investments per capita through 2000 are as follows:

Indonesia	$ 55
Thailand	$151
Hong Kong	$267
Korea, Rep.	$433
Malaysia	$184
Singapore	$312
Chinese Taipei	$489

What is noteworthy here is that the per capita environmental investments are not perfectly correlated with per capita income levels. While per capita incomes in Hong Kong and Singapore are above those in Korea and Chinese Taipei, per capita investments in the former are projected to be only between one-half and three-fourths as large as those in the latter. This reflects in part the fact that the structures of the economies are different (with the former two far more specialised in services), but in part also the fact that the former have been relatively early abaters, so their pollution problems are somewhat more manageable. In the case of Hong Kong, the most significant difference with Korea and Chinese Taipei is the relatively small size of investments for controlling transport-related pollution and treating industrial waste. In the case of transport, a well-developed mass transit system (in a rather confined area) no doubt contribute to explaining the difference. In the case of waste, the difference presumably reflects the sizeable recent investment Hong Kong made in a centralised hazardous waste treatment facility. In the case of Singapore, the major difference with Korea and Chinese Taipei is the small size of the anticipated investments in controlling energy- and transport-related pollution.

Pollution Prevention

There is a growing body of evidence that relatively simple, low-cost changes in products, inputs and production processes can reduce pollution while generating sizeable financial savings to the firm. The availability of such "win-win" opportunities would appear to be a function of the degree of x-inefficiency (or organisational slack) in an economy, industry or firm. Duan (1995) reports on the results of environmental audits conducted at some 27 Chinese enterprises to identify low/no cost technologies for reduction of COD load. Over 400 technologies were identified, whose total investment cost is an estimated 783,000 yuan and which would yield economic savings of roughly 24 million yuan per year while reducing COD load by an average 10-30 per cent. Thus, in the vast majority of cases the payback period was less than 6 months. A study of 22 chemical firms in the United States looked at 181 source reduction activities. Its major findings were that: *(i)* even simple changes in production techniques could yield sizeable pollution reductions and cost savings — with 20 per cent of the activities saving from $350,000 to $3.0 million per year; *(ii)* a quarter of these activities required no capital investment at all; and *(iii)* of those that did, the maximum payback period was 18 months and two-thirds of the activities had a payback period of six months or less (Dorfman 1992, cited in World Bank 1994a, p.159). A survey of the electronics industries in several of the HPAEs found similar scope for cost savings as firms began introducing measures to reduce their use of chlorinated solvents as part of national CFC phase-out programmes (O'Connor 1991).

V. LESSONS FOR TODAY'S LATE INDUSTRIALISERS

This paper began by asking whether the East Asian "miracle" is sustainable. It concludes that insofar as the environment is concerned, there is no such "miracle". The environmental performance of the HPAEs ranges from the very good to the not so good, though so far no country has veered too close to the edge of the environmental abyss, thanks in large part to sound economic policies. However, in certain cases, much more could have — and probably should have — been done early on in terms of stronger environment policies. Korea and Chinese Taipei perhaps stand out as the clearest examples. Some members of the next generation of late industrialisers — notably Indonesia and Thailand — also risk getting bogged down by serious environmental problems because of delay in implementing strong environmental policies, combined with failure to develop infrastructure like public transport that might have averted the present or looming transport crisis. The record of the last quarter of a century suggests that those HPAEs which invested early in environmental protection did not suffer significantly slower growth as a consequence. It remains to be seen whether those which waited until recently to address mounting environmental problems will pay a penalty in significantly slower growth in coming years.

The example of East Asia shows clearly that, while sound economic policies (e.g., the elimination of energy price subsidies and subsidies to heavy industry) may be necessary, they are not sufficient to ensure a healthy environment. Even with efficient resource use and an economic structure not explicitly biased towards pollution-intensive industries, the sheer growth momentum of the last few decades was bound to cause pollution loads to rise rapidly. Thus, as other developing country governments pursue rapid industrial growth, they do well to prepare early on to cope with the scale effects in terms of mounting pollution loads. Some of those preparations — like building an adequate public transport system or sewerage system — take considerable time (and money) to realise. Also, once set in motion, certain patterns of development (e.g., in urban transport and urban land use) are very difficult to reverse on short notice due to "lock-in" effects.

Besides having sustained high growth while maintaining a clean environment, Singapore stands out in another regard. It has been among the most innovative countries anywhere in the world in terms of environmental policy design, perhaps in part reflecting the priority attached to sound environmental management, though there are also notable examples of policy innovation in other HPAEs. Other than the United States, Singapore has been one of the few countries to employ permit trading (or rather auctions in the Singaporean case), which are used both for allocating the supply of CFCs and for bidding on the right to own a private automobile (see Chapter 5 of O'Connor 1994). When necessary, the government is also perfectly capable of strict enforcement of "command-and-control" measures. Malaysia was also early to adopt a form of economic instrument as part of its environmental policy in the form of its palm oil effluent fee (backed up by strong regulatory enforcement), which was quite effective in reducing the BOD load from that rapidly expanding industry during the 1970s and 1980s (see Vincent 1993). As yet, it is difficult to know whether the use of economic instruments like permit auctions and fees has been a significant factor in reducing the growth-environment tradeoff in these countries. In recent years, other HPAEs have been experimenting with the use of economic instruments (see O'Connor 1995 and Steele and Ozdemiroglu 1995 for examples).

Since economic instruments yield larger cost savings where abatement costs vary widely across sources, they are potentially of greatest benefit to countries like Korea and Chinese Taipei, which have a longer industrial history and a more varied industrial base (in terms of range of industries, age and type of equipment, generation of technology, etc.) — hence, presumably, wider variation in abatement costs — than the more recent industrialisers of Southeast Asia. By the same token, "old" industrial economies like China and India could stand to reap abatement cost savings from applying these instruments beyond what they have done so far. To apply them effectively, however, attention must be paid to the broader economic policy environment, since where prices are distorted or certain enterprises face "soft budget constraints", such instruments may have little or no effect on environmental quality.

Finally, economic instruments can contribute to the sustainable financing of environmental expenditures. They can generate revenue to cover both the costs of administering environmental policy and the costs of providing certain environmental services (like common waste treatment facilities). In a growing number of developing countries (including several of the HPAEs) and economies-in-transition, governments have established environmental funds, partly financed from pollution charges or other economic instruments, which are earmarked for environmental investments (whether public or private). While the practice of earmarking may not be advisable as a general rule, such funds can be a valuable instrument for dealing with situations where there is a large backlog of environmental investments and where, for reasons of government budget stringency, funds might not otherwise be available to make those investments. It is perhaps not surprising, then, that environmental funds have generated strong interest in Eastern Europe and the Russian Federation (see CCET 1995 for a discussion of guidelines in establishing and managing such funds). They may also serve a valuable "transitional" function in those Asian countries where there is a need to address accumulated problems from past environmental neglect[21].

ANNEX A

WHAT HAS HAPPENED TO ENVIRONMENTAL QUALITY IN THE HPAES?

The following summarises major trends in environmental quality indicators for the HPAEs (excluding Japan)[22]. For most, environmental quality data go back no farther than the 1980s. To facilitate comparisons, the discussion is organised according to environmental media or types of waste problem: air quality, water quality, solid and hazardous waste. So-called "green" issues (deforestation, biodiversity, fisheries and agriculture, etc.) are not considered here.

Air Quality Trends

Air quality matters principally for the effects that certain pollutants have on human health, though damage to plants and materials and amenity loss due to poor visibility can also be costs of air pollution.

Since the early 1980s, a number of the higher income HPAEs have registered improvements in air quality. Korea is a country which has historically had a serious SO_2 emission problem resulting from its heavy reliance on coal for cooking and for heating during its severe winters. Thus, SO_2 levels in cities like Seoul and Pusan have generally been well above those in the major cities of the other HPAEs. Thus, for example, in 1984, the ambient SO_2 level in Seoul was roughly two-and-three-quarters times higher than in Taipei. Between then and 1991, however, the Seoul level was reduced by 35 per cent and the Pusan level by 25 per cent (though both still exceeded the national standard), while the Chinese Taipei level remained virtually unchanged. In the case of Singapore, ambient SO_2 concentrations have remained quite low throughout the last decade: in 1992 the average recorded level was about one-fourth of the USEPA standard. Data for Kuala Lumpur and Bangkok are less complete: they show SO_2 levels rising quite significantly in the former from the early to the mid-1980s, but still only reaching half of WHO guidelines; in Bangkok no clear trend emerges over the 1980s and concentrations are also well within those guidelines.

With regard to suspended particulates, the picture is somewhat more varied. Korea once more appears to have registered a noticeable improvement since the mid-1980s, with total suspended particulate (TSP) levels falling by over 40 per cent in both Seoul and Pusan from 1984 to 1991[23]. Chinese Taipei's TSP levels were roughly on a par with Seoul's in 1991, but they showed only marginal improvement from mid-1980s levels. From relatively high levels in 1982 (though still below the USEPA standard), Singapore's TSP overall average TSP level fell steadily through 1988 before rising slightly; still, as of 1992 the level was 80 per cent of that a decade early and three-fourths of the USEPA standard. In Kuala Lumpur, TSP levels showed some improvement over the 1980s in commercial areas while remaining fairly high (on a par with Seoul's 1991 level) in industrial areas. Also, TSP levels exceed guidelines fairly frequently even in commercial and residential areas. The TSP levels in both Bangkok and Jakarta registered increases over the decade from already high levels. By 1992, the national TSP standard was being exceeded in Bangkok by anywhere from 40 to 100 per cent, depending on location. In Jakarta, despite some locational variation in trends over the 1980s, in the early 1990s monitoring stations were still registering TSP levels anywhere from 75 to 720 per cent higher than the proposed national standard (see Table A.2 of Wood, Amir and Bordt 1992). There is a direct connection to respiratory infection: according to a 1986 Household Health Survey, in the population as a whole inflammation of the respiratory tract was the sixth leading cause of death, accounting for 6.2 per cent of the total, while in Jakarta it accounted for 12.6 per cent of all deaths (World Bank 1994a).

Nitrogen dioxide (NO_2) levels are generally within standard in the HPAEs, though these levels have not fallen much in recent years — largely because of rapidly expanding motor vehicle traffic. The NO_2 levels in Korea, Chinese Taipei and Singapore as of the early 1990s were virtually unchanged from the mid-1980s. Chinese Taipei's were roughly half of the USEPA standard while Singapore's were between one-fifth and one-fourth of that standard. In Korea, NO_2 levels in Seoul are well above those in other major cities and are almost two-thirds of the USEPA standard. The limited NO_2 monitoring data for Bangkok points to either stable or increasing levels, depending on area, between 1987 and 1990. While the highest levels recorded were still within standards, it would be remarkable if those levels have not increased subsequently, given the traffic situation in the city. Similarly, in Jakarta, monitoring data at 11 stations shows generally low NO_2 levels, but they have been rising and the highest average is about half the proposed standard.

Airborne lead (Pb) exposure remains a matter of concern in some of the HPAEs, though most have made progress towards reducing ambient concentrations through policies to encourage a switch to low-lead or unleaded gasoline. In Singapore, lead levels have been falling significantly since the mid-1980s and are now one-fifteenth of the USEPA ambient standard. Lead concentrations appear to have begun to fall in Bangkok after the introduction of low lead and unleaded gasoline in 1991. Nevertheless, blood lead levels in Bangkok are reported to be among the highest in the world, suggesting the need for significant further reductions in lead exposure.

Water Quality

There are two sorts of water quality problems considered here: high levels of BOD/COD and suspended solids (SS), which reduce the fisheries and amenity values of surface water bodies, and toxics in surface and groundwater, which pose a long-term threat to human health. Microbiological contamination of water supplies — an acute human health risk — is not considered, though this is not because it is not serious, especially in countries like Indonesia and Thailand. (Some of the overall water quality measurements cited below do include microbiological contamination when calculating the water quality index.)

Water quality has shown some improvement in Korea, with BOD levels in the lower Han River having fallen by almost half between 1987 and 1993. Of the four major rivers, only the Keum has shown some sign of deteriorating quality. The accumulation of organic pollutants in lakes and reservoirs is a problem, however, with 46 out of a total of 207 affected by eutrophication. (Korea's per hectare fertiliser use is even higher than Japan's.) Surface water quality in Chinese Taipei appears to have deteriorated since the early 1980s. Whereas in 1983, roughly three-fourths of total river length was classified as "non-polluted", that share had fallen to two-thirds by 1991. Moreover, the portion classified as "heavily polluted" has roughly trebled to 14 per cent over this period. Since the mid-1980s, more than half of the water quality measurements taken each year in the major rivers have registered BOD levels above 5 mg/litre.

Thailand, Malaysia and Indonesia all face water pollution problems to varying degrees. The quality of water in Thailand's main river, the Chao Phraya, which flows through Bangkok, has seriously deteriorated in recent years. The number of monitoring stations receiving the lowest possible rating for water quality jumped dramatically between 1988 and 1992; in the latter year, almost 90 per cent of stations were rated in either the lowest or the second-lowest category. Standards for such pollutants as lead, chromium, ammoniacal nitrogen and nitrates were all exceeded between Bangkok and the mouth of the river though not in the stretch of the river from which the city's water supply originates.. However, measurements for several heavy metals and other toxic substances (including arsenic, cadmium, chromium, copper, and nickel) are lacking for the water flowing into and out of the metropolitan Bangkok's main water treatment facilities.

In Malaysia, river pollution has also been increasing. The Department of Environment calculates a composite pollution index based on several parameters, including BOD, suspended solids (SS) and ammoniacal nitrogen. The proportion of slightly to highly polluted rivers has increased from 1987 to 1991, with some 25 rivers in peninsular Malaysia heavily polluted from ammoniacal nitrogen and 29 from SS. Dissolved oxygen levels in the main rivers (the Klang and Linggi) are well below internationally acceptable levels of 6 mg/litre.

While water quality data for Indonesia is limited, the available data tells a mixed story. On the one hand, a report on water samples at various river monitoring stations suggests a decline since 1989 in the proportion meeting environmental quality standards. On the other hand, data on BOD and SS loadings in major rivers during the first two years after the onset of the PROKASIH (or 'Clean Rivers' programme) in 1989 shows a significant decline (Wood, Amir and Bordt 1992). Afsah and Lapante (1995, forthcoming) provide a more recent assessment of the impact of PROKASIH.

Solid and Hazardous Waste

Following a general pattern, levels of solid waste generated have risen steadily in the HPAEs along with per capita income. In Korea, for example, the volume of solid waste increased an average 8.3 per cent per year from 1988 to 1991 before declining rather steeply thereafter, in part as a result of the substitution away from coal briquettes to cleaner fuels like LNG and LPG. Still, Korea's per capita waste generation is around 550 kg. per year (the OECD average for municipal waste is 500 kg. per person per year; 600 if industrial waste is included). Chinese Taipei's total and per capita municipal waste generation has also been rising steadily, with the latter reaching about 365 kg. per year by 1991, roughly on a par with Germany (whose PPP per capita income was roughly twice as high in that year).

In the rapidly growing economies of Southeast Asia, solid waste is a mounting problem. A recent ranking of environmental priorities in Indonesia gave solid waste management in major urban centres the highest rank, along with water and sanitation, and vehicle emissions. Already solid waste per capita in Jakarta is on a par with the national average for Portugal and Greece, OECD countries with PPP per capita incomes roughly four times Indonesia's. While Bangkok's is only slightly higher than Jakarta's, it has been rising rapidly in recent years with growing prosperity and is on a par with that of Spain and Ireland, whose PPP per capita incomes are roughly three times higher[24]. Kuala Lumpur has one of the highest rates of per capita solid waste generation of any Asian city, much higher than Taipei's and lower only than Seoul's and Beijing's.

Hazardous waste has been a problem for some time in certain of the HPAEs, and it is becoming a more serious problem in others. In a number of countries, high-growth manufacturing industries are large generators of heavy metals and other toxic wastes. Moreover, in certain countries, a substantial portion of such wastes is generated by small firms, often widely dispersed, which are difficult to monitor.

In the case of Chinese Taipei, heavy metal levels in its major rivers showed an increasing trend in the latter half of the 1980s, at least in the cases of cadmium and lead. Heavy metal contamination of farmlands is also a serious problem in some counties of Chinese Taipei, in large measure as a result of past policies to promote industrial dispersion without adequate environmental controls on small and medium sized manufacturing enterprises. In peninsular Malaysia, monitoring data on major rivers along the industrial west coast point to high levels of arsenic, cadmium, copper, mercury, lead and zinc. Thailand has experienced a similar rising trend in hazardous waste generation, though it has made some progress towards coping with the problem through the investment in a central hazardous waste treatment facility at Bangkhuntien, which treats approximately 15 per cent of total industrial hazardous waste generated. This facility is designed to service principally small firms in the textile dyeing and electroplating sectors, but also treats sludge from large electronics and automobile assembly plants. (Another, large-scale hazardous waste treatment plant has been on the drawing boards in Thailand for the last few years, and it would primarily serve the petrochemical industry along the Eastern Seaboard.)

NOTES

1. These include Japan, Hong Kong, Indonesia, Malaysia, Republic of Korea, Singapore, Chinese Taipei and Thailand.

2. It should be noted, however, that because of limited time series data on pollution levels in developing countries, the fitting of curves to data on per capita income and pollution has generally relied on cross-sectional data.

3. BOD stands for biological oxygen demand, a measure of severity of organic pollution, which is oxidised by naturally-occurring micro-organisms; in the process dissolved oxygen is removed from the water; COD takes into account that the presence of other chemical pollutants in waste water may compound the effect of the organic pollutants on dissolved oxygen levels.

4. Also, the shortened duration of elevated pollution levels may make a difference to the effects on people's health and on the environment. This is likely to matter only for those pollutants whose health or other effects are the result of rather prolonged exposure.

5. All the dragons registered per capita income growth (1965-90) between 6 and 7 per cent per annum. Whether the fact that Singapore's growth rate was closer to the bottom of the range and Korea and Chinese Taipei's closer to the top has anything to do with their different environmental policies is unknown; in any case, one needs to bear in mind that, by the end of the period, Singapore's per capita income was double Korea's and 40 per cent higher than Chinese Taipei's.

6. Another intriguing possibility is that the early investment in environmental protection in Singapore provides a partial explanation of the relatively high incremental capital-output ratio (ICOR) in Singapore noted by A. Young (1992). In short, while investing early in the environment did not compromise Singapore's growth rate, could it have lowered measured capital productivity?

7. Also, in larger measure than in the formerly communist states, in the HPAEs pollution victims have had some political voice (if in some instances a muted one).

8. Toxic substances refer to those included in the USEPA's Toxic Chemical Release Inventory (TRI); the rankings are based on releases of TRI substances to air, water, or land (whether routine or accidental) and transfers of TRI substances for off-site disposal.

9. Since, however, the output figures (as in Korea) are in current prices, they may exaggerate the changes because of oil price movements over this period.

10. See World Bank (1993), *The East Asian Miracle: Economic Growth and Public Policy. Summary*, Washington, D.C., Figure 1.

11. It should be noted, however, that Indonesia does not rank as one of the more open economies during the period of the study (1973-85), where openness was defined in terms of Dollar's average price distortion index; see Table 1 of Wheeler and Martin (1992).

12. These figures are taken from Table 12 of IEA/OECD (1995), *Energy Prices and Taxes*, 4th Quarter 1994, Paris.

13. Japan reports statistics for inclusion in the OECD's *Environmental Indicators* series, which include comparable data for all Member countries.

14. It is not always easy to reconcile the dramatic increases in estimated emissions with the (admittedly quite patchy) ambient quality data, some of which is reported in Annex A.

15. In making such comparisons, it should be borne in mind that the measured GDP figures already reflect the adverse productivity effects of environmental damage — e.g., the reduced productivity of human labour resulting from pollution-related illnesses, while the health costs of pollution-related illnesses represent an opportunity cost to the economy through a diversion of resources.

16. This is quite apart from the issue of assigning liability for health or other damages incurred.

17. Environmental expenditures are a gross flow, so strictly speaking dividing them into GDP (a net flow) overstates their economic importance; still, it is adequate as a rough indicator for use in cross-country comparisons.

18. In the case of Hong Kong, while private pollution abatement figures are not available, public expeditures rose by more than one-third from 1989 to 1990, reaching 0.72 per cent of GDP.

19. In the major OECD countries, pollution abatement and control (PAC) expenditures ranged from 1.0 to 1. 6 per cent of GDP in 1990; see OECD (1993).

20. It should be noted that the investments reported here do not include all those estimated by Weatherly, but only those designed to address national (as opposed to transboundary and global) problems associated with urbanisation and industrialisation (i.e., not including investments in reforestation, soil conservation, biodiversity conservation, greenhouse gas abatement, etc.).

21. Local environmental funds are already used to finance pollution control expenditures in several Chinese cities. The author is not familiar with the Indian experience in this regard.

22. This section makes use of the following main sources of data: for Korea, Ministry of Environment, ROK, 1992; for Chinese Taipei, Environmental Protection Administration, ROC, 1992; for Singapore, PollutionControl Department, Ministry of the Environment, Singapore, 1992; for Malaysia, World Bank, 1993b; for Thailand, World Bank, 1994b.

23. Despite significant improvements since the mid-1980s, by 1990 SO_2 and TSP levels in Seoul were barely in line with national ambient standards, though both dipped well below standards between 1990 and 1991.

24. Admittedly there are difficulties in comparing cities with countries.

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