

ENVIRONMENTAL POLLUTION IN A RAPIDLY GROWING ECONOMY

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I. CHARACTERISTICS OF ENVIRONMENTAL POLLUTION IN JAPAN

AS IN THE CASE OF all advanced nations, Japan has a fairly long history of environmental pollution. After the establishment of the capitalistic system following the Meiji Restoration of 1868, the first case of environmental pollution occurred at the Ashio Copper Mine in 1889. However, the early cases of pollution did not create serious social problems because they were restricted to certain localities and the resultant damage was mostly confined to crops and property. From about 1955, though, environmental pollution underwent radical changes in character and began to take on a number of new features.

The first of these features is that environmental pollution has come to affect increasingly greater geographical areas. Until about 1955 environmental pollution had meant no more than damage limited to extremely narrow geographical localities, as in the case of the now famous "Minamata disease" and "itai-itai diseases." Ten years later pollution had spread throughout the entire industrialized Pacific seaboard. For example, the bronchial disease caused by sulfur dioxide, the so-called Yokkaichi asthma, has afflicted victims throughout the entire industrial belt along the Pacific shore from the Kashima Industrial District in the east to Mizushima on the Setonaikai (Seto Inland Sea) in the west. In the early 1960s Japan's environmental pollution spread from "points" to "lines," and in the late 1960s it further spread from "lines" to "planes." For example, damage from photochemical smog, said to be caused mainly by automobile exhaust gas, is now being reported in wide regions around many big cities. Another example is the "red tide" phenomenon, which is said to typify contamination of the Setonaikai. From 1950 to about 1955 this phenomenon occurred only in limited localities such as the northern part of Osaka Bay, one part of Hiroshima Bay, and a part of Yamaguchi Prefecture. Since 1965 the area of its occurrence has spread from the mouths of bays to offshore areas, until now almost the entire Setonaikai is affected. More than forty cases are now reported each year. In other words, environmental pollution has now enveloped almost the entire archipelago of Japan.

The second characteristic is that environmental pollution is causing not only property damage but also human injury, harming the life and health of man. Furthermore, the damage is no longer limited to direct injury by pollutants; secondary and tertiary damage in ecological terms is becoming more serious.

Typical cases of human injury are health impairment caused by ingestion of heavy metals, as in the cases of Minamata and itai-itai diseases. In addition, asthma caused by sulfur dioxide and illnesses ascribable to photochemical smog, the product of hydrocarbons and nitrogen oxides, are on the increase.¹

A typical example of secondary pollution damage transmitted through the medium of the ecological system is that of polychlorobiphenyl (PCB), which passes through fish and fowl into mothers' milk and is accumulated there to the detriment of the health of breast-fed children. Other examples of injury to man by harmful substances which cannot be easily decomposed and which enter into human bodies through the ecological system and food chains are pollution by mercury compounds, such as BHC, and pollution by lead, all of which began to be noticed since 1965.

The third characteristic is that while environmental pollution was previously looked upon only as a social phenomenon, it has come to be perceived as an inescapable economic problem of considerable importance because of the rapidly rising social costs of environmental degradation. Social costs related to environmental disruption may be generally divided into the cost of the damage caused by pollution and the cost of prevention of such damage. Specifically, the cost of damage may include: (1) cost of injuries inflicted on the human body; (2) cost of damage inflicted on agricultural crops, marine products, and forests by polluted water and air; and (3) cost of damage inflicted on buildings, furnishings, fixtures, and clothing by air pollution. The cost of prevention may include capital investments by private businesses for pollution control equipment and its operating

TABLE I
SOCIAL COSTS RELATED TO ENVIRONMENTAL POLLUTION

				(¥ billion)
Sector \ Year	1960	1965	1970	Remarks
Agriculture	4.5	9.7	22.0	Reduction in production due to water pollution
Fishery	3.6	9.9	16.1	Damage to fisheries due to water pollution
Household	197.9	266.9	413.9	Increased household expenditures due to air pollution
Industry	—	155.4	780.0	Total capital investment for pollution control
Government	—	—	302.3	Budget for pollution countermeasures
Total	206.0	441.9	1,534.3	
Per capita (yen)	2,205	4,497	14,793	

Source: [5, p. 15].

Notes: 1. The total for 1960 does not include industry and government; the total for 1965 does not include government.

2. Costs for industry and government do not include recurring expenses such as operating cost of pollution control equipment.

¹ Details on the medical aspect of pollution damage in Japan are to be found in [3].

costs, public expenditures by national and local governments for pollution monitoring networks, and similar expenses.

According to an estimate prepared by the national Environment Agency (Table I), the total annual amount of these social costs was approximately ¥1,534.3 billion (about \$4.1 billion) in 1970, not counting the cost of human injuries because of the difficulty in appraising the value of human life and health. This partial social cost comes to approximately ¥15,000 (about \$42) per capita [5], and compares with the estimated annual social costs of air pollution alone in the United States of some \$16.5 billion, or about \$80 per head.² It would appear that the social costs of pollution in Japan are still lower than in the United States. Estimates of the past social costs of pollution in Japan indicate that they may have amounted to ¥206 billion (about \$572 million) in 1960 and ¥441.9 billion (about \$1,227 million) in 1965, and that during the five-year period from 1965 to 1970 they registered a sharp increase of more than threefold.

II. ECONOMIC BACKGROUND OF ENVIRONMENTAL POLLUTION

What constitutes the background of the rapid geographic spread and multiplying complexity of environmental deterioration and its huge economic burden as observed in Japan since 1965?

A. *Increasing Congestion in the Japanese Economy*

The first principal background factor is the continual, fullspeed economic growth which has pushed both the Japanese economy and society to the limits of congestion in every sense. After all, the Japanese archipelago covers a narrow area of only 370,000 square kilometers, of which only 18 per cent is arable. With a population exceeding 100 million and a current GNP of more than \$300 billion on this limited area, congestion is a chronic state of affairs. This chronically excessive concentration probably was already approaching its limit in 1965.

For example, GNP per unit area of flat land, which is the most revealing index of a country's total economic congestion, tells the story well. Japan's GNP per unit area of flat land equalled that of the United Kingdom in 1959, surpassed that of West Germany in 1962, and in 1970 reached \$17,180,000 per 1,000 hectares, a full 11.3 times the level of the United States (\$1,520,000). This compares with only 2.1 times the level of the United States about twenty years before, which serves to point up the extremely rapid pace with which Japan's economic congestion has advanced. The United Kingdom, like Japan a small island nation, produces \$5,370,000 per 1,000 hectares, or only one-third the level of Japan.

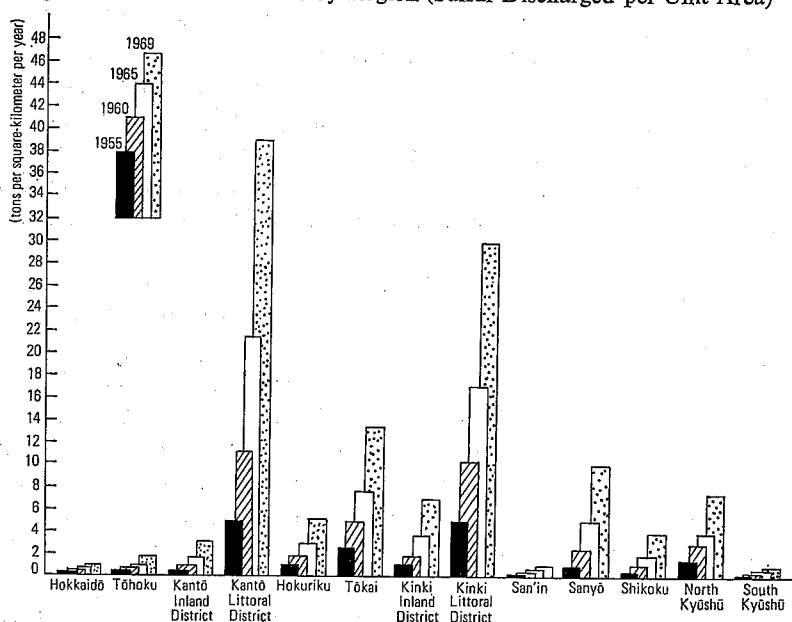
Reflecting the congestion of general economic activities, concentration of

² As stated in the second annual report of the Council on Environmental Quality of the United States, although one should be careful about simplistic comparison because of the different statistical approaches used.

sources of environmental pollution is approaching a critical point. Take energy consumption, for example. At the beginning of the 1960s energy consumption in Japan, equivalent to 9,510 tons of coal per 1,000 hectares of flat land, was roughly comparable with that of other nations, such as the United Kingdom, which consumed 11,470 tons, and West Germany, which consumed 11,540 tons. In 1969, however, while the United Kingdom consumed 12,700 tons, West Germany, 16,740 tons, and the United States, 3,420 tons, Japan's consumption jumped to a staggering 25,350 tons, or twice that of the United Kingdom and eight times that of the United States. Japanese owned only 155 automobiles per 1,000 hectares in 1960, compared with American ownership of 116 cars, British ownership of 312 cars, and West German ownership of 287 cars. In rapid succession, Japan surpassed France in 1961, Great Britain in 1964, and West Germany in 1965. In 1969 the automobile density in Japan reached 1,326 automobiles per 1,000 hectares, the highest among major countries, or eight times that of the United States and twice that of West Germany. These statistics indicate that noise, vibration, and air pollution by auto exhaust gas have been aggravated to a much more serious extent than in other countries.

Japan's economic activities, having surpassed the concentration of other nations, are approaching a limit of congestion. The trend is being further accelerated by regional concentration of people and industry. The so-called Pacific Belt area, consisting of the Kantō littoral district, Tōkai, Kinki littoral district, and

Fig. 1. Extent of Pollution by Region (Sulfur Discharged per Unit Area)



Sources: [5, p. 30]; which is in turn from Ministry of International Trade and Industry, *Kōgyō tōkei hyō* and Nihon kōgyō ritchi sentā, "Haien oyobi haisui gentan'i chōsa" [Smoke and waste water survey], mimeographed, Tokyo, 1970.

Sanyō accounts for only 26 per cent of the land area of Japanese archipelago, but the industry in this area was responsible for 76 per cent of the sulfur oxides discharged and 68 per cent of pollution in terms of BOD (biochemical oxygen demand) count in 1969 (Figure 1). Environmental pollution caused by households and industry is also heavily concentrated in this area. With the improving standard of living, the quantity of refuse generated by households has generally been on the rise. Refuse generation per person per day increased from 695 grams in 1965 to 921 grams in 1970, or about 30 per cent. Because of the concentration of population in the big metropolitan areas, the annual quantities of waste disposed per square kilometer in the south Kantō and Kinki districts have reached the huge totals of 605 tons and 300 tons, respectively, compared with 22 tons in Hokkaidō and 62 tons in southern Kyūshū.

Furthermore, the phenomena of excessive concentration are presenting themselves in the natural parks as well. While the area of natural parks in Japan increased only a little from 1960 to 1969 (2,269 hectares to 2,922 hectares), the total number of visitors jumped from 141.7 million in 1960 to 465.4 million in 1969, creating a state of overcrowding, with 160,000 users per hectare of the natural parks available. Such intensification of the concentration in all facets of our activities, including industry, family life, and recreation, has contributed greatly to the aggravation of pollution problems in Japan.

B. *Changes in the Industrial Structure*

The second economic background factor is the shift that has taken place in Japan's industrial structure. Some manufacturing industries, such as electric power, steel, and cement, are likely to cause air pollution by emitting a large quantity of sulfur oxides, while others, such as machinery, contribute relatively little to atmospheric contamination. Water is polluted mainly by effluents from the paper and chemical industries. For the sake of convenience, we might apply the term "pollution-prone industry" to the three industries which account for the largest sulfur oxide discharges, i.e., steel, power, and cement, as well as to the three industries responsible for the greatest BOD increases, i.e., paper and pulp, foodstuffs, and chemicals. It is recognized that since 1955 these pollution-prone industries have gradually increased their contribution to the emission of sulfur oxides and worsening BOD count. In 1970 Japanese industry discharged 3,140,000 tons of sulfur and 3,065,000 tons of BOD, of which the pollution-prone industries were responsible for 58.8 per cent in the case of sulfur and 81.0 per cent in the case of BOD. These figures compare with 49.4 per cent of sulfur and 72.8 per cent of BOD discharged by the pollution-prone industries in 1955, indicating that these six industries have been responsible for an increasing percentage of these pollutants.

There are a number of reasons why the pollution-prone industries have become an increasingly serious problem since 1955. The first reason pertains to the stages of economic development. One may observe in other countries, too, that as economic progress is made, basic consumer goods industries, such as foodstuffs and textiles, decline in relative importance, while, conversely, basic producer

goods industries, such as steel and chemicals, become relatively more important. As development proceeds further, manufacture of machinery, precision equipment, and other investment goods and consumer durables becomes more prominent. This is the pattern of development which is generally followed. It so happened that in Japan production of basic producer goods reached a peak in the period 1955-70, when industry was undergoing a transition to production of capital equipment and consumer durables.

The second reason was that from 1955 to 1965 Japan had suffered from chronic deficits in her balance of payments, a situation wholly different from that of today. To correct this condition it was necessary to shape the Japanese export structure to suit the demand structure of international trade in the 1960s. At that time worldwide demand for steel and chemicals was increasing considerably, giving Japan no alternative but to deliberately build an industrial structure centered around pollution-prone industries.

The third reason concerns changes in the energy structure. Until 1960, 74 per cent of Japanese electric power was generated hydroelectrically. Since 1960, however, the principal means of power generation has shifted to steam, partly because of the rapidly increasing costs of development of water resources and partly because of development of technology for operating large-capacity thermal power stations. Thermal power generation, which accounted for only 25.7 per cent of electricity production in 1955, was responsible for 48.5 per cent of production in 1961; 61.6 per cent in 1964; 71.3 per cent in 1967; and a full 76.4 per cent in 1970. Thus, the relative positions of hydroelectric and steam power generation were completely reversed, helping to promote an industrial structure which brought about contamination of the air with sulfur oxides.

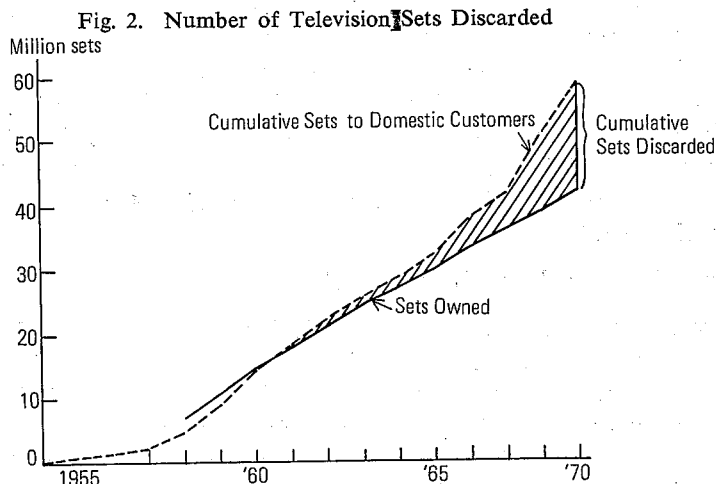
Japan's industrial structure has finally begun to shift in recent years from production of basic producer goods to production of information- and technology-intensive investment goods. However, in the course of its development thus far, one can say that change in industrial structure played a role in aggravating Japan's environmental pollution.

C. *Greater Sophistication of Consumption*

The third background factor in the intensification of Japan's environmental pollution is the change that has occurred in the pattern of consumption. Standards of consumption in Japan have advanced at a bewildering speed since 1955, accompanied by rapid sophistication of the structure of consumption. These changes have had the side effect of greatly contributing to the aggravation of environmental pollution. There are three facets to this negative contribution, the first of which is the increased volume of waste or garbage. Since 1955, electric refrigerators, television sets, and washing machines have found their way into almost every household in response to an explosive surge of demand for these appliances. Later, automobiles, air conditioners, and color television sets were sold at a pace unparalleled in other countries. At the same time, the life cycle of merchandise has shortened, resulting in additional refuse. With the rise in the standard of living, merchandise has come to be packaged in larger containers,

and this has increased further the quantity of trash. The amount of garbage from households has increased at a speed faster than the growth of population. For example, in Tokyo the population increased by 1 million, or about 12 per cent, from 1959 to 1970 (7,830,000 to 8,800,000), while the amount of garbage collected increased from 1,180,000 tons in 1959 to 3,600,000 tons in 1970, or more than 200 per cent.

The increased volume of garbage generation is creating knotty environmental problems because of two trends. One is the increase in plastic waste materials. A product of postwar technological innovation, plastics came to be widely used in all kinds of household goods because of its light weight, durability, and ease of fabrication. Plastics production, which was only 100,000 tons or so in 1960, rose to 5,000,000 tons in 1970, a fiftyfold increase. Increased production brought about a tremendous increase in discarded waste, which amounted to 2 million tons annually as of 1970. Disposal of plastics is creating a cumbersome problem because burning produces toxic gases and extremely high temperatures which can damage the incinerator. Dumping is unsatisfactory in view of the difficulty of decomposition. The second trend is the increase of bulk refuse, such as discarded television sets, washing machines, refrigerators, and automobiles. The increase in sales of consumer durables could be directly translated into a net gain in their ownership as long as the percentage of demand satisfied remained low. After 1965, however, when ownership of these durable goods had become fairly widespread, the number of used units discarded increased sharply. As many as 15 million used television sets alone have been discarded since 1955 (Figure 2). This bulk rubbish is not amenable to conventional methods of disposal such as incineration or land reclamation. It requires new disposal processes or techniques, such as crushing or compression. Such bulk refuse has added to the already serious problem of environmental disruption caused by the large volume



Sources: [5, p. 47], which is in turn from Bureau of Statistics, *National Survey of Family Income and Expenditures*.

of refuse generated in urban areas.

The second facet of the contribution made by changes in the pattern of consumption to environmental pollution is, of course, the increase in the number of automobiles. Motorization in Japan has progressed at a pace unmatched anywhere in the world. The number of cars owned, which was about 1.5 million in 1955, climbed to 19 million in 1970, representing a percentage of ownership of 22.1 per cent. Since automobiles pollute the air with their exhaust gas, they are a type of "merchandise which tends to devour environmental resources." The expanded ownership of cars has meant a major new source of air pollution. Automobile exhaust gas contains not only carbon monoxide, but also nitrogen oxides, lead compounds, hydrocarbons, and other pollutants. The Japanese government estimates that materials discharged from automobiles annually include 870,000 tons of carbon monoxide, 60,000 tons of nitrogen oxides, 180,000 tons of hydrocarbon, and 10,000 tons of sulfur oxides. Also, the photochemical smog which has frequently plagued big cities since 1970 is attributed to automobile exhaust fumes. In addition, automobiles, as sources of noise and vibration, are causing damage closely related to daily living, and the disposal of abandoned cars is becoming a serious environmental problem.

A third aspect of the changes in the pattern of consumption is the destruction of nature that results from recreational activities. With increased observance of the two-day weekend resulting in more leisure time, and with greater discretionary spending made possible by an augmented level of income, people have been encouraged to participate more in recreational activities since 1965. Recreation now accounts for 22.7 per cent of family expenditures and 54 per cent of all families make vacation trips each year. The sharp increase in tourists has caused extensive destruction of nature. The depth of transparency in Ashinoko, a lake at Hakone, for example, which was as much as thirteen meters at the beginning of the 1920s, has now diminished to only five meters owing to increased contaminants. Air pollution in Kamikōchi in Nagano Prefecture, a very famous resort area, is reported to have been so aggravated by sightseeing buses and private automobiles that the concentration of carbon monoxide has reached an urban level of 2.8 ppm. Climbers of Mt. Fuji left 853 tons of garbage on the mountain during the ten years from 1961 to 1971, and more than 10 million yen per year is expended for its removal. Thus, changes in the pattern of consumption are in many respects playing a major role in causing pollution and destruction of the environment.

D. *Insufficient Social Overhead Capital*

Inadequacy of social overhead capital in Japan has played a decisive role in worsening environmental pollution. To begin with, Japan's social capital stock plunged to an extremely low level after World War II. Then, during the twenty-odd years of rapid economic growth which followed, principal emphasis was laid on improving and expanding private capital equipment, resulting in an extreme imbalance between private capital and social overhead capital. For instance, the ratio between private and public investment in the overall economy of Japan

stood at 100:63 in 1960. In 1965 the balance began to crumble with fast-moving investment in the private sector, and by 1970 the imbalance came to a staggering ratio of 100:35.

Consequently, the rate of availability of sewerage facilities, for example, which are of great importance in preventing pollution, was only 21.0 per cent by 1970, a sorry state of affairs compared with the rate of 90 per cent in the United Kingdom, 71 per cent in Sweden, and 68 per cent in the United States. The paucity of urban parks, an important element in the preservation of environmental quality, is glaringly evident in Japan as one compares the per capita area of parks in Tokyo (1.2 square meters), Osaka (1.4 square meters), and Nagoya (2.9 square meters) to that in London (22.8 square meters) and New York (19.2 square meters).

Behind today's degradation of the environment in Japan lies the very pattern of economic growth we have seen above. The structure of production and consumption, the fast pace of economic growth, the imbalance of capital investments, and increasing congestion, in themselves are the major causes of pollution.

III. FORECAST OF ENVIRONMENTAL POLLUTION UP TO 1985

A. *How Far Will Pollution Spread?*

If Japan's environmental pollution were caused merely by lack of preventive efforts on the part of industry or by lack of social morals on the part of people in general, the remedy would not be very difficult. But, if the causes are deeply rooted in the very pattern of economic growth, there will be no way out except to change that pattern. The problem, then, becomes all the more serious because it is no easy task to change the pattern of economic growth. We will attempt to forecast just how far Japan's environmental pollution might spread if there is no significant change in the pattern of economic growth.

During the fifteen-year period from 1955 to 1970 Japan's economy experienced tremendous expansion within the cramped land space of 370,000 square kilometers. Indeed, real GNP increased more than four times. In contrast, the next fifteen years may see a gradual decline in the growth rate, as labor, natural resources, and land become less and less available and demands for a better national welfare system and closer international cooperation become more pressing. However, the potential growth capacity of the Japanese economy will not weaken overnight; there is no doubt but that it will continue to grow at an annual rate of 8 to 9 per cent.

Assuming an annual growth rate of 8.4 per cent for the next fifteen years, the real GNP will amount to about ¥190 trillion in 1965 prices (about \$527.8 billion) by 1985, more than three times the 1970 GNP of ¥60 trillion (about \$166.7 billion). This means that if the industrial structure does not substantially change and if emission of pollutants from different industries continues without significant abatement, then the burden of environmental pollution will naturally increase considerably by 1985.

TABLE II
QUANTITY OF POLLUTANT AND REFUSE DISCHARGE IN JAPAN, 1955-85

	1955	1960	1965	1970	1985 Projection
Sulfur oxides (thousand tons)	400	977	1,686	3,141	16,811
BOD (thousand tons)	543	1,012	1,852	3,172	16,977
Refuse (million tons)			24.9	34.7	78.9

Source: [1].

Note: Basis of calculation: For sulfur oxides and BOD, unit emission (data by Nihon kōgyō ritchi sentā) multiplied by value of shipment by industrial output; for refuse, unit discharge per person (695 grams in 1965, 921 grams in 1970, 1,800 grams in 1985) multiplied by population.

A forecast for sulfur oxides, which are representative air pollutants, projects the total amount of sulfur emitted into the air in 1985 to 16.8 million tons, or five times the current rate (Table II). Similarly, water contamination is expected to be further aggravated as the BOD load increases by over five times to an annual load of 17 million tons by 1985. The story is the same with garbage generation in cities. The quantity of refuse generated per person in major cities around the world is closely related to the income level [8]. The correlation between the two factors is expressed by the equation $Y = 0.320X - 2.03$ ($r = 0.94$), where X stands for income level and Y stands for refuse generated per year. Assuming that Japanese per capita GNP will increase from \$2,000 in 1970 to \$5,500 (in 1970 prices) in 1985, the quantity of refuse generated is expected to rise from 921 grams per person per day in 1970 to 1,800 grams in 1985.

These forecasts are based on a macroscopic view of the entire country. The magnitude of pollution in Tokyo or Osaka is not expected to quadruple or quintuple by 1985. Rather, as the economy expands in size industries will necessarily be located in outlying areas, as the limited availability of land and industrial water, among other things, will operate to restrict their establishment on Tokyo Bay or Osaka Bay. A region-by-region forecast of pollution based on analysis of the factors affecting industrial location by 1985, and incorporating current policy objectives of industrial location, indicates that pollution will increase 2.1 to 2.2 times on the average in the established industrial districts of the Kantō littoral region and the Kinki littoral region. The inland Kantō, Tōhoku, and Hokkaidō regions of northern Japan will see a 3.5- to 5.3-fold increase in pollution by 1985 and the Chūgoku, Shikoku, and Kyūshū regions to the south will experience a 3.8- to 4.4-fold intensification of degradation of environmental quality, according to this forecast. Furthermore, Kagoshima and six other prefectures rated to have been virtually free from pollution in 1970 are expected to become affected by 1985, and the number of heavily polluted prefectures, such as Metropolitan Tokyo, probably will increase from two in 1970 to eleven in 1985. This means, so to speak, that the entire Japanese archipelago will become more evenly polluted. This forecast is, of course, based on the assumption that there will be no change in the industrial structure and no change in the unit emission of pollutants. However, it is expected that Japan's industrial structure

will undergo a gradual change which will make the non-pollution-oriented, information-and-technology-intensive type of industry dominant by 1985, and that progress in technology will reduce the rate of discharge of pollution. The above forecast, therefore, should be taken as indicating a maximum projection of pollution.

B. *More Sophisticated Environmental Needs*

As Japan's environmental disruption is expected to become further aggravated during the next fifteen years, so is the people's need for a better environment expected to increase. A general trend observed throughout the world is that as the income level rises, the principal needs of the people shift from materialistic desires to more spiritual concerns, including satisfaction with the natural and human environments. One can observe that the value system in Japan has lately begun to change significantly in this direction. For instance, according to a public opinion poll on environmental problems conducted by the Prime Minister's Office in 1971 [9], as many as 77 per cent of the people are very much concerned with environmental pollution.

This tendency is evident even in relation to industrial development. According to a survey conducted in 1966, 29 per cent of respondents replied that pollution must be tolerated for the sake of industrial development, while 27 per cent answered that there must be absolutely no pollution. However, when the same questions were asked in 1971, those who thought that pollution must be tolerated had declined to 13 per cent, while those who insisted on absolutely no pollution had increased to 49 per cent. Furthermore, in the 1971 survey, as many as 51 per cent of the respondents believed that pollution should be eliminated and nature preserved even at some expense to economic development, while those who preferred greater economic activity and increased income were only 11 per cent of the total polled [9].

It is a well recognized fact that the more advanced the general income level and the more extensive urbanization, the greater the people's concern about environmental pollution. This means that as the income level rises in Japan as a result of economic development and as urbanization progresses throughout the country, the people's need for a better environment will be greatly increased. It also means that as we move toward 1985, the psychological impact of intensified pollution will be more intolerable than the physical impact of its spread.

IV. POLLUTION CONTROL MEASURES

A. *Measures against Environmental Pollution*

Since Japan's environmental pollution has become a serious problem, and is expected to get even more serious in the years to come, various measures have been instituted to prevent or control pollution. A measure taken by the government, effective as of 1970, had extended the scope of applicability of controls on emission concentration, previously limited to regions affected by particularly

serious pollution, to all areas of the Japanese islands. Under this measure no discharge of waste gas or water from industrial plants, or of exhaust fumes from automobiles, is allowed if the concentration exceeds a certain level. In addition to harmful substances, the scope of control has been extended to cover thermal pollution of water by power stations, as well as soil pollution, to cite two examples. Not only have regulations been made more stringent with respect to refuse, but a sizeable increase in budget appropriations has been provided to promote construction of sewerage systems and garbage disposal facilities.³ Also, the concept of no-fault liability has been incorporated into laws for the relief of victims of pollution, and a foundation to grant medical expenses to victims will soon be established.

To comply with such strengthened government regulations, business enterprises are installing facilities to prevent or reduce pollution at a rapid pace. A survey by the Ministry of International Trade and Industry indicates that while private investment in pollution control facilities amounted to only ¥29.7 billion (about \$82.5 million) in 1965, it increased to ¥163.7 billion (about \$455 million) in 1970, a 5.5-fold increase over the five-year period [6]. The ratio of pollution control investment to total capital investment increased from 3.1 per cent in 1965 to 5.3 per cent in 1970, and 9.1 per cent in 1971 (Table III). In the United

TABLE III
RATIO OF POLLUTION CONTROL INVESTMENT TO TOTAL
CAPITAL INVESTMENT, BY INDUSTRY

	1970 Actual	1971 Estimated	1972 Projected
All industries	5.3	9.1	11.5
Major pollution-prone industries	7.5	11.7	13.9
Thermal power	12.8	17.7	19.8
Mining (excluding coal)	8.3	15.7	17.7
Iron and steel	6.2	10.0	10.4
Nonferrous metals	7.8	12.1	14.8
Oil refining	10.1	14.1	15.5
Petrochemicals	4.5	5.1	8.9
Paper and pulp	6.1	14.2	17.8
Cement	7.3	8.5	15.3
Other industries	2.2	4.5	6.6
City gas	1.0	1.7	2.2
Machinery	1.6	3.0	14.1
Chemicals (excluding petrochemicals)	4.1	7.6	12.6
Textiles	2.6	6.8	11.3
Ceramics	2.3	5.8	16.1
Building supplies	1.7	5.6	4.6
Sundry goods	1.4	4.9	3.9
Coal	1.7	3.3	4.3

Source: [6].

³ Measures for prevention of pollution in Japan are summarized in [2] and [4].

States, according to a McGraw-Hill survey, the ratio of pollution control investment to total private capital investment is 10.3 per cent in the steel industry, 9.3 per cent in the paper and pulp industry, 6.0 per cent in the oil refining industry, and 5.4 per cent in manufacturing industries as a whole [7, p. 73]. According to a Swedish government survey, the ratio in that country is 6.3 per cent for steel and chemicals, 5.1 per cent for paper and pulp, and 5.4 per cent for nonferrous metals [5, p. 62]. Thus, the current Japanese expenditure on pollution prevention facilities may be said to be on an international level. However, Japan differs from the United States or Sweden in that capital investment for pollution control has begun to increase rapidly only in recent years and the amount of accumulated capital is very small. It has been estimated that capital accumulation for pollution control will not reach a satisfactory level until the total investment made from 1965 through 1969 is quadrupled.

Another important element in the prevention of environmental pollution is technology. As is well known, one of the driving forces which has made possible Japan's rapid economic growth has been the importation of technology from abroad. However, most of the techniques thus far introduced have been concerned with mass production, and relatively little technology related to pollution control, such as waste water and exhaust gas treatment or desulfurization, has found its way into Japan. For example, during the ten-year period from 1956 to 1965, only 64 items, or 2 per cent, of the total of 3,015 items of foreign technology imported into Japan were related to pollution prevention. There has been a similar situation with respect to technical research within Japan. In 1970 the total cost of research came to \$732 million, of which only \$3 million, or 0.4 per cent, was expended on research related to prevention of environmental pollution. Since about 1970 more importance has begun to be attached to importing pollution control technology from abroad and conducting domestic technological research in this area. However, in 1970 only 4.7 per cent of technology bought from abroad was related to pollution prevention, and only 0.8 per cent of Japan's research and development costs were for pollution research. Finding a way to promote technical development in this field at a greatly accelerated speed in the years to come will be a big challenge.

B. *Economic Growth and Measures against Pollution*

There seems to be no doubt that measures to prevent environmental pollution will be implemented at a faster speed from now on in all areas of the economy. The big question here is just what sort of impact these measures will have on Japan's economic growth potential. It is expected that the impact of pollution control measures on economic and social activities will not be of a static nature, but rather a dynamic equilibrium will be maintained involving many diverse elements. In order to perceive the dynamic effects involved in quantitative terms, one must resort to the techniques of system dynamics. We shall briefly describe below the results of an estimate which the Central Council for Control of Environmental Pollution [1] made by means of system dynamics techniques. First, a brief description of the structure of system dynamics is in order. As the economy

TABLE
SUMMARY OF SIMULATION

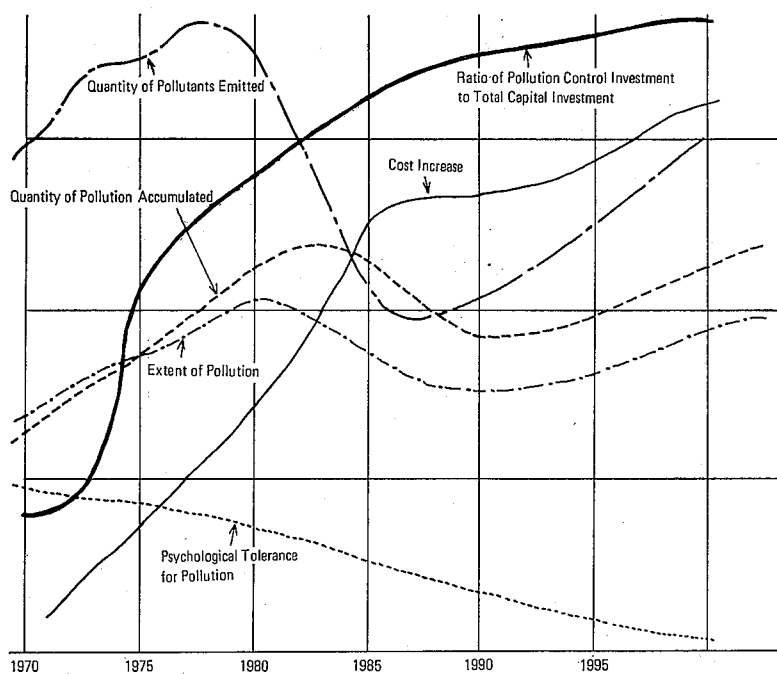
Case No.	Average Annual GNP Growth Rate (%)		Cumulative Total Investment for Pollution Control (Trillion Yen)		Ratio of Pollution Control Investment to GNP (%)	
	Fiscal 1972-77	Fiscal 1972-85	Fiscal 1973-77	Fiscal 1973-85	Fiscal 1977	Fiscal 1985
0	8.8	8.2	7.7	47.7	2.2	3.2
1	8.1	7.9	4.7	29.8	1.3	2.4
2	10.7	8.9	16.3	106.0	4.7	4.9
3	9.2	8.7	9.4	68.3	2.8	4.3
4	8.9	8.2	7.7	47.4	2.2	3.0
5	8.7	7.9	7.6	44.5	2.2	3.0
6	8.6	8.0	7.6	45.7	2.2	3.2

Source: [1].

Note: Case 0—the standard case. Case 1—more lenient regulations. Case 2—more severe regulations. Case 3—rapid strengthening of regulations. Case 4—faster tech-

advances, polluting elements increase, and the gap between the realities of pollution and what people desire in this regard widens, resulting in stronger measures for environmental protection. Increased investment for pollution control brings about increased costs, which result in fewer exports and more imports, all areas

Fig. 3. Simulation by System Dynamics



Source: [1].

IV
 RESULTS

Surplus or Deficit in the Current Account of the Balance of Payments (Billion Dollars)		Extent of Pollution (1967=1.0)			
Fiscal 1977	Fiscal 1985	Fiscal 1977	Fiscal 1985	Fiscal 1995	Fiscal 2005
1.58	-7.24	1.9	1.6	1.6	1.9
3.40	-0.78	1.9	2.2	2.1	2.4
-4.19	-29.41	1.7	1.1	1.1	1.1
0.49	-21.14	1.8	1.4	1.3	2.2
1.37	-7.11	1.7	1.4	1.6	1.9
1.40	-4.27	1.8	1.6	1.6	1.9
0.85	-10.66	1.8	1.6	1.6	1.9

nological progress. Case 5—extremely high cost increase because of investment for pollution control. Case 6—high elasticity of deterioration of the balance of international payments with respect to rising costs.

of the economy thus being affected. This effect also shows up in the determination of national income.

Table IV and Figure 3 show the results of a simulation with this environmental-economic model under various conditions. The table is explained below with reference to a standard case which assumes a rise in the level of environmental protection to twice the current level. Under this assumption the amount of required investment for pollution control will show a rapid increase to ¥7,700 billion during the five-year period from 1973 through 1977 and about ¥40,000 billion during the eight-year period from 1978 through 1985. As a result, the ratio of pollution control investment to GNP will increase from 2.2 per cent in 1977 to 3.2 per cent in 1985. The GNP growth rate will be higher during the first half of the eight-year period, 8.8 per cent for 1972 through 1977 and 8.2 per cent for 1972 through 1985, resulting in a rapid decline around 1983. The balance of international payments will continue to show a large surplus through 1976 or thereabouts, with a turnaround to deficits beginning around 1978.

Cases 2 through 6 show the results of simulation under different levels of environmental protection and other variations in the assumptions. One of the major characteristics observable in all these cases is that the greatest single short-term effect of investment for pollution control is on the income level, but the rate of economic growth is accelerated. This result contrasts sharply with the generally held notion that greater efforts for pollution control will tend to retard growth. Another noticeable feature is that it will be possible to bring Japan's environmental pollution under control by about 1980, even though the economy will progress further and industrial activities will expand. It is thought, however, that if there is to be any improvement in the current state of pollution, investment for pollution control alone will not be enough and fundamental changes must be brought about in the industrial structure, consumption pattern, or technology.

The above simulation is based on a macroscopic view of the entire Japanese

economy. Investment for pollution control variously influences the costs incurred by each industry and each corporation, as well as the rate of growth of individual businesses. Assuming, for example, that waste water quality standards are made doubly severe and 95 per cent desulfurization of exhaust gases containing sulfur oxides is required, the costs of pollution control will account for more than 30 per cent of the total costs of industries like the paper and pulp industry, perhaps making it impossible for many corporations in such industries to continue business on a commercial basis. Also, increased investment for pollution control will inspire greater demand for machinery manufacturers, and this will increase the importance of this and other related non-polluting industries. As a consequence, there may be a shift in Japan's industrial structure, with manufacture of machinery expanding greatly and the oil refining and paper and pulp industries undergoing a relative decline.

V. TOWARD ECONOMIC GROWTH WITHOUT POLLUTION

For the last twenty-odd years Japan's economy has advanced at a speed unmatched anywhere in the world. This high rate of growth has been made possible at the expense of neglecting the pollution that has resulted and allowing external diseconomies to impair human health and increase the tax burden of all the people. Given the very serious state of pollution in which Japan's economy finds itself, the present pattern cannot be allowed to continue. There is an urgent need to switch to a new pattern of development which will permit continued growth while preserving environmental quality.

The first thing that must be done is to change the structure of industry and the pattern of consumption so that they will be less disruptive of environmental resources. This means that vigorous efforts must be exerted to change the industrial structure from the basic resources type, such as steel and oil, to the technology-intensive type, such as machinery and electronics. It also means that the national pattern of consumption oriented toward pursuit of convenient and pleasant living must be transformed to a pattern which does not pollute the environment, even at the expense of some convenience or pleasure. To this end it is necessary to create a market mechanism which will build external diseconomies into business and consumption activities. Also, new taxation and price policies are likely to be required in order that business corporations foot all bills for pollution control, in accordance with the "polluter pays" principle.

Secondly, it is expected that investment for social overhead capital will be given priority and energetically implemented. Investment will be primarily in sewerage systems, waste disposal facilities, and the like, areas which previously were considered wasteful from the point of view of increasing production efficiency. This means that return on investment will decline measurably, and to that extent a brake will be applied on the speed of economic growth and industrial profits.

In addition, greater consideration should be given to environmental protection in technological development, national land development, and many other fields

of endeavor, resulting in great changes in the pattern of advancement of the economy. Indeed, these environmental pollution control policy issues mean that for the first time since the end of World War II, the Japanese economy is standing at a critical economic and social crossroads.

REFERENCES

1. Chūō kōgai taisaku shingikai [Central council for control of environmental pollution]. "Kankyō hozen chōki bijon ni kansuru chūkan hōkoku" [Interim report on long-term vision for environmental protection], mimeographed (Tokyo, 1972).
2. Environment Agency. *Air Pollution Control in Japan* (1972).
3. ————. *Pollution Related Diseases and Relief Measures in Japan* (1972).
4. ————. *Water Pollution Control in Japan* (1972).
5. Environment Agency., ed. *Kankyō hakusho, 1972* [Annual report on environmental pollution, 1972].
6. Ministry of International Trade and Industry. "Minkan ni okeru sangyō kōgai bōshi katsudō no genjō" [Industrial pollution control activities by private businesses], mimeographed (1972).
7. Ministry of International Trade and Industry, Environmental Protection and Safety Bureau. "Amerika gasshūkoku ni okeru kōgai bōshi tōshi no genjō" [Pollution control investment in the United States], *Sangyō kōgai*, Vol. 9, No. 2 (February 1973).
8. Nihon toshi sentā. *Keizai shakai no hembō to seisō jigyō* [Changes in economic society and public sanitation operations] (Tokyo: Nihon toshi sentā, 1969).
9. Office of the Prime Minister. "Kankyō mondai ni kansuru yoron chōsa" [Public opinion survey on environmental pollution problems], mimeographed (1972).