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An Econometric Analysis of The Impacts of Pollution Control in Japan

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CONTENTS

1. Introduction

- Core of the Issue and Scope of the Study -[1]

While there has been growing concern about pollution control in industrialized countries, the number of empirical studies on its economic impacts have been rather limited. There are different views about whether or not the impacts are expansionery. The pessimists argne that the rise in cost due to pollution control tends to squeeze the profit and investment, while consumption is also reduced because of rise in consumer prices. Thus, the economic growth is doomed to secular stagnation. The optimists, on the other hand, argue that there is a shift in growth rate from polluting to clean industries, merely resulting in better reallocation of resources without significant slow-down of economic growth rate. Some even argue that the growth rate is likely to be accelerated during its transition period due to higher rate of investment and introduction of new technology with lower pollution abatement cost. While price increase would be inevitable by internalizing the external cost, they argue, expansionery demand due to anti-pollution control is likely to exceed the contrationery forces affected by the cost increase.

The pourpose of the present paper is to make econometric analysis of the impacts of anti-pollution measures for short- or medium-term period. The positive and negative impacts on economic growth, balance of payments and rate of inflation are discussed in as much detailed as possible. Since longer-term econometric analysis has various difficulties in dada availability and uncertainty of technological progress, we confine ourselves to the shorter perspective which is usually rich in statistical data. An integrated use has been made for our analysis with a Leontief-type input-output model and a Keynsian-type macro-econometric model in order to assess both real as well as monetary impacts upon the Japanese economy.

The present analysis does not cover such items as damage costs, accumulated pollutants, technical progress, various administrative costs, public investment, etc. The damage costs were excluded mainly because of difficulties in definition and statistical measurement, although some of them such as medical cares are not necessarily undefined. The problems would be better treated in the framework of social indicators or related indices in the context to social welfare function.(2) The accumulated pollutants are usually outside of the study because of the lack of reliable information. Abatement costs for certain types of these pollutants are likely to become important, but they are usually dealt with by the government. Although the problem of technical progress is of vital importance for pollution control, we explicitly exclude it because of our main emphasis on shorter-term aspects and many uncertainties involved in longer-term analysis. Government expenditures including administrative costs for pollution control are not taken up in our study, as we are more interested in economic impacts on private sectors.

The present study covers six types of pollutants: SOx, NOx, COx, particulates, BOD, and industrial waste disposals. The other pollutants such as chemical disposals (mercury, PCB, etc.), household disposals, noise, smells, dust, submergence of ground, ocean pollution, etc. are excluded from our study for lack of reliable data.

For simplicity we assume that all pollution abatement costs come from capital expenditures, thus disregarding all current expenses other than depreciation. In view of insignificance of the latter items, this simplification would not distort the main results of our analysis.

Finally we discuss the impacts of oil price increase in the context to the present study. This additional analysis, though temporarily, deals with various impacts of oil price increase on antipollution measures and the entire economic system.

1/ See [3] [4] [5] [6] [8] [9] [11] [12]

2. Analytical Framework

A. Introduction

In assessing the overall impacts, three aspects have to be considered: a) expansionery impacts of anti-pollution investment b) rise in costs and prices for pollution control which tend to offset the above effect and c) structural changes in sectoral demand and output.

The first type of impact can be analyzed on the basis of certain pollution control standards and engineering data for pollution generated and its abatement requirement. Once these sectoral impacts are estimated in the Leontief-type input-output model of 60x60 sectors modified for pollution control, these full impacts are further analyzed through Keynsian-type dynamic multipliers with our quarterly macro-model of about 140 equations. Induced private investment and consumption, together with wage, price and monetary impacts, can be estimated with the latter model for our planning period, 1972-1977.

The second aspect of our analysis on cost-price relations is also dealt with in the same framework of the Leontief model so as to obtain final results of sectoral price changes. These results are again converted to several final demand price deflators, after the adjustment of dynamic responses of cost-price relations. These effects of changes in deflators are then fed back into our macro-model so as to derive dynamic responses of final demand, output and money for our planning period.

Since the above two aspects of pollution control are closely interrelated, joint impacts are obtained by integrated use of the two models. Thus, the expansionery impacts of the first aspect are likely to be cancelled by the contractionery but inflationery impacts of the second aspects. These joint effects are further analyzed on sectoral basis with the Leontief model so as to assess sectoral changes in resource allocation. Generally, polluting industries tend to slow down, while less polluting or anti-polluting sectors tend to grow faster. Dynamic responses of these sectoral changes, however, vary according to industry. Some respond immediately while others adjust themselves rather slowly. These relations can be analyzed by dynamic price adjustment functions and input-output interdependence.

The following procedures were taken for analyzing the above interelations.

a. Estimation of direct pollution abatement costs at 60 - sector level.

b. Estimation of direct and indirect price increase due to the rise in the above pollution cost at 60 - sector level.

c. Dynamic adjustment of prices and conversion to final demand deflators.

d. Estimation of anti-pollution investment based on (a) at 60 - sector level.

e. Conversion of (c) and (d) to macro-model variables.

f. Macro-model simulations

g. Re-conversion of macro-model simulation to sectoral output and employment at 60 - sector level.

In the followings we briefly discuss each step of the above analysis in more details.

B. Estimation of Pollution Abatement Costs and Investment

First we estimated three types of pollution matrix as below:

(1) $Pg, ij - Pa, ij = Pe, ij$

Where Pg is coefficients of pollution generated per unit of output, Pa is coefficients of pollution abatement cost per unit of output, and Pe is coefficients of pollution emitted per unit of output. The size of each matrix ij is 6x60 which contains six pollutants and sixty sectoral divisions. These pollutants are, as noted before, SOx, NOx, COx, particulates and other air pollutants, BOD and industrial wastes. The environmental goals of the government are usually stated as:

(2) $\sum_j Pe,ij.Xj = \sum_j (Pg,ij - Pa,ij)\ Xj$

where Xj is sectoral output. Required anti-pollution investment and the increase in capital cost are dirived from Pa,ij which are directly or indirectly regulated by the government, once the sectoral output levels are roughly assumed. The relationship between pollution abatement and investment is:

(3) $I_{\pi},ij = \Delta K_{\pi},ij$

(4) $K_{\pi},ij = \alpha\, ij\ Pa,ij\ Xj$

(5) $C_{\pi},ij = d_{\pi}i.K_{\pi},ij.$

where I_{π} is pollution abatement investment, K_{π} is pollution abatement equipment, α is coefficients of investment required per unit of pollutant, C_{π} is pollution abatement cost and d_{π} is rate of depreciation of $K\pi$. The results of our estimation of Pgij and α ij are shown in Table 1 and Table 2.

C. Estimation of Direct and Indirect Price Increase and Conversion to Final Demand Deflators

Our sectoral price study is based on an expanded input-output model which includes a newly constructed price block. The latter consists of two sub-system: a) static and b) dynamic, defined as below.

(static system)

(6) $p_d^* = pA + (\omega + \kappa + \tau)\,\hat{v}$

(7) $p^* = p_d^*(I - \hat{\mu}) + p_m \cdot \hat{\mu}$

where p_d^* is imputed price of domestic producers, p^* is imputed price of supply, p_m is import price, A is technical coefficient matrix, $\omega = \frac{w \cdot Lw}{V}$ (unit labor cost in terms of value added), w is wage rate, $\kappa = \frac{(r+d)K}{V}$ capital cost in terms of value added (r = net capital cost including tax, d = depreciation cost), $\tau = T/V$, $\hat{\mu} = M/(X+M)$, i.e. diagonal matrix of import dependency, $\hat{v} = V/X$, i.e. diagonal matrix of value added ratio. p_d^*, p^*, p_m, ω, κ, and τ are row vectors.

The above price block is further transformed into the following dynamic one by introducing external market conditions and the rate of capacity utilization.

Table 1

Coefficients of Pollutants Generated (Pg)

(ton per million yen of output in 1965 prices)

Sector	SOx	BOD	Wastes	Sector	SOx	BOD	Wastes
1	0.0052			31	0.0004	0.0157	0.0658
2	0.0036			32	0.0955	0.0089	0.0658
3	0.0			33	0.0313	0.0195	0.1873
4	0.0018			34	0.0252	0.0194	0.5442
5	0.0028			35	0.0251	0.0373	0.5442
6	0.1242			36	0.0083	0.0010	0.6170
7	0.0020			37	0.0023	0.0006	0.6305
8	0.0359			38	0.0038	0.0008	0.0234
9	0.0101			39	0.0017	0.0013	0.0135
10	0.0053			40	0.0050	0.0013	0.0341
11	0.0551			41	0.0068	0.0007	0.0341
12	0.0130	0.3885		42	0.0071	0.0000	0.0074
13	0.0011	-	0.1217	43	0.0010		0.0180
14	0.0184	0.3910	0.1217	44	0.0011		1.2854
15	0.0229	0.3921	0.1217	45	0.0045		1.2854
16	0.0118	0.3957	0.1217	46	0.0022		1.2854
17	0.0030	-	0.1217	47	0.4121		1.2854
18	0.0146	0.1731		48	0.0197		1.9180
19	0.0031	0.1715	0.0194	49	0.0001		
20	0.0123	0.1722	0.0194	50	0.0041		
21	0.0067	0.0002	0.0194	51	0.0001		0.0201
22	0.0070	0.0005	0.4421	52	0.0076		
23	0.0045	0:0004	0.2824	53	0.0006		0.0072
24	0.0233	1.2172	0.1952	54	0.1589		0.0072
25	0.0	0.0005	0.2321	55	0.0015		0.0072
26	0.0008	0.2999	0.0549	56	0.0005		0.0072
27	0.0214	0.0036	0.0790	57	0.0		0.0032
28	0.0392	0.4267	0.0167	58	0.0040		
29	0.0501	0.4280	0.1338	59	0.0054		0.0270
30	0.0432	0.0158	0.1338	60	0.0037		0.0186

Table 2

Required Investment Per Unit of Pollution Abatement (α)

(Thousand Yen Per Ton in 1965 Prices)

Sector	SOx	BOD	Wastes	Sector	SOx	BOD	Wastes
1	219			31	219	5,915	70
2	219			32	219	5,846	44
3				33	219	9,200	44
4	219			34	219		71
5	219		222	35	219		66
6	219		222	36	219	7,664	3
7			222	37	219		3
8			222	38	219		3
9	219		222	39	219		3
10				40	219		27
11	219		96	41	219		132
12	219	206	96	42	219		-
13	219		96	43	219		176
14	219	208	192	44	219		-
15	219	216	203	45	219		208
16	219	206	203	46	219		208
17	219		142	47	219		208
18	219	129	200	48	219		208
19	219	128	114	49			203
20	219		293	50	219		
21	219		52	51	219		203
22	219		52	52	219		203
23	219		166	53	219		
24	219	138	166	54	219		
25			73	55	219		
26		500	14	56	219		
27	219		14	57			
28	219	207	45	58	219		
29	219	209	3	59	219		
30	219		87	60	219		

(dynamic system)

(8) $p_d - p_{d-1} = \lambda (p_d^e - p_d)_{-1}$

(9) $p_d^e = f.(p_d^*, p_m, \rho)$

(10) $p = p_d (I - \hat{\mu}) + p_m \cdot \hat{\mu}$

(11) $p_c^* = p.Bc$

(12) $p_e^* = p.Be$

(13) $p_c = f(p_c^*, t)$

(14) $p_e = f(p_e^*, t)$

Where p_c^* is consumer price deflator by 20 major groups, p_e^* is export price deflator by 6 major groups, Bc is convertor-matrix of 60 x 20, Be is convertor-matrix by of 60 x 6, p_d^e is expected value of domestic output price, ρ is rate of capacity utilization, λ is adjustment coefficients. p_d, p, p_c, p_e are actual values.

As easily noted, the increase in anti-pollution costs $C\pi$ affects K and then p_d^* and p^*, and finally the entire price system through interindustry dependence and dynamic adjustments. A similar price adjustment was made for other final demand deflators such as those for various investment, government consumption, and change in inventories.

D. Conversion to Macro-Model Variables

The results of the above analysis on sectoral investment and prices need to be further adjusted to quarterly macro-variables, as our macro-model is based on quarterly data and the impacts of anti-pollution investment are not explicitly included in the specification of the model. Since the model has about 17 functions of price deflators for different final demand items and three private business investment functions, constant terms of those functions have been adjusted by using the aggregate amounts derived from the imput-output model. A similar adjustment was also made for private capital stock, as the anti-pollution investment has no productive impacts on capacity and rate of utilization. This implies that while being expantionery in macro-economic terms, the anti-pollution investment is unproductive and inflationery in micro-economic terms.

Several qualifications, however, are needed to the above approach. Firstly, a favorable impact of replacement investment is not explicitly considered which tends to increase environmental efficiency through its vintage effect. Secondly, regional aspects in relocation of industrial plants which also affect pollution standards of the government are neglected. Thirdly, coefficients of pollution generated are assumed to be constant over time but there is an increasing tendency of technical progress in this area. Lastly, government investment, especially that for sewerage system which tends to have substantial impact on environment and economy is not included in the present study.

In view of these qualifications, it should be pointed out that the aggregate required anti-pollution investment and price increase tend to be over-estimated in some sectors, while under-biased in the public investment.

E. Macro-Model Simulation

Based on the adjustments derived from the input-output model, dynamic impacts on aggregate variables have been obtained by the EPA Quarterly Macro-Model with about 140 equations for 1972 to 1977.[13] Since this model consists of three sectors: primary, secondery and tertiary, the policy impacts can be analyzed for sectoral output, employment, investment, as well as various price deflators. Monetary impacts are also obtained in terms of money supply, financial transactions and various interest rates.

In order to distinguish the effects between those of aggregate demand and of prices, an attempt is made to run the model separately for these two different impacts. This lends itself to the analysis of the policy impacts in view of the complex nature of the present study.

F. Estimation of Sectoral Output and Employment

The results of the macro-model simulation are again converted to sectoral demand, trade, output and employment by the input-output model. The final demand structure is also affected by the change in relative prices, especially for exports and private consumption. Thus, polluting sectors tend to be adversely affected while other sectors tend to respond rather expansionery. As discussed later, their response patterns are different according to the dependency on anti-pollution activities, price sensitivity, etc.

3. The Results of Policy Simulation

A. Goals of Pollution Control

The desired goals for pollution control are indicated in Table 3. For 1977, Case A indicates lower, less anbitions targets which is similar to the present five-year plan,[8] while Case B shows higher, more ambitions targets which roughly correspond to those presently considered desirable by the authorities concerned.

In the following we deal with six cases of policy simulations:

Case A ..... lower pollution control targets

Case B ..... higher pollution control targets

Case B-1 ... do. for air pollution

Case B-2 ... do. for water pollution

Case B-3 ... do. for industrial wastes

Case C ..... do. under increased oil prices

Table 3 - A

Goals for Pollution Control

	1971	1977	
		Case A	Case B
A. Air			
SOx : amount of emission (million t)	2.72	.97	
NOx : amount of elimination (million t)	-	0	5.49
Dust, etc. (anti-pollution equipment, billion yen)	294	1,915	
CO (additional cost per unit of automobile, 1000 yen)	-	8.22	
B. Water			
BOD : amount of emission (million t)	8.75	5.78 (120 ppm)	1.36 (20 ppm)
C. Industrial Wastes			
Amount of emission (million t)	2.23	104	0
Rate of elimination (%)		75	100

Note : Case A ... lower target ; Case B ... higher target

Table 3 - B

Anti-Pollution Investment

by Type of Pollutants 1/, 2/

(1965 prices)

	1972	1973	1974	1975	1976	1977	1972 - 1977
Case A : Lower Target							
1. SOx	132	163	153	121	171	119	859
2. Particulates, etc.	294	363	341	271	382	264	1,951
3. NOx	-	-	-	-	-	-	-
4. CO 3/	-	-	-	(854)	(-10)	(45)	(,889)
5. BOD	76	222	305	477	581	191	1,852
6. Wastes	73	91	107	204	315	97	887
Total 4/	574	840	906	1,073	1,448	672	5,513
Case B : Higher Target							
1. SOx	132	163	153	121	171	119	859
2. Particulates, etc.	294	363	341	271	382	264	1,915
3. NOx	369	456	429	340	479	331	2,404
4. CO 3/	-	-	-	(854)	(-10)	(45)	(,889)
5. BOD	146	537	634	852	943	372	3,484
6. Wastes	73	173	205	309	293	129	1,182
Total 4/	1,013	1,693	1,762	1,893	2,267	1,216	9,844

Note : 1/ Derived from I-O model
2/ CO is not included in Total
3/ Expenditures for anti-pollution
4/ Includes rounding errors

Cases B-1, B-2, B-3 indicate the components of pollution controls by type of pollutants such as, air, water, and industrial wastes, while Case C is related to the Case B under the increased oil prices which is considered wore realistic at the present moment.

The pollution abatement investment in 1965 prices which corresponds to the above two targets are indicated in Table 3-B. These estimates are derived from the formula discussed earlier, but those for particulates, NOx, and COx are estimated directly because of the weakness of the pollutants-generation matrices. Accumulated investment over six years, is 5.5 trillion yen for the lower control target, while 9.8 trillion yen for the higher control target. In percentage of GNP, the averate annual rate of this investment stands at about 1.5 to 2.4 percent for 1970 - 1975. In terms of share by type of pollutants the air pollution control accounts for the highest contribution. The lower share of the water pollution control is mostly due to the exclusion of the public works for sewerage system. As for the time pattern, the rates of increase of the anti-pollution investment are higher for the early three years especially for SOx, but they tends to decelerate for the later period. This changing time pattern is important in interpreting policy impacts as discussed later.

B. Sectoral Assumptions

Now we discuss sectoral components of pollution controls. As shown in Table 4, pollutants' tend to be generated in selected industries, especially a) oil-consuming sectors such as chemicals, steel, electric power, transportation, and b) sectors with heavier water-pollution and industrial disposals such as pulp and paper, food manufacturing, non-ferrous metals, construction, etc.

Looking at the table in more details, air pollutants, SOx, are generated mostly by electric power, other transport, iron and steel and chemicals which account for about fifty percent of total SOx. We assume here that these air pollutants, including other sectors are to be reduced to one fifth of those generated in 1977, with special emphasis on cleaner oil consumption.

As for water pollution of BOD, pulp and paper, food manufacturing, and chemicals account for more than n nety percent of the total. We assume here that total generated BOD is to be cut to one-third in the lower target and to one-tenth in the higher target in 1977, with special reference to those three sectors.

Industrial disposals tend to be rather widely distributed as against other pollutants. Relatively, higher shares are observed for basic metals and metal products, apparels, wood products, construction and electric power. In our assumption those disposals are to be reduced gradually to once-fourth in the lower target and to zero in the higher target.

Table 4

Amount of Pollutants Generated and

Eliminated in Million Ton

1977

G ... Pollutants Generated
A_L ... Abatement for Lower Target
A_H ... Abatement for Higher Target

A. SOx

	G	A_L A_H		G	A_L A_H
1	14.1	2.9	31	0.3	0.1
2	0.6	0.1	32	357.0	74.6
3	-	0	33	207.0	43.3
4	3.2	0.7	34	276.8	57.8
5	2.0	0.4	35	75.6	15.8
6	105.0	21.9	36	57.1	11.9
7	0.2	0	37	34.0	7.1
8	0.1	0	38	70.9	14.8
9	0.9	0.2	39	18.7	3.9
10	0.1	0	40	17.4	3.6
11	63.0	13.2	41	13.4	2.8
12	25.8	5.4	42	38.9	8.1
13	1.5	0.3	43	9.3	1.9
14	15.8	3.3	44	7.5	1.6
15	96.1	20.1	45	23.6	4.9
16	32.4	6.8	46	12.4	2.6
17	3.3	0.7	47	1494.5	312.2
18	10.1	2.1	48	8.6	1.8
19	2.6	0.5	49	0.1	0
20	46.4	9.7	50	85.2	17.8
21	16.3	3.4	51	0.5	0.1
22	19.2	4.0	52	12.5	2.6
23	8.1	1.7	53	3.6	0.7
24	95.7	20.0	54	700.5	146.3
25	-	0	55	3.3	0.7
26	0.2	0	56	3.2	0.7
27	27.0	5.6	57	-	-
28	313.3	65.5	58	33.1	6.9
29	156.3	32.7	59	59.0	12.3
30	198.0	2940.7	60	9.6	2.0
			Total	4890.8	3921.0

Note: For classification see Appendix.

B. BOD

	G	A_L	A_H		G	A_L	A_H
1				31	12.3	1.5	5.1
2				32	33.8	0.7	11.7
3				33	129.7		
4				34	215.2		
5				35	115.1	15.6	95.2
6				36	7.1		
7				37	9.6		
8				38	14.6		
9				39	14.9		
10				40	4.7		
11				41	1.3		
12	766.3	679.8	751.9	42	0.2		
13				43			
14	331.8	294.3	325.5	44			
15	1620.6	1437.8	1590.1	45			
16	1060.4	940.8	1040.5	46			
17				47			
18	118.3	70.9	110.4	48			
19	141.3	84.7	131.9	49			
20	645.4	386.9	602.4	50			
21	0.6			51			
22	1.4			52			
23	0.7			53			
24	4984.5	3373.1	4715.9	54			
25	1.4			55			
26	56.9	53.3	56.3	56			
27	4.6			57			
28	3414.7	1423.6	3082.9	58			
29	1333.0	555.7	1203.5	59			
30	71.9	9.0	30.0	60			
				Total	15,112.3	9,327.9	13,753.2

C. Industrial Wastes

	G	A_L	A_H		G	A_L	A_H
1				31	322	241	322
2				32	4,377	3,282	4,377
3				33	22,522	16,891	22,522
4				34	37,356	28,017	37,356
5				35	11,611	8,708	11,611
6				36	27,112	20,334	27,112
7				37	2,159	1,620	2,159
8				38	1,574	1,181	1,574
9				39	2,343	1,757	2,343
10				40	743	557	743
11				41	91	68	91
12	1,510	1,132	1,510	42	616	462	616
13	1,064	798	1,064	43	74,668	56,001	74,668
14	654	490	654	44	54,465	40,848	54,465
15	3,193	2,395	3,193	45	42,062	31,547	42,062
16	2,090	1,567	2,090	46	45,253	33,940	45,253
17				47	43,472	32,604	43,472
18	84	63	84	48			
19	100	75	100	49			
20	458	343	458	50	2,610	1,958	2,610
21	6,736	5,051	6,736	51			
22	4,835	3,626	4,835	52	74	56	74
23	2,185	1,639	2,185	53	269	202	269
24	5,959	4,469	5,959	54	198	149	198
25	923	692	923	55	98	73	98
26	94	71	94	56	126	95	126
27	132	99	132	57			
28	6,684	5,013	6,684	58	1,398	1,049	1,398
29	2,609	1,957	2,609	59	1,271	953	1,271
30	1,885	1,413	1,885	60			
				Total	417,984	313,488	417,984

In terms of capital cost, Table 5 indicates the amounts of capital required for anti-pollution by industry. This table is important, as it provides the basis for incremental investment and cost required for pollution abatement. The table also implies that a relatively higher priority is placed on air pollution which accounts for about half the total capital required.

Since, for simplicity, we disregard replacement of these anti-pollution capital stock, as noted before, the fow of fixed investment can be obtained as the net increase in those capital stock by industry.

Table 5

Capital Stock for Pollution Control

1977 (billion yen)

Sector	I	II	Sector	I	II
1	6.2	13.1	31	13.2	35.8
2	.3	.5	32	186.0	467.3
3	.0	.0	33	114.3	224.0
4	1.4	2.9	34	160.2	309.4
5	.9	1.9	35	192.4	855.0
6	45.9	97.5	36	31.1	61.2
7	.1	.1	37	28.9	50.3
8	.1	.1	38	39.3	76.9
9	.4	.8	39	15.9	27.7
10	.1	.1	40	10.1	19.4
11	27.5	58.5	41	6.4	13.1
12	177.0	213.0	42	20.0	40.2
13	18.4	25.1	43	20.9	31.0
14	73.7	96.5	44	15.5	23.3
15	392.5	489.0	45	19.8	34.5
16	243.5	291.7	46	15.6	25.1
17	1.5	3.1	47	741.5	1505.6
18	14.2	24.5	48	3.8	8.0
19	12.8	20.4	49	.0	.1
20	73.7	125.5	50	71.7	125.1
21	104.1	144.5	51	.2	.5
22	82.0	116.0	52	6.6	13.2
23	36.8	51.8	53	5.8	8.9
24	570.3	823.7	54	309.4	654.8
25	13.8	18.5	55	3.0	5.1
26	26.9	28.7	56	3.3	5.5
27	14.7	28.9	57	.0	.0
28	457.5	963.3	58	35.8	59.2
29	193.5	407.7	59	45.2	80.6
30	798.2	1027.0	60	4.2	8.9
			Total	5512.7	9843.9

Note: 1) I… lower Target II… higher target

2) For classification see Appendix.

These estimates are obtained by multiplying the capital cost coefficients α in Table 2 to the amount of pollutants eliminated in Table 4.

In terms of total capital cost, in both control targets, oil refinery and electric power industry indicate the highest contributions, while those by food, pulp, chemicals and basic metals are also noticeable in pollution control investment.

C. Sectoral Price Changes

As discussed earlier, anti-pollution investment in our model increases sectoral capital cost and prices accompanied by certain time lags and interindustry repercussions. The input-output model in equations (6) to (14) provides total impacts of these changes in price system which are shown in Table 6-1. The results include indirect as well as direct impacts of pollution control on sectoral prices over the planning period.

In both targets higher price-increases are observed in 1977 for pulp and paper, petroleum refining, iron, electric power, automobiles, other transport. Minor in share but similar trends are indicated for dairy products, processed marine products, leather products, and apparels.

While contributions to these price changes vary according to industry as shown in Table 6-2, most of the larger changes are due to the cost for air pollution, but those for pulp and paper, leather products, dairy and marine products and non-ferrous metals are affected chiefly by the cost for water pollution. The price increase for industrial wastes are noted for apparels and wood products.

On the whole the average price increase is rather insignifant as it includes various machineries and equipment and services which are hardly affected by pollution controls.

Generally in the case of higher target the prices tend to rise further especially for the above pollution generating sectors, while the average price increase also becomes more significant.

In Table 6-3, these sectoral prices are converted to final demand deflators which tend to affect the changes in demand components. In both cases of target, deflators for inventories and exports tend to rise faster, while other deflators move to rise almost similarly. As for consumer prices, deflators for light and fuels, fishing products, dairy products, eating-out, etc. rise more than other items. It is rather striking that price effects of pollution control tend to affect items with relatively lower income elasticity. In other words, anti-pollution measures need to be accompanied by certain type of policies for income re-distribution.[1]

With respect to exports, the price effect is relatively high for miscellaneous manufacturing products, metals, textiles and chemicals, while the lowest impacts are observed for machineries and equipments.

The effects of these prices on demand components in volume will be discussed later.

Table 6-1

Pollution Control Impacts on Prices

A. Sectoral Price Changes (%)

Sector	I	II	Sector	I	II
1	.2	.3	31	.7	1.5
2	.1	.1	32	3.4	7.4
3	.0	.0	33	7.6	14.5
4	.7	1.0	34	2.5	4.7
5	.1	.1	35	1.4	5.3
6	3.2	6.1	36	1.1	2.1
7	.0	.0	37	.8	1.5
8	.0	.0	38	.4	.8
9	.3	.6	39	5.9	6.6
10	.0	.0	40	.5	.9
11	.0	.0	41	1.1	2.1
12	4.4	5.7	42	.3	.6
13	- .4	- .5	43	1.3	2.3
14	6.4	9.0	44	.8	1.4
15	2.9	3.8	45	1.4	2.5
16	3.1	4.2	46	1.3	2.4
17	.3	.6	47	6.2	11.8
18	.8	1.3	48	1.6	2.5
19	2.1	3.9	49	.0	.0
20	2.1	3.7	50	.9	1.3
21	3.2	4.8	51	.1	.1
22	2.3	3.5	52	1.5	2.7
23	1.6	2.6	53	.9	1.1
24	7.7	11.6	54	6.3	12.5
25	.4	.6	55	.2	.4
26	11.8	13.5	56	.1	.2
27	1.4	2.7	57	.0	.0
28	2.7	5.4	58	.5	.9
29	.4	.8	59	.6	1.0
30	6.6	8.5	60	2.1	4.1
			Total	1.9	3.1

Note: For classification see Appendix.

Table 6-2

Sectoral Price Changes in Higher Target

by Types of Pollutants

1977 (%)

	Air	Water	Wastes		Air	Water	Wastes
1	.2	.1	.0	31	.7	.6	.2
2	.1	.0	.0	32	5.4	1.5	.5
3	.0	.0	.0	33	12.2	1.1	1.2
4	.4	.4	.1	34	4.0	.3	.4
5	.1	.0	.0	35	1.0	4.0	.3
6	5.6	.4	.1	36	1.7	.2	.2
7	.0	.0	.0	37	1.1	.2	.2
8	.0	.0	.0	38	.5	.3	.1
9	.5	.1	.0	39	6.1	.3	.2
10	.0	.0	.0	40	.7	.1	.1
11	.0	.0	.0	41	1.3	.6	.2
12	1.1	3.8	.8	42	.4	.2	.1
13	.2	.0	- .7	43	1.4	.2	.7
14	3.8	4.2	1.0	44	1.0	.2	.3
15	1.0	2.2	.5	45	2.0	.2	.3
16	.9	2.7	.6	46	1.8	.2	.4
17	.4	.2	.0	47	10.5	.4	.9
18	.8	.5	.1	48	2.2	.2	.1
19	1.8	1.9	.2	49	.0	.0	.0
20	1.9	1.6	.2	50	1.0	.1	.2
21	1.4	1.0	2.4	51	.1	.0	.0
22	1.2	.3	2.0	52	2.4	.1	.2
23	1.0	.3	1.2	53	.9	.1	.1
24	2.5	7.9	1.2	54	12.1	.3	.2
25	.2	.2	.1	55	.3	.0	.1
26	1.4	11.3	.8	56	.2	.0	.0
27	1.9	.6	.2	57	.0	.0	.0
28	2.5	2.6	.2	58	.6	.1	.2
29	.3	.4	.0	59	.7	.1	.1
30	6.9	1.3	.3	60	3.5	.5	.2
				Total	2.2	.7	.3

Note: For clacification see Appendix.

B. Consumer Price Deflators

	I	II	Price 1/ Elasticity
1. Cereals	1.3	1.7	
2. Vegetables	.4	.7	- .38
3. Fish	3.8	5.8	- .38
4. Dairy produes	2.8	3.8	- 1.06
5. Processed food	2.9	4.0	- 1.33
6. Seasonings	2.5	3.3	- .97
7. Liquers	2.7	3.7	- .95
8. Cakes, etc.	1.7	2.3	- .69
9. Tobacco	.6	1.1	
10. Meals outside home, etc.	4.8	7.0	
11. Apparels	1.5	2.4	- 1.66
12. Light and fuels	5.2	8.8	- 1.39
13. Water	-	.0	- .76
14. Rent	.2	.3	
15. Durables	.7	.9	
16. Health	.6	1.0	- .51
17. Transport and communication	2.1	3.8	- .73
18. Reading and recreation	.3	.6	- .85
19. Education	- .3	- .5	
20. Miscellaneous	.3	.4	
21. Total	1.4	2.1	
A Foods	2.5	3.5	
B Durables	.6	.9	
C Others	1.0	1.7	

Note: 1/ Taken from EPA report [7]

C. Export Price Deflators

	I (%)	II (%)	Price Elasticity 1/
1. Foods	3.3	4.7	- .49
2. Textiles	2.7	4.9	- .90
3. Chemicals	1.8	3.6	- .87
4. Metals	3.6	7.1	-2.85
5. Machineries	1.5	2.1	-1.41
6. Others	4.9	8.2	-1.00
7. Total	2.5	4.1	-1.40

Note: 1/ Taken from EPA report [7].

C. Macro-Economic Impacts

As mentioned before, the above results of the input-output model were used for adjusting constant terms of private investment and price determination functions in our quarterly macro-model which includes financial as well as real transactions. The dynamic responses of the entire economy obtained from the latter model are shown in Table 7.

Table 7

Macro-Economic Variables

A. Real and Price Variables

I ..... lower target

II .... higher target

(1965 billion yen)

	CY	1972	1973	1974	1975	1976	1977
V	I	731	2,134	2,638	1,876	1,702	580
	II	1,301	4,192	5,596	3,611	2,501	746
V^c	I	150	919	2,105	3,065	3,721	4,218
	II	267	1,714	4,173	6,128	7,124	7,684
C	I	19	87	152	138	72	-50
	II	34	165	317	301	158	-54
C_f	I	1	1	-14	-50	-97	-147
	II	3	3	-20	-87	-175	-262
C_d	I	3	14	21	9	-8	-13
	II	5	26	44	21	-19	-30
C_o	I	15	72	144	179	176	111
	II	26	136	293	367	352	238
C_g	I	0	-2	-4	-6	-11	-15
	II	0	-2	-6	-11	-15	-23

I_g	I	-9	-33	-41	-63	-120	-147
	II	-17	-61	-79	-110	-207	-276
I_h	I	18	59	77	13	-32	-87
	II	32	114	163	26	-92	-170
I_p	I	585	1,906	2,557	2,045	1,929	1,230
	II	1,040	3,702	5,363	3,982	2,993	1,795
I_{p1}	I	8	7	1	-2	2	11
	II	17	17	5	-1	9	30
I_{p2}	I	444	1,397	1,827	1,366	1,310	633
	II	754	2,715	3,838	2,562	1,867	798
I_{p3}	I	133	502	729	682	617	585
	II	269	971	1,520	1,422	1,116	967
J_p	I	224	501	406	89	127	-202
	II	398	1,009	908	89	-1	-386
E	I	-11	-32	9	89	119	120
	II	-20	-61	4	181	275	252
E_c	I	-13	-37	3	85	116	124
	II	-22	-69	-10	174	272	260
M	I	94	351	516	430	382	269
	II	165	673	1,074	847	608	392

0	I	4.1	12.7	16.4	12.4	11.5	5.8
	II	7.3	24.9	34.7	24.0	17.3	8.2
κ_p	I	76	818	2,362	3,698	4,380	4,831
	II	138	1,532	4,769	7,654	8,838	9,302
V/V_c	I	.8	1.6	.7	-1.1	-2.0	-3.6
	II	1.5	3.2	1.8	-2.3	-4.4	-6.7
p^c	I	0	.1	.7	1.5	2.1	2.2
	II	0	.2	1:1	2.8	3.9	3.8
p_{cf}	I	.2	1.0	2.7	4.2	5.1	5.2
	II	.3	1.8	4.9	7.8	9.2	8.8
p_{cd}	I	.1	.3	.4	.2	.3	.6
	II	.2	.6	.7	.4	.3	.6
p_{co}	I	- .1	- .4	- .3	.5	1.1	1.2
	II	- .2	- .8	- .8	.8	2.1	2.2
p_{cg}	I	0	.1	.1	.3	.5	.6
	II	0	.1	.5	.5	.6	1.0
p_{ig}	I	.2	.6	.8	1.1	1.7	1.8
	II	.3	1.2	1.6	1.9	3.0	3.5
p_i	I	.3	1.0	1.0	.4	- .3	-1.3
	II	.5	1.8	2.1	.7	-1.1	-3.1

p_h	I	.2	.6	.9	1.3	1.7	1.6
	II	.3	1.1	1.8	2.3	2.9	2.8
p_j	I	.1	.3	.2	.2	.5	.5
	II	.3	.5	.4	.3	.8	1.1
p_e	I	.2	.2	-.1	- .4	- .1	- .2
	II	.4	.5	-.2	- .9	- .5	- .4
p_{ec}	I	.2	.2	- .2	- .5	- .2	- .3
	II	.4	.4	- .4	- 1.2	- .8	- .7
p_m	I	- .1	- .4	- .6	- .6	- .6	- .5
	II	- .1	- .7	- 1.1	- 1.2	- .9	- .7
p	I	- .1	- .2	- .2	.2	.5	.8
	II	- .2	- .5	- .5	.2	.9	1.3
p_w	I	.3	.5	.3	.2	.5	.4
	II	.5	.9	.5	.0	.6	.6
p_{wi}	I	.3	.5	.3	.1	.5	.3
	II	.6	1.0	.5	- .1	.4	.2
p_{wf}	I	.0	.1	.2	.2	.2	.3
	II	.0	.2	.3	.4	.4	.5
p_{wo}	I	.0	.2	.3	.6	.8	1.1
	II	.1	.2	.6	1.2	2.0	3.1

p_k	I	.2	.8	1.1	1.2	1.5	1.7
	II	.4	1.4	2.1	2.3	2.4	2.6
w	I	4.2	21.7	50.5	71.7	76.1	55.7
	II	7.4	40.3	100.2	144.5	145.0	97.2

Note: V = real GNP V^c = potential GNP

C = real private consumption

C_f= do., for food Cd = do. for durables Co = do., for others,

Cg= real government consumption

Ig= real government investment

Ih= real private housing investment

I_p= real private business investment

I_{p1}= do., primary sector, I_{p2}= do., for secondary sector, I_{p3}= do., for tertiary sector, J_p= change in private inventories, E= exports, Ec= commodity exports, M= imports O = industrial production (1940 = 100), K_p = business capital stock, p_c = consumer price deflator, p_{cf} = do., food, p_{cd}= do., durables, p_{co}= do., for others , p_{cg}= government consumption deflator, p_{ig}= government investment deflator, p_i= business investment deflator, p_h= private housing deflator,

p_j= inventory deflator, p_e= export price deflator, p_{ec}= commodity export deflator, p_m= import price deflator, p_{wi}= wholesale price deflator, industrial products, p_{wf}= do, farm products, p_{wo}= do., other, p_k= user cost of capital, w= wage rate (1000 yen)

B. Monetary Variables

(billion yen)

		1972	1973	1974	1975	1976	1977
1. Money supply (=2.+3.+4.)	I	-196	-948	-1,304	-626	-289	-196
	II	-347	-1,812	-2,849	-1,232	97	174
2. Credit to private sectors	I	- 26	- 25	239	623	608	449
	II	- 45	- 64	361	1,297	1,389	841
3. Credit to public sectors	I	- 83	-498	- 823	-675	-441	-343
	II	-148	-935	-1,705	-1,379	-616	-303
4. Credit to abroad	I	- 87	-424	- 719	-573	-456	-302
	II	-154	-935	-1,705	-1,379	-616	-303
5. Call money rate (%)	I	.01	.01	.24	.26	.18	.15
	II	.02	.16	.48	.54	.31	.19
6. Interest rate on bank loan (%)	I	0	.02	.04	.05	.03	.03
	II	0	.03	.09	.10	.06	.03

Although anti-pollution investment is here treated as non-productive and tends to raise depreciation and price deflators expecially capital cost which reduces business investment, its expansionery impacts on real demand stimulate real output and expenditures expecially for the earlier three years and then gradually level off. It should also be noted that potential GNP, capacity of total economy, is also raised because of active induced investment. In both cases the rate of growth of real GNP is raised by 1.2 to 2.6 percent for the earlier and by 0.1 to 0.2 percent for the entire period respectively. Most of this expansion is accounted for by active private investment including anti-pollution expenditures whose share is about half as much as the total investment. The private consumption also actively increases for the first three years and then turns to level off rather sharply. The commodity exports in volume indicate some-what opposite moves; i.e. falling slightly in the first two years and then start rising fast thereafter because of price effects of earlier pollution control and growing capacity pressures for the latter period.

With respect to prices, it should be noted first that inflationery pressures in earlier period turn to be rather deflationery in the latter period due to growing excess capacity and level-off in the rate of growth of real output. This tendency is reflected more or less in the moves of various price deflators. The business investment prices, for example, start rising for the first half of our period and then tend to fall slighty for the second half. This implies that a) rising cost for pollution abatement and b) expantionery pressures of business investment tend to raise the prices for earlier period but later they turn to be dominated by growing deflationery forces. Consumer price deflator, on the other hand, continue to rise untill the last year, because of its rigidity against market conditions and larger increase in pollution abatement cost. Between these two extremes there are mixed type of price defators. Deflators for private housing construction start rising fast, but in the last two years they turn to level off slightly. Export prices also follow a similar pattern to those of business investment but they turn to fall much earlier because of the increase in productivity and growing capacity pressure in manufacturing.

There is an adverse trend in the balance of international payments, as easily noticed from the above. This is due mostly to the expansionery impact of the pollution abatement investment, but partly to the decline in exports and the rise in imports for earlier period. The latters are attributed to the rise in the export prices and wholesale prices. The average annual value of these balance of payment deficit amounts to about 1.5 billion dollors in the lower target and 2.6 billion dollors in the higher target. These would have led to a gradual devaluation of the yen in the absense of government intervention in foreign exchange market. The significance of this balance of payment effect, however, would be certainly reduced, if similar pollution control costs are imposed in competing contries.

In regard to monetary transactions, there are a declining tendency in money supply and a tightning of money market which are accounted for by the increase in government surplus and continuous deficits in balance of payments. Thus, the interest rate on call money and bank loans tend to rise so that they produce a negative impact on business investment. This kind of automatic stabilizing effect of the money market would be some-what reduced if the exchange rate of the yen were left to float and to be devaluated somehow. In other words, inflationery pressures of pollution control would be greater under the floating exchange rate system than in the case of fixed rate system. This also implies that countercyclical policy tends to have stronger impacts under the floating exchange rate system.

The above discussions on macro-economic impacts can be summarized in terms of aggregate output, capacity and price chances under the assumption of fixed exchange rate Table 8. The price effects are derived from the input-output model, while the income effects are obtained as residuals between the total effect and the price effect. Thus the income effects are regarded as direct and indirect impacts of anti-pollution investment through Keynsian-type multiplier. As noted above, even in the case for lower pollution control target, the price effects on output are relatively smaller but tend to gradually increase. The capacity, on the other hand, indicates continous increase, but the price effects are also smaller than the income effects.

Table 8

Summary of Macro-Economic Simulation,

- Case for Lower Target 1/ 2/

	1972	1973	1974	1975	1976	1977
1. Output	731	2,134	2,638	1,876	1,702	580
a. price effect	-32	-250	-624	-620	-640	-970
b. income effect	763	2,384	3,262	2,496	2342	1550
2. Capacity	150	919	2105	3065	3721	4218
a. price effect	-6	-74	-296	-578	-802	-1081
b. income effect	156	993	2401	3643	4523	5299
3. Export Prices	.2	.2	-.2	- .5	- .2	- .3
a. price effect	0	.1	.2	.4	.6	.9
b. income effect	.2	.1	0	- .9	- .8	-1.2
4. Inventory Prices	.1	.3	.2	.2	.5	.5
a. price effect	0	0	.1	.2	.2	.3
b. income effect	.1	.3	.1	0	.3	.2
5. Consumer Prices	0	.1	.7	1.5	2.1	2.2
a. price effect	0	.8	.2	.4	.7	1.0
b. income effect	0	-.7	.5	1.1	1.4	1.2

Note: 1/ 1. and 2. in 1965 billion yen.

3. to 5. in percent.

2/ Based on Table 7.

Though the overall impacts on price deflators tend to vary, the sensitive deflators such as export prices indicate rather negative sign in the later period while the price effect tends to increase gradually. For the other deflators, the positive income effects are slightly higher than the price effects.

These pattern implies that empirical results are rather in favor of the optimists' view which emphasize the expansionery impacts of the pollution control, but its contractionery effects are not necessarily insignificant as they tend to grow, though slightly, in the longer terms.

D. Sectoral Output and Employment

With the input-output model the aggregate levels of final demand are converted to final bill of goods and then to sectoral levels of output and employment through the same technical coefficients and import coefficients as those used for the price analysis.

A similar changing pattern can also be observed with respect to income and price effects of pollution control. In accordance with macro-variables most of sector output expand greatly centering around machinery industries for earlier period and later they turn to level off gradually due to relatively increasing price effects of pollution control.

Main features in sectoral changes of output are a) increase in general and electric machineries and transport equipments, primary and fabricated metals, b) decline in food and primary products, textiles, and electricity and gas, and c) relatively stable but slight decline in chemicals and paper, as shown in Table 9. At 60 - setor level a declining tendency of oil refining is also noted.

The first group in the above is naturally affected by the expansion of anti-pollution investment as easily noticed. The second group is adversely affected by the price effects of private consumption and exports. The decline of the share of agricultural output is mostly attributed to the decline of food consumption due to the increase in water and air pollution cost.
This tendency implies that the price effects of anti-pollution are likely to adversely affect the lower income classes as they depend more on these essential goods with low income elasticity. (See, for instance, W. Baumal [ ].)

The third group is rather against ordinary anticipation, as they are regarded as highly polluting industries. Although their price effects are significant as in Table 6, indirect income effects of final demand have compensated the negative impacts of prices. This is also the case with basic steel in which negative price effects on exports are cancelled by the positive income effect of anti-pollution investment.

As for employment a very similar pattern is observed at 20 - sector level.

Table 9.

Sectoral Output

A. Rate of Increase

(%)

	Standard case	Lower Target	Higher Target
1	3.92	3.90	3.83
2	8.72	8.73	8.68
3	7.72	7.73	7.45
4	6.07	6.00	5.98
5	10.15	10.32	10.15
6	10.12	10.13	10.15
7	9.93	10.17	10.27
8	11.38	11.55	11.65
9	10.73	11.57	12.20
10	14.43	15.00	15.38
11	10.58	10.87	10.98
12	11.10	11.17	11.67
13	11.97	12.12	12.15
14	10.57	10.43	10.35
15	10.57	10.65	10.65
16	8.22	8.30	8.33
17	11.38	11.58	11.63
18	10.18	10.27	10.28
19	10.22	10.22	10.18
20	10.07	10.13	10.15
Total	10.43	10.60	10.67

Note: For 60 - sector level of output of standard case, see Table 13.
For classification see appendix.

B. Percentage of Components

	1974			1977		
	S.C.	L.T.	H.T.	S.C.	L.T.	H.T.
1	3.01	2.92	2.82	2.52	2.50	2.49
2	.55	.55	.55	.54	.54	.54
3	4.76	4.45	4.53	4.55	4.48	4.45
4	2.40	2.36	2.30	2.15	2.13	2.12
5	1.70	1.69	1.68	1.67	1.66	1.65
6	4.49	4.44	4.36	4.52	4.50	4.49
7	8.80	8.95	9.09	8.39	8.41	8.41
8	2.71	2.73	2.76	2.80	2.80	2.80
9	6.37	6.76	7.13	6.01	6.20	6.32
10	7.26	7.48	7.66	7.60	7.73	7.82
11	6.13	6.18	6.23	5.89	5.91	5.92
12	11.50	11.44	11.32	11.71	11.65	11.61
13	10.21	10.31	10.40	10.97	10.97	10.95
14	1.88	1.86	1.82	1.91	1.88	1.87
15	8.37	8.29	8.21	8.46	8.42	8.41
16	2.12	2.08	2.00	2.08	2.08	2.08
17	5.58	5.55	5.49	5.78	5.77	5.76
18	2.55	2.52	2.48	2.57	2.56	2.56
19	8.55	8.39	8.13	8.81	8.75	8.72
20	1.06	1.05	.10	1.05	1.05	1.05
Total:	100.00	100.00	100.00	100.00	100.00	100.00

Note: S.C. ... Standard case, L.T. ... Lower Target
H.T. ... Higher Target
For classification see Appendix.

Table 10

Components of Sectoral Employment (%)

No.	1974			1977		
	S	I	II	S	I	II
1	13.0	12.9	12.7	9.3	9.3	9.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	2.0	2.0	2.1	2.1	2.1	2.1
4	4.1	4.1	4.1	4.1	4.1	4.2
5	0.6	0.6	0.6	0.6	0.6	0.6
6	1.2	1.2	1.2	1.2	1.2	1.2
7	1.5	1.6	1.6	1.6	1.6	1.6
8	3.0	3.0	3.1	3.3	3.3	3.4
9	2.4	2.4	2.5	2.3	2.4	2.4
10	3.4	3.5	3.6	3.8	3.9	4.1
11	2.1	2.1	2.2	2.2	2.2	2.3
12	7.3	7.4	7.5	7.7	7.7	7.7
13	8.9	9.0	9.2	10.0	10.0	10.1
14	0.5	0.5	0.6	0.6	0.6	0.6
15	20.8	20.7	20.4	21.0	21.0	20.9
16	0.6	0.6	0.6	0.7	0.7	0.7
17	7.1	7.2	7.3	7.9	8.0	8.1
18	2.4	2.4	2.4	2.6	2.6	2.6
19	18.6	18.4	18.0	18.5	18.4	17.9
20	0	0	0	0	0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Note: S ... Standard Case, I ... lower target, II ... higher target.
For classification see Appendix.

Total employment increases actively for the first three years and, though it tends to level off later, the employment level is still higher in 1977 for both lower and higher targets. As indicated in Table 10, the increase in employment centers around machinery, metal and construction industries for early period, while there are slight declines for primary sectors, food, pulp and paper and other manufacturings. In terms of structural changes, there is a noticeable shift of employment from the primary and tertiary sectors to the secondary sector, expecially to machinery industries, The declining shares of employment in the tertiary sector are noted for trade and service sectors, thought there is a slight increase in their absolute levels.

This finding also supports the earlier stated tendency of output that pollution control does not tend to reduce but to increase the share of industrial activity as against primary or tertiary activities.

4. Impacts of Oil Price Increase on Pollution Control and the Economy

The recent drastic rise in oil prices is supposed to affect the entire economy in terms of relative prices and resource allocation, thus giving rise to significant impact on pollution control policies.

As discussed earlier, anti-pollution investment and price changes tend to save energy consumption such as petroleum and electric power, etc. This implies that energy-saving policy is generally compatible with pollution control policy. There might, however, be competitive relations between the two policy targets, if limited amount of resources are to be utilized for the two purposes. In this chapter we shall not deal with the second problem explicitly because the levels and likely pattern of expansion of oil-saving and energy-saving investment can not be clearly assumed at this moment. Thus we focus our attention on the short-term impacts of oil prices upon pollution generation and anti-pollution investment and general changes in price and output structures.

Our procedures for this type of impact analysis are summarized as below.

a. Analysis of oil price increase on macro- and sectoral variables through macro-model and input-output model.

b. Changes in environment and anti-pollution investment at sectoral levels.

c. Changes in macro variables affected by both changes in oil price and anti-pollution investment.

d. Sectoral changes in output and employment derived from macro variables in c.

First we assumed that the price of crude oil imported is to rise to 9 $ per barrel in 1974 and this new price will continue until 1977. Because of limited time and highly tentative nature of this type of analysis, the results of the simulation here should be regarded as the first approximation.

A. Results of Oil Price Increase

The macro-model simulation on the impacts of oil price increase is summarized in the second colomum of Table 11.

The rise in import price affects adversely the profit and business investment unless the prices are sufficiently raised. The private consumption and other final expenditures are also significantly reduced, including exports. The rate of growth of real GNP is reduced by 0.5 and 2.1 percent for 1974 and 1975 respectively chiefly because of the fall in the profit and business investment. The balance of payments in current account also fall drastically by about 6 and 3 billion dollors in 1974 and 1975 respectively.

Table 11

Changes of Macro-Economic Variables due to Oil Price Increase

		1972	1973	1974	1975	1976	1977
V	II	1301	4192	5596	3611	2501	746
	oil			-385	-2113	-2015	-1182
	II'	1301	4192	5374	2987	2275	936
	III	1301	4192	4989	874	260	-246
V^c	II	267	1714	4173	6128	7124	7684
	oil			-80	-735	-1597	-2027
	II'	267	1714	4143	5903	6758	7434
	III	267	1714	4063	5168	5161	5410
C	II	34	165	317	301	158	-54
	oil			-21	-101	-212	-250
	II'	34	165	307	253	95	107
	III	34	165	286	152	-117	-143
Cg	II	0	-2	-4	-6	-11	-15
	oil			-	-	-	-
	II'	0	-2	-6	-11	-15	-23
	III	0	-2	-6	-11	-15	-23
Ig	II	-17	-61	-79	-110	-207	-276
	oil			-5	-51	-58	-31
	II'	-17	-61	-78	-105	-212	-280
	III	-17	-61	-83	-156	-270	-313

Ih	II	32	114	163	26	-92	-170
	oil			-7	-63	-78	-44
	II'	32	114	154	-13	-115	-174
	III	32	114	147	-76	-193	-218
Ip	II	1040	3702	5363	3982	2993	1795
	oil			-372	-1659	-1636	-853
	II'	1040	3702	5209	3469	2775	2004
	III	1040	3702	4837	1810	1139	1151
E	II	-20	-61	4	181	275	252
	oil			-43	-104	-224	-262
	II'	-20	-61	10	193	267	217
	III	-20	-61	-33	89	43	-45
p_c	II	0	.2	1.1	2.8	3.9	3.8
	oil			.7	1.1	.6	.1
	II'	0	.2	1.2	2.8	3.9	3.7
	III	0	.2	1.9	3.9	4.5	3.8
p_w	II	.5	.9	.5	0	.6	.6
	oil			3.0	3.9	3.6	2.6
	II'	.5	.9	.6	.4	1.2	1.4
	III	.5	.9	3.6	4.3	4.8	4.0
p_e	II	.4	.5	-.2	-.9	-.5	-.4
	oil			1.7	2.2	2.5	2.2
	II'	.4	.5	-.2	-1.1	- .4	-.3
	III	.4	.5	1.5	1.1	2.1	1.9

Note: For notations, see Table 7. II ··· higher target in Table 7, oil ··· oil price impacts, II' ··· revised higher target
III ··· joint effect (= oil + II')

The price increase exceeds the standard rate of increase especially in 1974: by 17.2 percent for the average import prices, 3.0 percent for the wholesale prices, 1.7 percent for the export prices, .7 percent for the consumer prices. These differences from the standard simulation tend to grow further until 1977. In view of the present drastic rise in verious prices, these differences appear to be rather modest and they can be accounted for by

a) speculative moves of the prices including other imported materials in fear of oil supply shortage which, however, did not happen as seriously as expected earlier and

b) the sensitivity of the model in cost-price relations.

At sectoral level, there is an indication that the production structure tend to shift to an oil-saving pattern, though gradually.

As shown in Table 12-1, the price rise of imported crude oil twice as much give rise to various repercussions to different sectors. The highest impacts are observed in energy sectors such as petroleum products, electric power, manufactured gas, etc. The second largest impacts are noted for oil consuming sectors such as steel, non-ferrous metals, basic chemicals, cement, road and water transport, fishing, etc. It should be noted that the estimates are slighly underbiased as the prices of imported petroleum products are assumed unchanged.

Table 12

Oil Price Impacts on Prices

A. Sectoral Price Changes After Oil Price Increase (%)

No.	1974	1977	No.	1974	1977
1	0.5	0.3	31	-0.0	-0.2
2	0.1	0.0	32	1.0	2.2
3	0.0	-0.0	33	2.2	7.8
4	0.2	0.2	34	0.3	2.8
5	0.1	-0.1	35	0.6	0.4
6	1.8	-0.7	36	0.3	1.4
7	-0.0	-0.0	37	0.1	0.5
8	-0.0	0.0	38	0.1	0.4
9	0.4	0.3	39	0.7	-0.4
10	81.7	81.4	40	0.1	0.7
11	0.0	0.0	41	0.4	-0.3
12	0.3	0.2	42	0.0	0.3
13	0.1	0.5	43	0.3	0.5
14	1.2	-0.6	44	0.2	0.6
15	0.4	0.0	45	0.4	0.4
16	0.3	0.1	46	0.2	0.3
17	0.1	0.1	47	8.7	12.4
18	0.3	0.1	48	9.5	11.4
19	0.5	1.4	49	-0.0	-0.0
20	0.3	0.6	50	0.4	0.2
21	0.4	-0.1	51	0.2	0.5
22	0.4	0.1	52	1.8	1.6
23	0.5	0.1	53	1.1	-0.2
24	0.7	1.6	54	1.3	1.4
25	0.0	0.0	55	1.0	-0.5
26	0.4	-0.1	56	0.1	-0.6
27	0.2	1.0	57	0.1	-2.0
28	0.6	2.9	58	0.3	-1.3
29	0.1	0.1	59	0.4	-0.8
30	14.3	27.9	60	0.3	0.7
			Total:	1.5	2.1

Note: For classification see Appendix

B. Consumer Price and Export Price Deflators after Oil Price Increase (%)

Consumer Price		
No.	1974	1977
1	0.5	0.8
2	0.5	0.3
3	1.1	-0.3
4	0.3	0.2
5	0.6	0.0
6	0.4	0.1
7	0.3	0.1
8	0.5	0.2
9	0.2	0.2
10	1.3	-1.0
11	0.3	0.2
12	8.9	14.1
13	-0.0	-0.0
14	0.2	0.5
15	0.2	0.1
16	0.3	-0.8
17	1.4	0.7
18	0.2	-0.3
19	-0.1	0.2
20	0.2	-0.6
Total	0.7	0.4

Export Price		
No.	1974	1977
1	0.3	0.0
2	0.5	1.3
3	0.4	1.8
4	0.6	3.8
5	0.2	0.3
6	1.5	2.3
Total	0.5	1.1

Note: For classification, see Table 6-3.

With regard to sectoral output all the sectors indicate fall in output. But in terms of percentage in Table 13 the shares of petroleum products, steel, machineries and equipment and electric power decline slightly due to the higher relative prices. As we assume no explicit changes in technical coefficients after the oil price impacts, these changes in shares are mainly reflected by the percentage changes in private consumption and exports. In view of the fact, however, that oil price changes are highly international, the changes in export components are likely to be overestimated.

Table 13

Oil Price Impact on Sectoral Output

S ... Standard Case
O ... Case of Oil Price Increase

No.	1974		1979		No.	1974		1979	
	S	O	S	O		S	O	S	O
1	1.4	1.4	1.1	1.1	31	0.3	0.4	0.3	0.3
2	0.1	0.1	0.1	0.1	32	1.5	1.5	1.5	1.5
3	0	0	0	0	33	2.7	2.9	2.7	2.7
4	0.8	0.8	0.7	0.7	34	4.5	4.7	4.5	4.4
5	0.4	0.4	0.3	0.3	35	1.2	1.3	1.2	1.2
6	0.4	0.4	0.3	0.3	36	2.7	2.7	2.8	2.8
7	0.1	0.1	0	0	37	6.0	6.3	6.0	5.9
8	0	0	0	0	38	7.3	7.3	7.6	7.5
9	0	0	0	0	39	4.5	4.7	4.5	4.4
10	0	0	0	0	40	1.4	1.4	1.4	1.4
11	0.4	0.4	0.5	0.5	41	0.8	0.8	0.8	0.8
12	0.8	0.8	0.8	0.8	42	2.1	2.0	2.2	2.2
13	0.7	0.7	0.6	0.6	43	3.2	3.1	3.8	3.8
14	0.4	0.4	0.3	0.4	44	3.0	3.2	2.8	2.7
15	1.8	1.8	1.7	1.7	45	1.9	1.7	2.1	2.2
16	1.1	1.1	1.1	1.1	46	2.2	2.2	2.3	2.3
17	0.5	0.5	0.5	0.5	47	1.5	1.4	1.5	1.4
18	0.3	0.3	0.3	0.3	48	0.2	0.2	0.2	0.2
19	0.3	0.3	0.3	0.3	49	0.2	0.2	0.3	0.3
20	1.7	1.7	1.5	1.6	50	8.5	8.4	8.5	8.5
21	1.0	1.0	1.0	1.0	51	2.2	2.1	2.1	2.1
22	1.2	1.2	1.1	1.1	52	0.7	0.7	0.7	0.7
23	0.7	0.7	0.7	0.7	53	2.4	2.3	2.4	2.4
24	1.7	1.7	1.7	1.7	54	1.8	1.8	1.8	1.8
25	1.1	1.1	1.1	1.1	55	0.9	0.9	0.9	0.9
26	0.1	0.1	0.1	0.1	56	2.6	2.6	2.6	2.6
27	0.6	0.6	0.5	0.5	57	1.1	1.1	1.0	1.0
28	3.2	3.3	3.3	3.3	58	3.5	3.4	3.4	3.4
29	1.3	1.3	1.3	1.3	59	4.3	4.1	4.4	4.5
30	1.8	1.8	1.9	1.8	60	1.1	1.0	1.1	1.1
					Total	100.0	100.0	100.0	100.0

Note: For classification see appendix.

B. Oil Price Increase and Pollution Control

On the basis of the above simulation, we have simulated our two models by introducing anti-pollution investment and related price increase under the same environmental goals. For convenience, we take up the case for the higher target concerning air, water and industrial wastes.

In deriving the required anti-pollution investment under the same pollution target, we have utilized the same pollution coefficient matrices for generation and elimination of pollutants. ~~Since~~ Because of the decline of aggregate output and changes in sectoral components, the required investment by type of pollutants are slightly lower than the previous case for the higher pollution control target, as shown in Table 14. The total investment accumulated for 1974 to 1977 is lower only one percent than the previous case B which was used before the oil price increase under the same environmental target. Slightly larger values for 1976 and 1977 are consistent with macro variables which rise faster as the result of stock adjustment after two-year decline of the output and investment as shown in Table 11.

Joint effects of oil price and pollution control are indicated in column III for each macro-variables in Table 11. Since this column is a sum of the second and the third columns, dynamic pattern of the two types of impacts can be followed clearly. In terms of multiplier effects the column II' shows a similar changing pattern but they are a little smaller than the column II as noted above. Thus the expantionery effects of pollution control tend to be

Table 14

Anti-Pollution Investment by Type of Pollutants

(After Oil Price Increase)

	1974	1975	1976	1977	1972 - 77
1. SOx	150	104	173	128	849
2. Particulates, etc.	335	234	386	286	1893
3. NOx	421	292	485	359	2377
4. CO 1/		(854)	(-10)	(45)	(889)
5. BOD	628	804	940	402	3457
6. Wastes	203	293	291	139	1173
Total 2/	1737	1726	2275	1315	9750
Case B (Higher Target) 3/	1762	1893	2267	1216	9844

Note: 1/ CO is not included in Total.

2/ Includes rounding errors.

3/ Taken from Table 3-B.

partly offset by the oil price impacts especially for the last two years. The price levels, on the other hand, tend to become significantly higher in the case of the joint effects in particular for the wholesale prices and the export price deflator.

At sectoral levels, absolute and relative price levels indicate the most significant differences from the standard case. These changes are also noticeable for consumer prices and export prices as shown in Table 15.

In the order of the increase, the highest price rise is observed for crude oil, petroleum products, electric power, and basic iron. In the second highest group are included marine products, paper and pulp, leather goods, cement, manufactured gas and water transport, which are affected by both pollution costs and oil price increase. In consumer prices, those for light and fuels show the highest increase, while those for foods also rise significantly mostly due to the pollution control costs. The price rise for transport and communication is also noticeable which reflects mostly the oil price impacts. As for exports, the price effects are similar to the case of pollution control before the oil price increase, but general levels appear to be raised as compared with Table 6-3, C.

Finally we discuss the structural changes in production in Table 16. As compared with the previous case before oil price increase in Table 9, only the shares of petroleum products, steel, electric power decline, while those of tobaco and public service increase slightly, although the rate of expansion as a whole has been lowered considerably.

Table 15

Impacts of Pollution Control and Oil Price Increase on Prices

A. Sectoral Price Changes (%)

No.	1974	1977	No.	1974	1977
1	0.6	0.6	33	0.2	1.3
2	0.1	0.2	32	2.9	9.6
3	0.0	-0.0	33	5.2	22.1
4	0.4	1.1	34	1.2	7.4
5	0.2	0.1	35	2.4	5.6
6	4.3	5.3	36	0.7	3.4
7	-0.0	-0.0	37	0.4	1.9
8	-0.0	0.0	38	0.3	1.2
9	0.7	0.9	39	1.1	6.3
10	81.7	81.5	40	0.2	1.6
11	0.0	0.0	41	1.0	1.7
12	1.8	5.9	42	0.1	0.9
13	0.0	-0.0	43	0.7	2.8
14	4.4	8.3	44	0.5	2.0
15	1.6	3.8	45	0.8	2.9
16	1.2	4.3	46	0.6	2.8
17	0.2	0.7	47	13.6	24.1
18	0.7	1.4	48	10.4	13.9
19	1.2	5.3	49	-0.0	-0.0
20	0.9	4.3	50	0.7	1.5
21	1.5	4.6	51	0.2	0.6
22	1.4	3.6	52	2.5	4.3
23	1.1	2.6	53	1.3	0.9
24	3.1	13.1	54	6.9	13.6
25	0.1	0.6	55	1.1	-0.1
26	3.7	13.3	56	0.1	-0.3
27	0.7	3.7	57	0.1	-2.0
28	1.5	8.3	58	0.5	-0.4
29	0.3	0.9	59	0.7	0.2
30	16.7	36.3	60	1.8	4.7
			Total	2.2	5.3

For classification see Appendix.

B. Price Changes in Consumer and Export Prices

No.	Consumer Price		No.	Export Price	
	1974	1977		1974	1977
1	1.0	2.5	1	2.0	4.7
2	0.7	1.0	2	1.3	6.1
3	3.1	5.5	3	1.1	5.4
4	1.3	3.9	4	2.0	10.8
5	2.0	4.0	5	0.5	2.5
6	1.4	3.3	6	3.4	10.5
7	1.1	3.8			
8	1.1	2.5			
9	0.5	1.3			
10	3.1	5.9			
11	0.8	2.6			
12	12.2	22.8			
13	-0.0	-0.0			
14	0.3	0.8			
15	0.3	1.0			
16	0.5	0.2			
17	2.7	4.4			
18	0.4	0.3			
19	-0.2	-0.3			
20	0.3	-0.1			
Total	1.3	2.5	Total	1.3	5.2

For classification see Table 6-3.

As against the standard case in Table 13, however, pollution control with higher oil price, the present case for joint effects, is featured by a) a decline of energy-related sectors noted above, basic chemical, trade and services and b) an active increase of machinery industries. It can be safely stated that the changes of the pattern in resource allocation are mostly consistent with the structural changes of relative prices noted above.

Table 16

Impacts of Pollution Control and Oil Price Increase on Sectoral Output Components (%)

No.	1974	1977	R.I.	No.	1974	1977	R.I.
1	1.3	1.1	1.5	30	0.4	0.3	6.6
2	0.1	0.1	2.5	32	1.5	1.5	10.2
3	0.0	0.0	0	33	3.0	2.7	8.3
4	0.7	0.7	7.9	34	4.8	4.4	8.8
5	0.4	0.3	0.5	35	1.3	1.2	10.6
6	0.4	0.3	3.9	36	2.8	2.8	11.2
7	0.1	0.0	-8.5	37	7.1	6.3	10.4
8	0.0	0.0	-5.2	38	7.7	7.8	13.3
9	0.0	0.0	4.9	39	4.8	4.5	10.4
10	0.0	0.0	1.7	40	1.4	1.4	10.3
11	0.4	0.5	10.5	41	0.8	0.8	12.2
12	0.8	0.8	9.5	42	2.0	2.2	14.6
13	0.7	0.6	0.1	43	2.9	3.7	16.2
14	0.4	0.3	6.1	44	3.7	2.9	5.9
15	1.7	1.7	7.9	45	1.6	2.1	13.1
16	1.0	1.1	10.7	46	2.3	2.3	11.0
17	0.5	0.5	7.3	47	1.4	1.4	9.3
18	0.3	0.3	3.9	48	0.2	0.2	7.5
19	0.3	0.3	11.2	49	0.2	0.3	11.4
20	1.7	1.5	6.4	50	8.2	8.4	10.3
21	0.9	1.0	10.4	51	2.0	2.1	8.4
22	1.2	1.1	7.7	52	0.6	0.7	10.0
23	0.7	0.7	10.5	53	2.3	2.4	11.7
24	1.7	1.7	10.1	54	1.7	1.8	10.7
25	1.0	1.1	10.8	55	0.8	0.9	11.0
26	0.1	0.1	6.6	56	2.5	2.6	10.0
27	0.6	0.5	8.6	57	1.1	1.0	5.3
28	3.2	3.2	11.5	58	3.2	3.4	9.3
29	1.2	1.3	10.5	59	3.9	4.4	12.2
30	1.8	1.8	10.4	60	1.0	1.0	9.4
				Total	100.0	100.0	10.1

Note: R.I. denotes annual rate of change for 1972 to 1979.

For classification see Appendix.

Concluding Remarks

Although our analysis does not cover all types of pollutants and the models used are not originally designed for environmental studies, the results of the present study, probably the first in Japan in terms of the coverage and the degree of industrial breakdown, can now be summarized as below.

Firstly, in regard to the arguments over the effects on economic growth, the expansionery impacts of anti-pollution investment and related demand are greater than contractionery effects of costs and prices for the earlier three years, and then gradually turn to level off with increasing effects of the prices for the later period. As compared with the U.S. case, the demand effects seem to be greater because of an active response of induced business investment [4]. On sectoral basis, the expansionery impacts are largely accounted for by various engineering industries except automobile sector, while slightly decelerating tendencies are noted for food, pulp and paper, sundry goods and energy sectors. In this context, the policies toward energy-saving technology and structural adjustment are quite compatible with those for anti-pollution. The growth rates of basic steel and chemical industries are not significantly affected against ordinary anticipation. This implies that on macro-economic aspect the internalization of the external costs gives rise to accelerating effects on output and employment at least for short term and favorable impacts on welfare in the long run. It should also be noted that the aggregate capacity in terms of potential GNP tends to be expanded which can be met by ordinary demand management policy. A pessimism on economic growth appears to be a little exagerated as it is chiefly based on micro-economic view point.

Secondly, some qualifications are needed to derive the above tentative conclusion. For instance, the price effects on exports are likely to be offset somehow by similar tendencies abroad. The assumption of constant technology for anti-pollution is likely to overestimate the required pollution abatement investment. On the other hand, a) replacement investment accompanied by cleaner technology and efficiency and b) public investment for sewerage system which are excluded from the present study rather tend to underestimate the effects of expansion. Another important international aspect is related to direct investment to abroad. Trade-off of investment decision between domestic or foreign sites are often dependent on relative cost for anti-pollution and the analysis still remains to be solved because of the paucity of relevant data.

The third problem is concerned with the relationship with other economic policies. Demand management, as noted above, needs to be restrictive for earlier three years, and be expansionery for the later period in order to keep a stable economic growth. Mixed use of floating exchange rate system will make for the effeciency of the stabilization policy. As for income distribution, tax and social security policies need to be more strengthened in favor of lower income classes because of relative increase in prices of living necessaries as a result of pollution control.

Fourthly, oil price increase and drastic change in price system as a whole tend to reduce expansionery impacts of pollution control on output and employment if pollution control standards remain unchanged. These effects, however, are not too significant and is likely to be offset by the increase in oil-saving alternative investment in energy resources or related manufactured products. Though they are not explicitly dealt with in this paper, they are becoming important in a longer-term perspective.

Fifthly, the data used are still tentative and need further improvement in terms of quality and coverage. The data on damage costs, in particular, are essential for an integrated econometric study on welfare and economic growth. The highest priority should be given by the related organization to the improvement of those data with special reference to international comparison.

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Appendix

1. Industrial Classification

60-SECTOR	7-SECTOR
1. General crop 2. Industrial crop 3. Livestock for textiles 4. Livestock 5. Forestry 6. Fisheries	1. Agriculture, Forestry and Fishing
7. Coal mining 8. Iron ores 9. Nonferrous metallic ores 10. Crude petroleum and natural gas 11. Other mining	2. Mining
12. Meat and Dairy products 13. Grain products 14. Manufactured sea foods 15. Other food 16. Beverages 17. Tabacco 18. Natural textiles 19. Chemical textiles	

20. Other textiles 21. Wearing apparel 22. Wood products 23. Furniture 24. Pulp and paper 25. Printing and Publishing 26. Leather products 27. Rubber products	3-1. Light Manufacturing Industries
28. Basic Chemicals 29. Other Chemicals	3-2. Heavy Manufacturing Industries
30. Petroleum products 31. Coal products 32. Ceramics	3-1. Light Manufacturing Industries
33. Primary iron 34. Steel products 35. Primary Nonferrous Metals 36. Fabricated Metals 37. Machinery 38. Electrical machinery 39. Automobile 40. Other transport equipment	3-2. Heavy Manufacturing Industries
41. Instrument and related products 42. Miscellaneous manufacturing	3-1. Light Manufacturing Industries

43. Residence 44. Non-resisence 45. Public engineering work 46. Other engineering work	4. Construction
47. Electricity 48. Gas 49. Water and sanitary service	5. Public Utilities
50. Wholesale and retail trade 51. Real estate	6. Commerce and Services
52. Railway transport 53. Road transport 54. Other transport 55. Communication	5. Public Utilities
56. Bank and other financial institution 57. Government service 58. Public service 59. Other personal service	6. Commerce and Services
60. Unallocated	7. Unallocated
61. Total	8. Total