The Introduction of an Environment Tax and Forecast Simulation of Change in Industrial Structure

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Introduction

Today, just two and a half years before the turn of the century, the earth is in the grip of environmental pollution. A look back on the origins of environmental pollution reveals that waste has been gradually accumulating since the beginnings of our planet, albeit relatively slowly until industrialization grew rapidly during the 19th century. And as the process of industrialization has gathered pace, so pollution has accelerated. Environmental pollution primarily refers to: (1) Warming of the earth; (2) Destruction of the ozone layer; (3) Acid rain; (4) Desertification; (5) Loss of rain forests; (6) Pollution of the oceans; and (7) An increase in waste(1). The economic losses created by the environmental pollution afflicting Japan is estimated to have been ¥8 trillion throughout the 1990s (June 1995 estimate by the Japanese Economic Planning Agency), equal to 5.7 percent of gross domestic product (green GDP). If the current trend continues unchecked, Japan will suffer environmental destruction totaling at least ¥80 trillion over the ten-year period from 1990 to 2000. Given this situation, new policies must be formulated to build an economic and social system, based on the recycling of resources, that will impose a lesser burden on the environment as noted in the Basic Environmental Act (1), which went into effect in December 1994. However, before such policies are formulated, the problem of recovering the financial losses inflicted by environmental destruction will become a major threatening issue. This paper simulates the changes in industrial structure up to the year 2050 that would be caused by the introduction of an environment tax, primarily allocated among energy-related industries, as a means to compensate for the financial losses caused by environmental destruction. A dynamic system model was developed for this purpose.

1. Processes leading to the introduction of an environment tax

Global environmental issues, notably the warming of the earth, are of great importance to mankind and must be dealt with urgently. For human beings to achieve sustained growth on an earth of limited size and resources, an investment of green GDP equal to least five or six percent of total GDP, appears necessary in order to solve environmental issues. The investment must be used not only to create new industries and businesses which we might generically term "global environmental industries," but it must also influence all industries from the primary to tertiary sectors. Moreover, changing industry alone is not enough: changes must also take place in the awareness and habits of consumers. Various measures need to be taken to restore the damaged environment and to prevent future environmental destruction. Restoration of the damaged environment would require a national budget of some 8 trillion. Taking the example of carbon dioxide (CO_2) emissions, it takes about ten years for the gas to reach the sky. This means that regardless of whether we curtail CO_2 emissions now, gas emitted in the past is already in the system. Eliminating gas emissions from today would mean a gradual decline in the amount of the gas in the environment, but environmental destruction, caused by past gas emissions, would continue for at least the next ten years. Stricter environmental regulations to stop further deterioration in the environment are planned to combat anticipated environmental destruction. Legal measures were proposed by the European Union as an environmental audit system and were introduced in the form of ISO 14000, which Japan introduced on October 20, 1996. Application of this environmental audit system in developing nations as well as industrially-advanced countries would help prevent environmental destruction. However, developing nations will not implement the system for the time being, which is a matter of grave environmental concern. Funds are thus required to recover from environmental destruction; however, financial resources drawn only from an energy tax(2) will be inadequate, so an environment tax needs to be introduced at an early stage. The seven sectors listed in the Introduction raise similarly grave issues. However, global warming and acid rain caused by nitrous oxide and sulfuric oxide emissions from industry have been the focus of environmental concerns.

1.2 Environment taxes introduced in other nations and coal tax

Environment taxes are already in place in EU member countries and their neighbors, Denmark, Finland, Norway, Sweden, and the Netherlands. As Japan has not introduced an environment tax, figures related to energy taxes converted into an environmental tax equivalent were used instead. Table 1.1 compares environment taxes among these nations(3). The table shows that as Japan imposes no tax on coal, Japan's total tax rate is less than half of those imposed by most other nations. Carbon dioxide emissions will be the target of the future environment tax. (The increase in energy prices resulting from the introduction of carbon and energy taxes will change the relative prices in the market mechanism and therefore change the industrial structure itself.) However, continued improvements in energy efficiency will help meet the CO_2 emission regulations. Other targets of these new taxes are listed below.(1) Nuclear energy (Although it supplies clean energy without CO_2 emission, an accident in the production of this energy type would cause tremendous damage. Therefore, the use of nuclear energy must comply with the safety standards.)(2) Large-scale hydraulic power generation (The percentage of energy consumption is calculated based on the difference between the reduction in the rain water amount and the available rain water amount in remote regions.)(3)Water (The increase in the amounts of water and sewerage

Table 1.1 The Introduction Countries of CO_2 Tax

(1994~1995 year) (Unit: $ / CO_2 Ton)

Country	Energy	Cost	VAT	CO_2 Tax	Another Tax	Another VAT	Total Tax
Denmark	Gasoline	454.5	674.8	0.0	1.9	282.3	959.0
	Kerosene	370.9	31.5	57.0	0.0	114.9	203.4
	Diesel	160.1	0.0	29.8	0.0	0.0	29.8
	Coal	155.3	0.0	25.5	0.0	0.0	25.5
Finland	Gasolin	631.1	847.8	184.3	16.9	365.1	1,414.2
	Kerosene	350.0	14.1	14.0	16.4	83.0	127.5
	Diesel	178.1	7.9	12.5	12.9	0.0	33.3
	Coal	86.4	0.0	12.4	0.0	0.0	12.4
Norway	Gasolin	576.9	1038.8	183.9	0.0	359.9	1,582.6
	Kerosene	407.9	0.0	89.3	15.6	99.4	204.4
	Diesel	218.0	0.0	84.1	14.7	0.0	98.9
	Coal	85.2	0.0	109.6	0.0	0.0	109.6
Sweden	Gasolin	540.0	898.5	182.2	0.0	405.4	1,486.0
	Kerosene	376.5	126.8	216.1	0.0	179.9	522.8
	Diesel	171.8	0.0	51.0	30.0	0.0	81.0
	Coal	116.9	0.0	67.4	75.8	0.0	143.1
Netherland	Gasolin	467.2	923.8	20.1	8.3	261.1	1,213.3
	Kerosene	386.4	78.5	20.8	7.8	89.9	197.0
	Diesel	168.9	23.3	21.1	6.8	0.0	51.3
	Coal	113.9	0.0	21.3	0.0	0.0	21.3
Japan	Gasolin	775.1	621.6	0.0	0.0	41.9	663.5
	Kerosene	527.0	24.9	0.0	0.0	16.6	41.5
	Diesel	283.1	22.9	0.0	0.0	9.2	31.5
	Coal	110.4	0.0	0.0	0.0	3.3	3.3

only increases the size of treatment plants. If the current trend continues, these plants will no longer be able to treat water to the level stipulated before they become incapable of treatment. Therefore, a minimum consumption will be set, beyond which different tax rates will be imposed depending on the usage.(4)Commercial fertilizer (The supply of type of fertilizer exceeds demand for agricultural use. The amounts of nitrate fertilizer recycled on farms should determine the reduction or increase of taxes based on the recycled amount category.)(5)Land use (tax will be imposed on land used for construction purposes, based on the efficiency of land use.)(6)Metal and other raw materials (aimed at providing incentives for reducing the amount of waste through recycling of metals and other raw materials that do not contain hazardous substances)(7)Solvent (tax which includes exemption clauses for recycling and collection of solvents)(8)Chlorine and halogen(9)Hazardous compounds. Among the various feasible measures, a carbon tax appears to be the most appropriate.

2.Formulation of optimum investment return and environment tax introduction in the energy industry

Business profitability in the energy industry is assessed by the maximum return obtained from limited funds applied in a series of flows from imports of crude oil to production and sales of energy. To quantify these, the investment return V is given by equation (1) proposed by J. Happel.

$$V = (1-\tau)\{\sum_i s_i S_i - \sum_j r_j R_j - \sum_k u_k U_k - lL\} - \{\kappa(1-\tau) + \varepsilon_m\} L \qquad (1)$$

Where:(3)

r: tax rate s_i: Ex. factory sales price of product I S_i: Production amount of product, i (annual) r_j: Price at which to accept raw material, j R_j: Amount of raw material, j, required (annual) u_k: Unit utility price U_k:Unit utility price (annual) l: Labor costs (annual) L: Number of workers required k: Rate of annual expenditure accompanying the facility investment e_m: minimum acceptable rate of return l: Facility costs

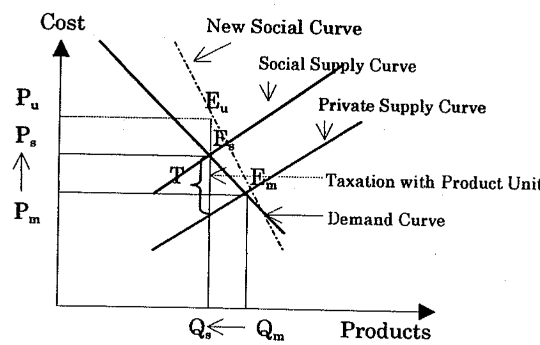
Equation (1) above represents the investment return assuming that crude oil prices remain within a certain price range. The equation can still cover crude oil price fluctuations in the range of fifty cents to one dollar a barrel. However, equation (1) fails to deal with fluctuations greater than one dollar. Accordingly, equation (1) becomes equation (2) which averages crude oil prices by introducing a variable coefficient (critical coefficient).

$$\bar{V} = \frac{\varphi_1 V_1 + \varphi_1 V_2 + \cdots + \varphi_n V_n}{\varphi_1 + \varphi_2 + \cdots + \varphi_n} \qquad (2)$$

Where,

φ_n: Critical coefficient(3) φ_n:$(1+\varepsilon)^{-n}$, ε : interest(4)

However, the market prices of chemical products and gasoline, for example, which are produced and released on the market, do not reflect the social expenses per production unit. This means that as the market prices only reflect the private expenses of the producer (critical expenses), inclusion of social expenses in the production costs will increase the prices, ultimately pushing up consumer prices. To limit such increases in the consumer prices and limit the financial burden on the producer, a measure was proposed by A. C. Pigou(4) in 1918. This incorporates a tax on chemical products and gasoline imposed per production unit into the private expenses to form social expenses, thus increasing the tax-inclusivemarket prices and limiting the amount of production (amount of consumption). This measure is called Pigou's tax, and has been the basis of the environment tax until today, just before the 21st century. Figure 2.1 shows the mechanism of Pigou's tax. However, when we look at the balance between supply and demand in consumption as well as rapid economic growth, the amount of product does not equal the amount of consumption. Although the production plant ships products regularly, these products are usually stored at sales points. Therefore, it appears difficult to limit Q_m shown by Figure 3.1 to Q_s. Modifying Figure 2.1 to make it correspond to the current status indicates point E_u in Figure 2.1 Judging from this actual status, the production amount is given by equation (3)



P_m: Cost P_s: Increasing Cost Q_m: Product

Q_s: Cost of Control T: Tax ($T = E_s - E_t$)

Fig.2.1 The Relation Between A.C.Pigou Tax and Real Social Curve

$$Q_m \fallingdotseq Q_s \quad (3)$$

As a result, the amount of environmental tax per production unit based on equation (3) becomes: equation (4)

$$\bar{T} = \psi \times T \quad (4)$$

Where,

Ψ (environment tax introduction coefficient) = 0.01 - 0.05

Therefore, the price increase resulting from introducing the environment tax is between 1/200 and 5/100. Substituting environment tax introduction coefficient, W, of equation (4) into equation (2) produces equation (5) which represents average investment return, V:

$$\overset{\epsilon}{V} = \frac{\varphi_1\psi_1 v_1 + \varphi_2\psi_2 v_2 + \cdots + \varphi_n\psi_n v_n}{\varphi_1\psi_1 + \varphi_2\psi_2 + \cdots + \varphi_n\psi_n} \quad (5)$$

Where,

Ψ_n: environment tax introduction coefficient

This means a decrease in the investment return, and also suggests the existence of a new point E_u, which does not correspond to the supply-demand curve shown in the figure. The difference between E_u and Es is expected to be reflected as an increase in price.

3. Simulation of System Dynamics Model and Simulation Results

3.1 Simulation of System Dynamics Model[5]

Figure 3.1 shows the flow from crude oil to production of each petroleum based fuel, indicating changes in the industrial structure in petroleum related fields resulting from the introduction of an environment tax. The level of recycling of waste oils (surplus oil, waste oil and wash oil) generated by the production of petroleum based fuels has become fairly advanced. This recycling was incorporated as an element of SD model feedback. A model of the system dynamics was constructed based on Figure 3.1 Also, to examine changes in the industrial structure, the focus was placed on pig iron production, which was selected from the various production sectors in the iron and steel industry as it consumes much energy and makes a significant contribution to GNP.

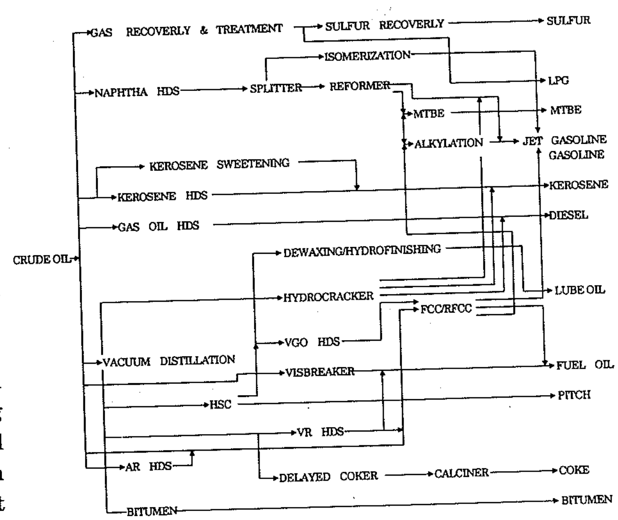


Fig.3.1 Model for Oil Products Flow

Figure 3.2 shows the pig iron production flow which is used as the basis for the SD model.

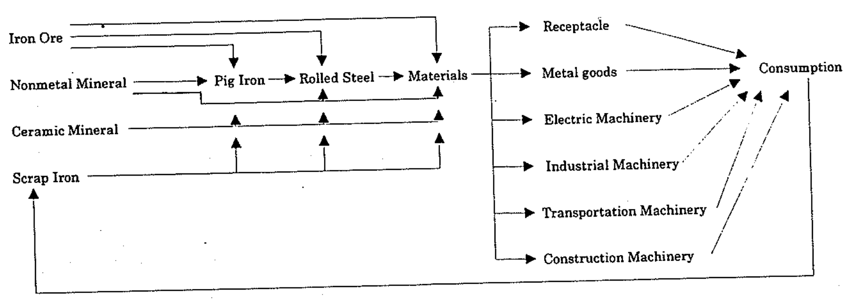


Fig.3.2 Flow for Iron Products

3.2 Simulation results

Figures 3.3 and 3.4 show forecasts up to the year 2050. These forecasts are based on the petroleum-fuel production SD model and on the pig-iron production SD model prepared in section 3.1 above, respectively. Figure 3.3 simulates the forecast consumption of petroleum-based fuels produced from crude oil and expresses the results as forecast crude oil consumption. According to Figure 3.3, consumption will gradually increase until 2005, □decrease until 2015, and then experience a gradual decline until around 2035, followed by a further drop sometime between 2040 and 2050. Figure 3.4 forecasts pig-iron production, which accounts for a significant proportion of total iron and steel production, based on the amount of energy produced by crude oil.

The figure reveals a temporary increase in the amount of energy generated in 2005, followed by a continual downward trend.

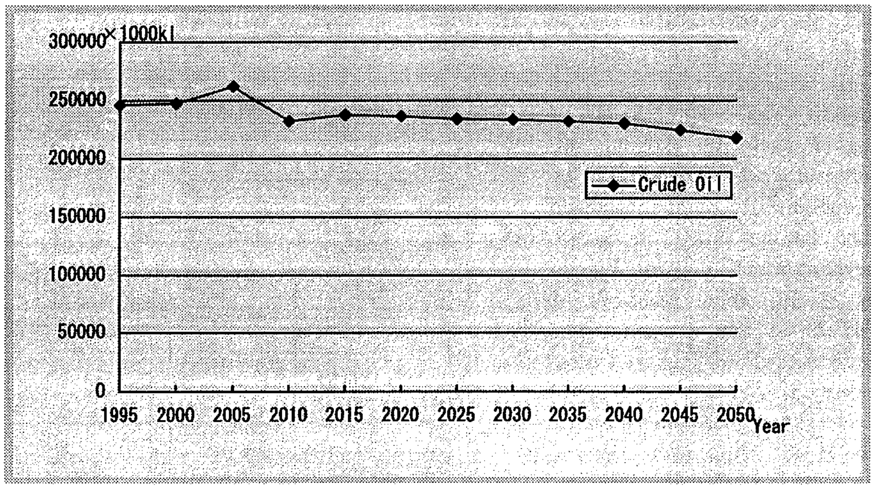


Fig.3.3 Simulation for the Crude Oil Consumption

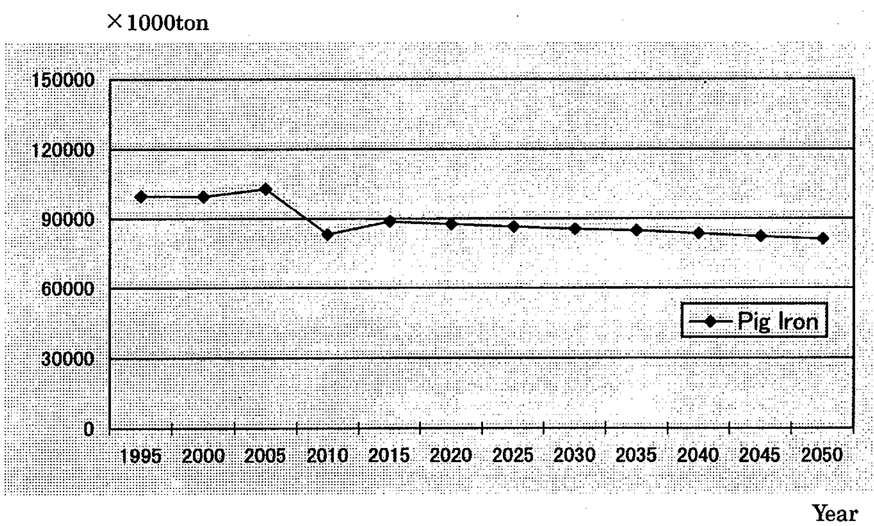


Fig.3.4 Simulation for the Production of Pig Iron

4. Considerations

(1) Forecast crude oil consumption amount

As is clear from the result of the simulation of section 3.2, the amount of crude oil consumption starts declining until it reaches a level in 2050 that is approximately 15% less than that in 1997. Factors supporting the results of this simulation are as follows: The current findings of the advisory committee of the central government suggest that a 5% environment tax will be introduced in Japan in 2005 to help restore the environment. Prior to 2005 (at the latest, around 2004), when the tax is scheduled to be introduced, a significant increase in the amount of crude oil imports is predicted. Importers will naturally import crude oil before the environment tax is introduced and will seek greater profits by adding the environment tax to the imported crude oil when the environment tax is introduced. In response, the Ministry of International Trade and Industry, as the acting government agency, will inevitably prohibit the practice of adding environment tax to such crude oil. However, given the traditional relationship of interdependence between the ministry and industry, policies are likely to be developed that will actually protect crude oil importers. Following the introduction of the environment tax, crude oil importers may raise product prices by 15% for reasons of production adjustments and the introduction of the environment tax, to prevent a loss of revenues resulting from sluggish consumption coupled with the decline in energy production. The effects of introducing a 5% environment tax on crude oil are different from those of the 5% consumption tax; final product prices are likely to rise between 15 and 20%. The situation is therefore expected to repeat that seen in 1975, when the first oil crisis triggered an increase of 20% in consumer prices (a dramatic consumer price increase). The forty years from 2010 to 2050 will probably see a decline in crude production resulting from the introduction of environmental regulations. Moreover, Japanese energy policies are shifting to the increased use of clean energy, specifically, natural gas. Tokyo Gas Co., Ltd. plans to switch 80% of its energy resources to natural gas by the year 2000, which supports the prediction that crude oil consumption will decline.

(2) Forecast changes in the industrial structure

The level of recycling is fairly advanced in the iron and steel industry. The industry is output fell significantly following the bursting of the so-called 「Bubble Economic」. Although production recovered somewhat from the post-bubble period during the 1990s, dark clouds still hang over traditional industries requiring large investments, such as iron and steel, heavy electrical equipment and petrochemicals. The introduction of an environment tax will promote pig-iron production to follow the same trend as that forecast for energy consumption. However, future advances in recycling in the industry should be factored as these are important elements. Based on the forecast, the Japanese economy is expected to move away from its focus on traditional industries that require large investments, resulting in a significant change in the industrial structure. To take the example of iron and steel manufacturers, these producers will have scaled back approximately 15% by 2010 from their 1997 operations. These industries will, therefore, face the choice of either cutting back on operations, or shifting the drop in capacity to other operations. The year 2010 will undoubtedly be a period of major restructuring in Japanese industry.

References

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(4)Pigou A.C. 1918 'The Economics of Welfare, Macmillian, Chapter 9'

(5)HPS 1996 'Stella-Dynamic Modeling Across the Curriculum'