2.4 AN ECONOMETRIC APPROACH TO CO2 EMISSIONS IN JAPAN

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1. INTRODUCTION

In this paper, some results of a newly developed energy macro-econometric model of the Japanese economy are provided. In this model, an increase in the real energy prices has played an important role in improving the energy efficiency of the Japanese economy since the first oil shock. High energy prices usually slow down the growth of the economy. However, they stimulate the substitution of energy with other inputs. We have observed that energy and capital were substitutes in the major industries in Japan. This means that business firms are encouraged to make active investments in order to conserve energy inputs, thus mitigating the depressing impacts of high energy prices on the Japanese economy.

Two alternative policies for reducing CO2 emissions in Japan are evaluated. The possibility of stabilizing the level of CO2 emissions in 2000 within the 1990 level is investigated. It is shown that a carbon tax on fossil fuels is an efficient way to achieve this target. Even though imposing a carbon tax will leads to a reduction of GNP, its welfare losses will be smaller than those associated with legislative regulation of CO2 emissions. It is also shown that the impact of a carbon tax might be mitigated by substitution among factor inputs as compared with legislative regulation.

2. THE STRUCTURE OF THE MODEL

There are three producer sectors in the model, iron and steel, chemical, electric power and other industries. There are four consumers goods, fuel and power, automobile, house appliances, and other goods. Relative prices play a most important role in the model. Figure 1 summarizes the model.

3. THE IMPACT OF A CO2 EMISSIONS TAX ON THE JAPANESE ECONOMY

In this section, the costs of reducing carbon dioxide (CO2) emissions are evaluated. Many legislative proposals have set physical targets for emission reductions. The Japanese Government declared that CO2 emissions in 2000 should be stabilized at the 1990 level.

The amount of CO2 released in Japan was 267 million tons of carbon in 1975, peaked at 282 million tons in 1980, and declined to 270 million tons in 1985. That is, CO2 emissions stabilized during the period from 1975 to 1985. This was mainly due to stable energy consumption. However, CO2 emissions increased again since 1986 because of a decline in energy prices.

Figure 2 shows the amounts of CO2 emissions by major industries in 1988. Thirty-two percent of CO2 was released from the electric utilities, twenty percent was released from the transportation industry, and eighteen percent was released from the

iron and steel industry. These three major industries, which were investigated in the previous section, released almost seventy percent of the total CO2 in Japan.

In this section, two alternative policies to reduce CO2 emissions during the period from 1991 to 2000 are evaluated. One policy is a carbon tax on coal, fuel oil and LNG. The tax is fuel-specific, since CO2 emissions are generally proportionate to the carbon content in each fossil fuel. The tax is levied on imported primary fuels, and is assumed to change the relative price of each energy. In the case of Japan, almost all fuel oil and LNG are imported, and more than ninety percent of coal is imported. So, even though the tax is applied to the import of primary fuels, distortions between domestic and imported fuels are avoided.

The other policy is legislative regulation of CO2 emission. Each industry or household is endowed with initial quotas of emission rights. If the amount of CO2 emissions are limited at initial endowments, each industry has to slow down its activity to keep within this upper limits. Then, some industries will also develop the technologies to reduce the CO2 emissions , or buy emission rights from other industries, while some industries will sell their emission rights and withdraw. If emission rights were perfectly marketable, the price of emissions would be determined as the equilibrium carbon tax rate with emission constraints. However, the initial endowment is too arbitrary to be allocated. These regulations might cause huge welfare losses from an economic point of view.

In order to evaluate these two alternative policies, the following two simulations were undertaken during the period from 1990 to 2000. The price of fossil fuels is expected to increase by four percent at an annual rate in the baseline scenario.

In the case of a CO2 tax policy, the rate of the carbon tax is assumed to be thirty percent on coal, twenty four percent on fuel oils, sixteen percent on LNG, respectively. These carbon taxes have a major impact on relative prices and government revenue. On the other hand, in the case of legislative regulation, output of the iron and steel industry, electric utilities and the gross national product have to be slowed down to achieve the level of CO2 emissions under the limits.

Figure 3 illustrates the impact of introducing a carbon tax on CO2 emissions. In the case of a baseline scenario, CO2 emissions are expected to increase from 292 million tons of carbon in 1990 to 362 million tons in 2000, that is, an increase at an annual rate of 2.2 percent. On the other hand, if a carbon tax is introduced, CO2 emissions in 2000 will be 298 million tons of carbon. This means that the rate of carbon tax to be imposed is enough to stabilize CO2 emissions at the 1990 level. The same path of CO2 emissions can be obtained by legislative constraints. Reducing CO2 emissions will mainly occur via the costly route of a policy-induced reductions in energy use. Table 1 shows the impact of the two alternative polices on energy use. A reduction in CO2 emissions is mainly due to a decreases in coal usage. Coal contains the most carbon among fossil fuels, and its price elasticity is the highest.

Table 1 The Impact on Energy Use

	Final Energy Consumption	Electricity	COAL	OIL	LNG
CO2 Tax	-6.0	-4.3	-24.0	-6.2	-3.5
Regulation	-3.4	-7.8	-20.0	-2.8	-7.4

Figure 4 illustrates the impact of the two alternative policies on the growth rate of real GNP. In the case of a carbon tax, the growth rate is reduced by 1.1 percent in 1991

(from the baseline of 4.3 percent to 3.9 percent with the carbon tax), and by 0.3 percent in 1992 (from the baseline of 4.6 percent to 4.0 percent). However, it recovers thereafter and overshoots for several years, then oscillating to converge with that of the baseline scenario. In the case of the legislative constraint, the impact is more drastic. Real GNP shows a growth rate of zero percent in 1991. However, it also overshoots the baseline by 0.5 percent in 1992, and 1.5 percent in 1993, then converges with that of the baseline scenario. The relatively moderate impact of the carbon tax is mainly due to price adjustments. Higher energy prices force business and households to substitute energy with other inputs. It also stimulates the business investments for conserving energy, because capital and energy are usually substitutes in major industries in Japan.

The impact of the two alternative policies on the growth rate of the economy will apparently diminish in the late 1990s. However, the components of GNP will change drastically. Table 2 shows the percent deviation of each component from the baseline scenario in 2000. A carbon tax changes relative prices, which forces business firms and households to substitute energies with other goods and services. It also stimulates business investment. Of course, high energy prices have an inflationary impact on the economy, which results in a decrease in exports. A decline in imports is mainly due to the decrease in imports of fossil fuels. On the other hand, a policy of legislative regulation will only depress the economy. There is no substitutional effect. As a result, an increase in exports and a decrease in imports will offset the decrease in domestic demand. This is known as "the beggar-thy-neighbor" action.

Table 2 The Impact on GNP Components in 2000

	Consumption	Investment	Exports	Imports
CO2 Tax	-0.4	3.2	-2.6	-1.6
Regulation	-1.7	-5.0	1.7	-5.6

Figure 5 illustrates the accumulated welfare losses in terms of reductions in GNP. In the case of a carbon tax, the accumulated reductions in real GNP will be 28 trillion yen in 1986 prices. On the other hand, it will be 41 trillion yen in the case of legislative constraint. The impact of a carbon tax on welfare losses will be only two-thirds as large as that of legislative constraint in magnitude.

4. CONCLUSIONS

Two alternative policies for reducing CO2 emissions in Japan are evaluated. The baseline solution that predicts trends in the absence of control policies shows a growth of two percent in CO2 emissions at annual rate until 2000. The possibility of stabilizing the level of CO2 emissions in 2000 within the 1990 level is investigated. It is shown that it is necessary to introduce a carbon tax of more than thirty percent on fossil fuels in order to achieve this target. Imposing this carbon tax leads to a reduction in GNP, totaling 28 trillion yen during the period from 1991 to 2000. This welfare losses will be smaller than that associated with legislative regulation of CO2 emissions. The impact of carbon tax might be mitigated by substitution among factor inputs as compared with legislative regulation.

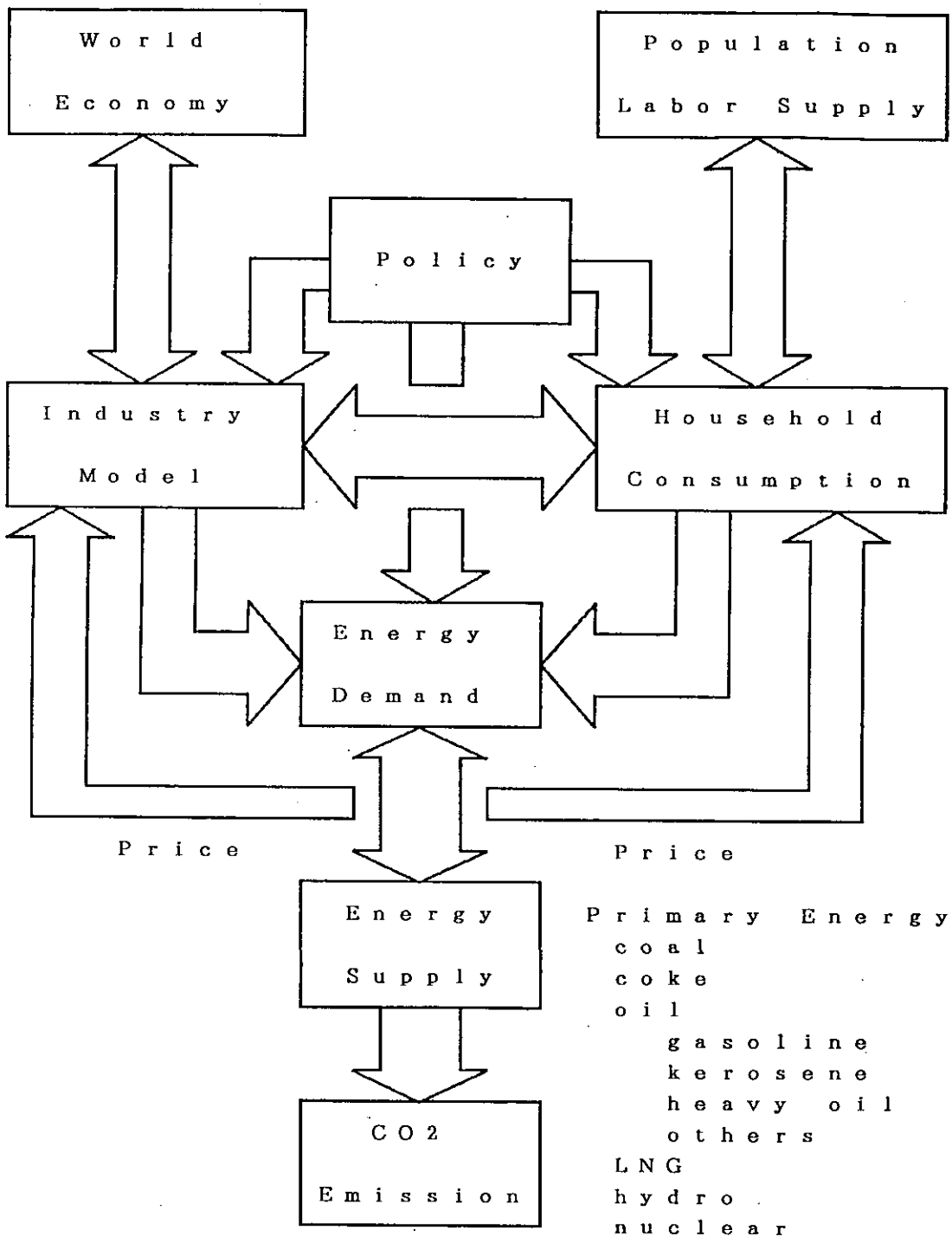

Figure 1 Structure of the Model

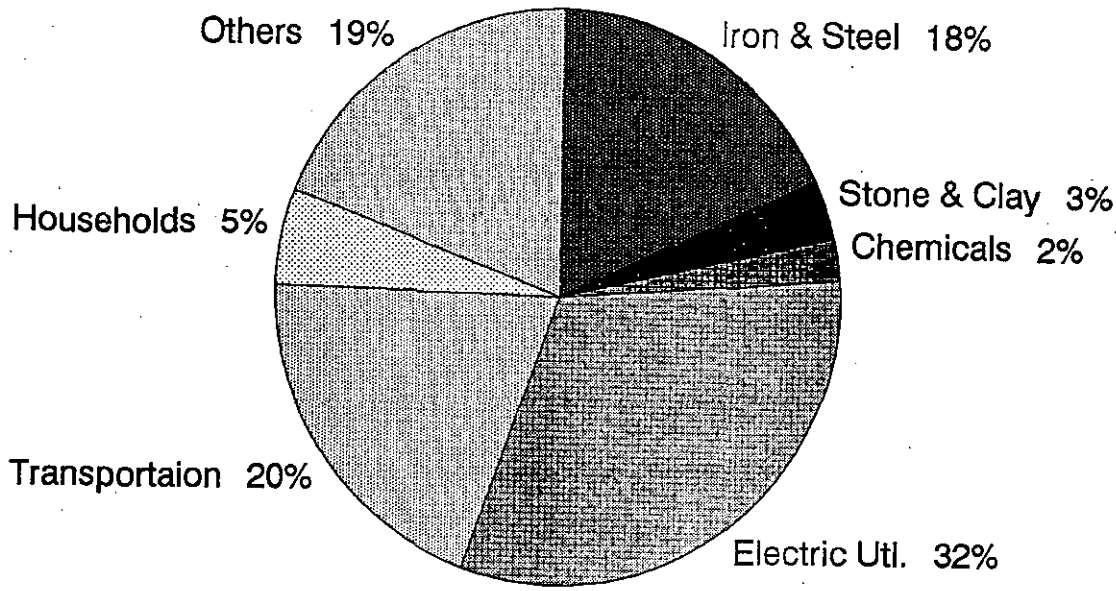

Figure 2 CO2 Emissions in Japan
276 million tons of carbon in 1988

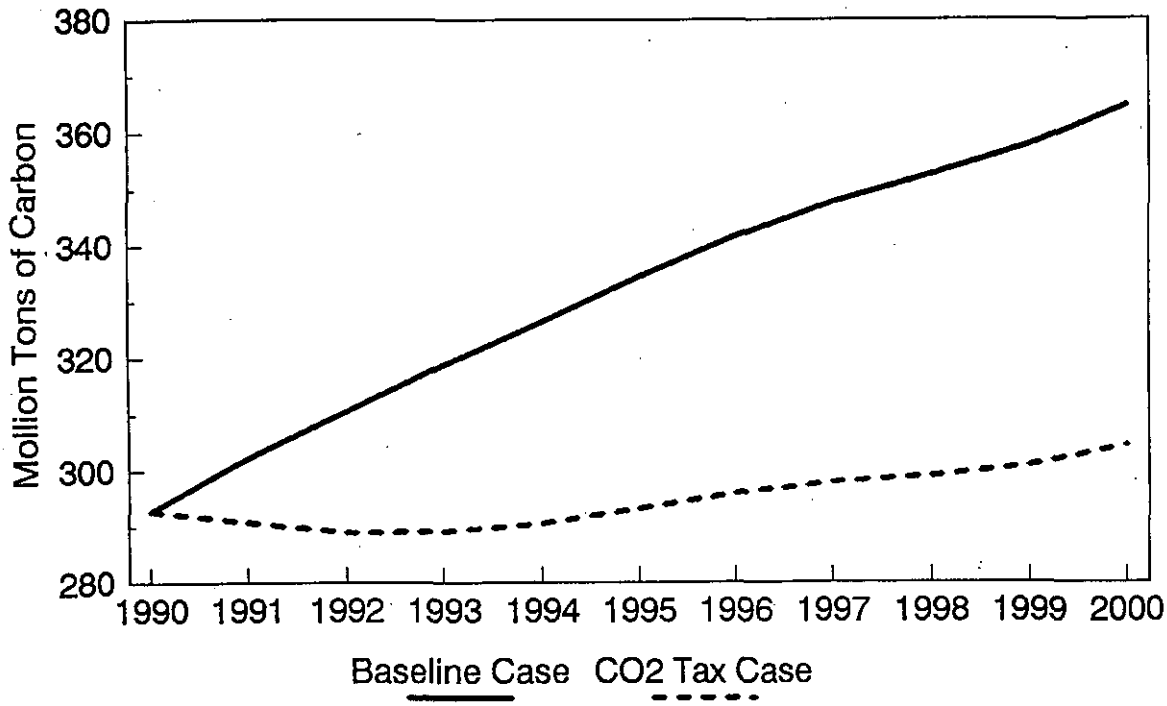

Figure 3 CO2 Emissions

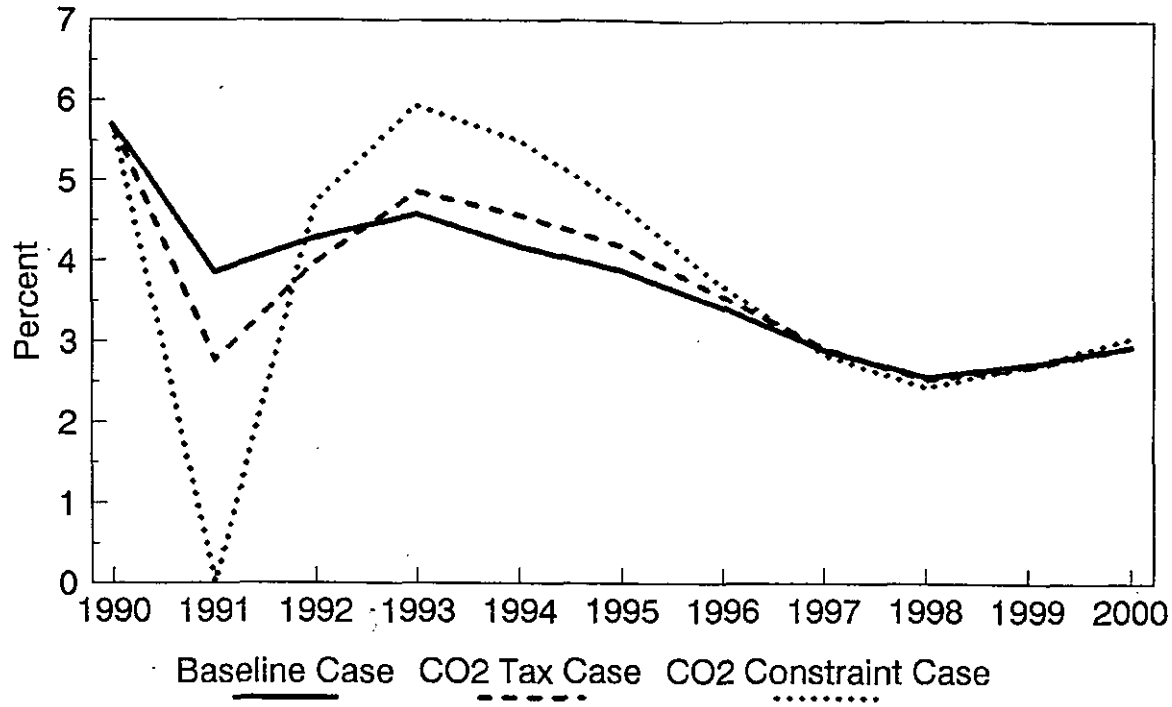

Figure 4 Impact on GNP Growth

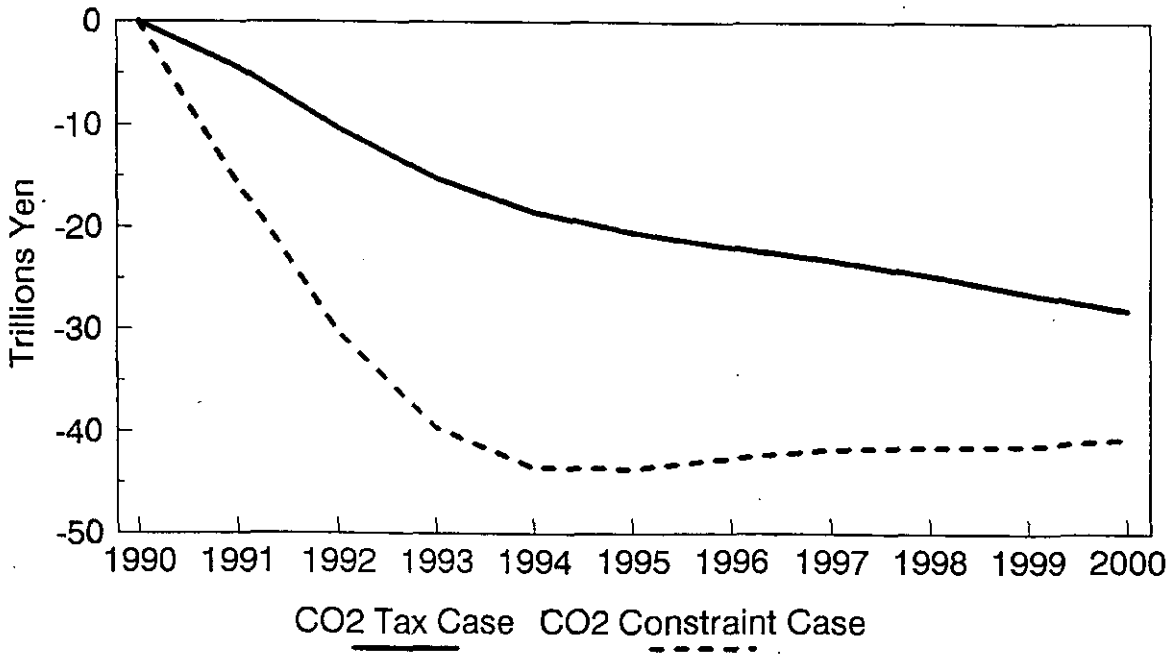

Figure 5 Welfare Losses
Reduction of GNP in 1985 Prices