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Policy evaluations under environmental constraints using a computable general equilibrium model

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Abstract

In this paper, the AIM/Material model, a country-based computable general equilibrium model with recursive dynamics, is applied to Japan and simulations are carried out on various policies for the concurrent solution of CO_2 reduction and solid waste management. To ensure the consistency of waste flows, the material balance is maintained in the model in addition to the monetary balance. Using this model, the GDP loss derived from the environmental constraints on CO_2 reduction under the Kyoto Protocol and reduction of final disposal of solid wastes according to the target of the Japanese government is estimated to be 0.2% in 2010 compared to the business-as-usual case. On the other hand, the GDP loss in 2010 will be mitigated by 55% by introducing the following environmental policies: Enhancement of environmental investment, improvement of waste management technology, taxation reform for the introduction of waste power generation, and changes in consumption patterns.

Keywords: Environment; Computable general equilibrium model; CO_2 reduction; Waste management

1. Introduction

Climate change is a global environmental issue of vital importance. On the other hand, waste management is one of the most severe domestic environmental problems in Japan, because of the scarcity of final disposal sites for solid wastes. This waste management problem is becoming a crucial issue not only for Japan, but other developed and developing countries as well. In order to solve these global and domestic environmental problems at the same time, it is necessary to develop an economic model to assess comprehensive environmental policies. The AIM (Asia-Pacific Integrated Model) team has developed several models to assess the climate change problem. One of these is the AIM/Material model, which has been developed to assess the integration of policies for climate change and waste management (Masui et al., 2002).

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In the area of climate change policy, many models have been developed and applied to the policy making process (OECD, 1998; Weyant, 1999; IPCC, 2000). On the other hand, models for solid waste management are still under development. Masui et al. (2000a) analyzed waste management using a dynamic optimization model, but the economic and waste classifications are relatively rough. Other major activities are based on input–output analysis (e.g., Nakamura, 1999). Masui et al. (2000b) attempted to link CO_2 reduction and waste management policies based on a computable general equilibrium model. These two environmental issues are related to each other. For example, the introduction of waste plastic injection to the steel industry is one of the most effective CO_2 reduction options. In contrast, Masui et al. (2000b) have shown that the introduction of low-emission vehicles as a CO_2 reduction policy produces a negative effect on the waste management problem.

For sustainable development, not only economic development but also the solution of both these environmental problems is necessary. The AIM/Material model has been developed to contribute to the policy making process for realizing a sustainable society. This paper introduces the latest structure of the AIM/Material model and its application to Japan. In the next section, the brief structure of this model will be introduced. The detailed model description is represented in Appendix A. In the following sections, the scenarios and the simulation results, and conclusion will be shown.

2. Structure of aim/material model

The AIM/Material model is a country-based computable general equilibrium model. The base year is 1995, and the model is calculated year by year until 2010. That is, the dynamics of AIM/Material are recursive. Not only ordinary economic activity but also solid waste management is treated. The present version of AIM/Material, shown in Table 1, has 41 economic sectors and 49 commodities. Solid wastes are categorized into 18 types in this model, as shown in Table 2. Fig. 1 shows the structure of AIM/Material. In order to produce economic goods, capital, labor, energy, other intermediate inputs, and pollutants are required. The presence of pollutants as an input factor means that the generated pollutants should be treated as producer's costs. Pollutants are handled in three ways. The first is self-management, in which the production sectors manage and treat pollutants using inputs such as environmental capital and labor. The second is contract treatment such as sewage treatment and waste management, in which the production sectors pay the costs of treatment to the pollution management sectors. The third is discharge into the environment without treatment, in which an upper limit is set on direct discharges so as not to violate environmental regulations.

Solid wastes are disaggregated into industrial wastes and municipal wastes. Industrial wastes are defined as wastes generated from production processes, and municipal wastes as wastes from household and business activities. Each generated waste is treated in the process of direct reuse, direct final disposal, or intermediate management. The residuals of intermediate management are reused or disposed of. Total reused wastes are supplied to the market as recycled materials. At present, recycled wastes are used as intermediate inputs in the specific production sectors shown in Table 2. For example, ash is used in the construction sector; the ceramic, stone, and clay products sector; and so on as a substitute for mining products such as sediment.

Fig. 2 shows the structure of production activity. In order to maintain the equilibrium of both the economic balance and material balance in production activity, the elasticity of substitution between recycled materials and competitive economic goods is defined as 0. This means that the share of recycled material input is determined from the installed capital, and additional investment is necessary for the enhancement of recycled material inputs. According to the energy inputs, the elasticity of substitution among energies is also defined as 0. Although the energy input share is fixed in advance, this share is changed by the introduction of new equipment. The reason for this assumption is that the time step of this model is one year. From the viewpoint of a short term such as one year, the substitution of energy input and recycled