Modelling environmental problems: an introduction

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One of the major goals in environmental studies is the development of a useful theory or hypothesis that yields valid and meaningful predictions. Even though most people admit the science is imperfect, the mounting evidence of global warming and other phenomena needs to be examined more carefully. The papers selected in this issue focus on logic modellings and their applications to environmental problems. Needless to say, much has been written on the topics of global warming, rising sea-level and increasing chlorofluorocarbon and carbon emissions. However, the results are in general inconclusive, embedded in the complex environment labyrinth.

This issue of the *International Journal of Environment and Pollution* consists of a varied menu, which yet makes up a well-balanced feast. The first paper, by Cohen and Labys, is an extension of their important findings published in 1994. They use the data for total anthropogenic carbon emissions for 1850 to 1990 from the Intergovernmental Panel on Climate Change. The large sample provides reliable statistical estimates for predicting the annual change in the atmospheric concentrations of CO_2. From the estimated equation, after adjusting for first-order serial correlation, Cohen and Labys are able to compute a steady-state CO_2 concentration of 550 parts per million in the year 2100. This solution is feasible under the assumption that industrial carbon emissions decline at a 4.45% annual rate between 2050 and 2100. In addition, they explore alternative CO_2 disequilibrium paths, with the inevitable conclusion that the share of fossil fuels in primary energy supply must be reduced to a small proportion if the CO_2 concentration is to be stabilized.

The next two papers, by Huang and Loviscek and Shih *et al.*, analyse the severe environmental pollution problems in Taiwan, which is an excellent example of a developing country. The paper by Huang and Loviscek highlights the lack of efficacy of the policies administered by the Environmental Protection Administration (EPA). Using the linear transfer model developed by Box and Jenkins (1976) with the famed intervention analyses by Box and Tiao (1975) and Chen and Liu (1993), they conclude that (1) the carbon monoxide concentration has not been reduced because the seasonal trend variables are positive, and (2) the antipollution policies established by the EPA brought about only a temporary reduction in carbon monoxide concentration. Given that the five outliers are positive in sign, it clearly suggests an increasing trend in carbon monoxide concentration in Taiwan.

Shih *et al.* propose and solve a linear programming (LP) model of 39 sectors in Taiwan. Although LP is frequently and conveniently employed in energy modelling, their model is set out to maximize gross domestic product (GDP) with varieties of restrictions regarding GDP and pollution controls. Emission levels from the 39 sectors obtained from the input–output table published by the Taiwan government are explicitly incorporated into the model. Upper bounds on sulfur oxides, nitrogen oxides, carbon oxides and total suspended particles are imposed to generate 24 scenarios regarding GDP growth rates for

the year 2000. The iterative nature of the model, coupled with energy conservation and energy-switching scenarios, suggests that a 6.28% GDP growth rate is feasible only under the assumptions of (1) 20% energy conservation ratio, (2) 6% and 4% increases, respectively, in coal and oil prices, and (3) an allowance of 8.58 tons of carbon emissions, per person per year.

Much like the others, Raehsler's paper places great emphasis on modelling. Using the Granger causality, vector autoregression (VAR), variance decomposition, and impulse response function analyses, he comes to the following conclusions. First, chlorofluorcarbon gases in the atmosphere and world population statistically cause changes in average global temperature. Second, the impact of the global warming is primarily driven by industrial growth, which is the result of growing world population. Third, the rising average temperature, surprisingly, hinders world grain production and hence indirectly reduces livestock production.

Li *et al.*, in an interesting paper, propose a model that can be readily applied to the North American Free Trade Agreement. In the wake of the growing trend of economic integration in other parts of the world, their paper sheds some light on an important issue: the impact of a non-discriminatory pollution tariff on the welfare of the participating member countries. Within the famed theoretical framework described by Cournot (1838), they derive the welfare-maximizing pollution tariff. Unambiguously, a uniform tariff is shown to be a useful vehicle to mitigate environmental degradation via higher product prices that consumers have to pay. The loss in consumers' welfare is more than compensated by increasing tariff revenues of importing countries over a wide range of the pollution tariff. Although the uniform tariff is non-discriminatory and thus politically feasible, it penalizes the producers with higher costs, i.e. the firms in the country that has higher environmental protection standards. By contrast, it has much less impact on the level of output for the firms subject to less rigorous environmental regulations.

The final paper, by Irwin and Yang, is an application of their theoretical papers (Irwin and Yang, 1982; 1983) on the eastern United States natural gas and steamcoal market. Employing the linear complementarity programming (LCP) model developed in the late 1970s, they show from the empirically estimated demand and supply functions that regional coal consumption and production are expected to decrease in the presence of a federal carbon tax on steamcoal. However, the impact on gas consumption and production are generally unpredictable, and may actually increase in the presence of such a carbon tax. Furthermore, a federal carbon tax can cause the prices of steamcoal and natural gas to increase or decrease. Consequently, one cannot expect all energy prices to increase in the face of a federal carbon tax. This surprising result, however, is in agreement with the well-known Edgeworth taxation paradox (Hotelling, 1932).

A common thread in all six papers is that they place great emphasis on formal modelling. The statistical estimates by Cohen and Labys are based on a large sample and as such their results are robust and reliable in terms of the steady-state CO_2 concentration level by the year 2100. Huang and Loviscek, using a rather complicated statistical technique, show that the antipollution policies of the EPA in Taiwan are largely ineffective owing to loose enforcement. Shih *et al.* study the impact of different emission levels and energy prices on the growth rate of GDP in Taiwan. The combination of the LP and the input–output table provides useful information. Although Raehsler's study is not based on large samples, it reveals important causal relationships between population growth and global warming and CFC concentration. These results are encouraging, especially because they are derived from sound statistical procedures (e.g. Granger

causality and VAR models). The paper by Li *et al.* illustrates the potential impact of a uniform pollution tariff in the presence of NAFTA within the framework of Cournot–Nash competition. Irwin and Yang investigate the impact of a federal carbon tax on the consumption, production and prices of natural gas and steamcoal. Because the LCP model is mathematically consistent, the results can shed useful light on policy implementations.

Acknowledgement

The author thanks Dr Joseph P. Grunenwald, Dean of the College of Business Administration, Clarion University of Pennsylvania, for his assistance.