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Analysis of the impacts of combining carbon taxation and emission trading on different industry sectors

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Abstract

Application of price mechanisms has been the important instrument for carbon reduction, among which the carbon tax has been frequently advocated as a cost-effective economic tool. However, blanket taxes applied to all industries in a country might not always be fair or successful. It should therefore be implemented together with other economic tools, such as emission trading, for CO_2 reduction. This study aims to analyze the impacts of combining a carbon tax and emission trading on different industry sectors. Results indicate that the "grandfathering rule (RCE2000)" is the more feasible approach in allocating the emission permit to each industry sector. Results also find that the accumulated GDP loss of the petrochemical industry by the carbon tax during the period 2011–2020 is 5.7%. However, the accumulated value of GDP will drop by only 4.7% if carbon taxation is implemented together with emission trading. Besides, among petrochemical-related industry sectors, up-stream sectors earn profit from emission trading, while down-stream sectors have to purchase additional emission permits due to failure to achieve their emission targets.

Keywords: Carbon taxes; Emission trading; Industry sectors

1. Introduction

The Kyoto Protocol went into effect on February 16, 2005. In the post-Kyoto phase, Taiwan, as a newly industrialized country, needs to draft feasible strategies with lower economic impact for the coming CO_2 reduction. Application of price mechanisms has been the important instrument for carbon reduction, among which the carbon tax (CT) has been frequently advocated as a cost-effective economic tool. Some countries in Europe, such as Netherlands, Denmark, Sweden, Finland, and Norway, have implemented CTs for over 10 years, while Italy, Germany, and UK also began to levy CTs since 1999–2001. Also, emission trading (ET) has been recommended as one of the flexible mechanisms in the Kyoto Protocol to reduce greenhouse gas emissions in a cost-effective way. The EU has introduced a carbon-trading system in the beginning of 2005 as a means for achieving its CO_2 reduction target. In the first phase of the system, 2005–2007, power plants and some energy-intensive industries are included (Kara et al., 2006). It is therefore essential to simulate and to compare the impacts of various carbon reduction tool combinations on industry sectors.

The effectiveness of carbon taxation has been discussed in many relevant researches. A study by Baranzini et al. (2000) showed that CTs may be an interesting policy option and that their main negative impacts may be compensated through the design of the tax and the use of the generated fiscal revenues. Nakata and Lamont (2001) applied a partial equilibrium model to evaluate the impacts of CTs on energy systems in Japan. Their results suggest that CTs decrease CO_2 emission according to a proposed target, but also cause a shift in fuel use from coal to gas. In New Zealand, a computable general equilibrium model is used to assess the relative effectiveness of CTs on the economy, and results show that carbon taxation would

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adversely affect GDP (Scrimgeour et al., 2005). However, blanket taxes applied to all industries in a country might not always be fair or successful. Norway's high CT since 1991 contributed to only 2% reduction in CO_2 emissions because of widespread tax exemptions and inelastic demand of various sectors affected by this tax (Bruvoll and Larsen, 2004). As in the case of Norway's relatively high CT since 1991 and its resulting low CO_2 reduction, Gerlagh and Lise (2005) developed an economic partial equilibrium model to demonstrate that CTs have a modest effect on emissions. Johansson (2006) theoretically evaluated the possibility of different policy instruments to contribute to reductions in industrial CO_2 emissions while preserving the competitiveness of the industry.

However, blanket taxes for CO_2 reduction applied to all industries in a country might not always be fair or successful (Lee et al., 2007). The authors constructed a fuzzy goal programming model to assess the effects of CTs on different industries (Lee et al., 2007). The results indicated that some industries show improved CO_2 reduction while others fail to achieve their stabilization targets. The results also suggested that the CTs should be implemented together with other economic tools, such as carbon trading. Thus, industries that show significant carbon abatement may sell their surplus emission allowances to industries that need additional permits, and then the industrial GDP losses induced by CO_2 reduction can be compensated. The impacts of ET on the industries have been studied in the literature. Szabó et al. (2006) present a global simulation model to quantitatively analyze the impacts of three carbon ET schemes on the cement sector. In Finland, the impacts of the EU CO_2 ET on power plant operators, energy-intensive industries, and other consumer groups were analyzed by Kara et al. (2006). Their results found that large windfall profits were estimated to incur to electricity producers in the Nordic electricity market, while the metal industry and private consumers were estimated to be most affected by the electricity market price increases. Among various energy-intensive industries, the pulp and paper industry may actually be a net beneficiary of the EU ET. Lund (2007) investigated the cost impacts of the European Emission System (ETS) on energy-intensive manufacturing industries. Their results indicate that the ETS affects the industry sectors quite differently. The cost impacts of the steel and cement industries are 3–4-fold compared with the least-affected pulp and paper and oil refining. They therefore suggest that some correcting mechanisms may be worth considering in securing the operation of some industry sectors.

This study compares the impacts between only a CT and a CT combined with ET on different industry sectors in Taiwan. A fuzzy goal programming model that was originally constructed in the author's previous paper (Lee et al., 2007) is adopted to simulate the CO_2 reduction potential and the accompanying economic impacts of a CT on five petrochemical-related industry sectors: petrochemical materials (PMs), plastic materials (PLs), artificial fibers (AFs), plastic products (PPs), and rubber products (RPs). Based on the results from carbon taxation, we further quantify the effects of implementing ET on financial flows among different industry sectors. The CO_2 reduction target is set as "returning the emission amount to year 2000 level by 2020", and the carbon ET is assumed to be implemented together with a CT scenario since 2011.

The paper is structured as follows. The applied methods are presented in Section 2. The model for assessing the impacts of a CT is briefly described. Then the methods about ET used in this paper are introduced. Section 3 presents the outcomes from the model. The results for the base scenario and the CT scenario are shown and discussed. In Section 4, we discuss the results of emission permit allocation firstly, and then compare the impacts between only a CT and a CT combined with ET on different industry sectors. Finally, some conclusions are given in Section 5.

2. Methods

2.1. The model for CO_2 reduction

Industrial CO_2 reduction is a multi-objective decision-making problem. In this paper, we apply a fuzzy goal programming model to assess the impacts of a CT on different industry sectors. The original model is composed of two objectives, which seek the maximum industrial GDP value and the minimum CO_2 emission, and 78 constraints. Two model objectives are then treated as fuzzy numbers since the decision-makers usually would accept an approximate result as long as it is within a tolerable range. For the detailed model structure please refer to the author's previous publication in Energy Policy (Lee et al., 2007).

2.2. Emission trading

2.2.1. CO_2 abatement target

The CO_2 abatement target of the petrochemical industry is set as "returning the CO_2 emission to year 2000 level by 2020", which is one of the possible options of CO_2 stabilization for Taiwan. Besides, the annual emission target during 2011 through 2019 is designed to decrease linearly as shown in Fig. 1. The linearly declining emission targets have the advantage of advancing gradually. In ET, the annual emission targets are defined as the annual allowances for the petrochemical industry, and the annual permits for five industry sectors are allocated based on the annual emission targets.

2.2.2. Permit allocation

With regard to permit allocation methods, Vesterdal and Svendsen (2004) tried to find a politically feasible allocation method by considering how greenhouse gas permits should be allocated at both the national and the power plant levels. Their results indicated that a common grandfathered allocation principle is to be preferred over an allocation principle based on past emission. Sijm et al.