A UNILATERAL CLEAN DEVELOPMENT MECHANISM SCHEME FOR A DEVELOPING COUNTRY: A GENERAL EQUILIBRIUM ANALYSIS

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Overview

This study analyses economic and environmental impacts of a scheme to reduce greenhouse gas (GHG) emissions under the Clean Development Mechanism (CDM) of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). The scheme assumes a Non-Annex I country (here Thaland) with no mandatory obligation to reduce GHG emissions under the Kyoto Protocol, to introduce a carbon tax and exports the resulted emission mitigation to Annex I countries as certified emission reduction units (CERs). The scheme is termed as a Unilateral CDM (UCDM) scheme, as the Non-Annex I countries can implemets it unilaterely without involving an Annex I Party. A carbon tax of US$40 per ton of carbon and CER prices varying from US$10 per unit (i.e., per ton of CO_2) to US$ 200 per unit are considered. The total revenue (i.e., carbon tax- and CER- revenue) is recycled to the economy through three alternative schemes: (i) recycling to households through a lump-sum transfer ('Scheme 1'), (ii) financing cuts in existing labor tax rate ('Scheme 2') and (iii) financing cuts in existing indirect tax rates of non-energy goods ('Scheme 3').

Methods

A static computable general equilibrium (CGE) model of Thailand was developed to simulate the UCDM scheme. Detailed descriptions of the model are available in Timilsina and Shrestha (2002), Timilsina and Shrestha (2006). The economy is disaggregated into 21 production sectors of which 6 are energy sectors. Production behavior of each sector is represented by a nested constant elasticity substitution (CES) production function in line with some esxiting studies such as Bohringer and Rutherford (2004), Capros et al. (1997) and Bovernberg and Goulder (1996). The model, however, differs from most of the existing ones in representing the electricity sector. First, the electricity sector is divided into seven sub-sectors based on technologies used for electricity generation to allow for substitutions between the technologies. Secondly, the nested CES structure used for the electricity industry differs from those used in the rest of industries to allow direct substitution between capital and fuel in electricity generation. The model considers a representative household that follows a five-step hierarchical optimization process to maximize its utility. As in the case of the production sector, CES functional forms are mostly used. Similar to most existing general equilibrium models (e.g., Bohringer and Rutherford, 1997; Shoven and Whalley, 1992 and Ballard et al., 1985), Hicksian equivalent variation is used to measure welfare impact of the policy considered. Government income is allocated to public consumption and government savings. Total government consumption is maintained at the same fraction of GDP as that in the base case (i.e., before the introduction of the carbon tax and selling the migrated emissions as CERs). The total government consumption is then distributed to various goods and services at the same proportion as in the base case. The modeling of the foreign sector follows Armington (1969) assumption according to which domestically produced and imported goods are considered to be imperfect substitutes. Following Dervis et al. (1982) export demands are assumed to be downward sloping. The model follows the Walrasian approach to clear goods and factor markets (Shoven and Whalley, 1992). Similar to a number of existing general equilibrium models such as Dervis et al (1982) and Benjamin (1994), nominal exchange rate is kept fixed; domestic prices fluctuate against the fixed foreign price level, which serves as the price numéraire in the model. A social accounting matrix (SAM) of Thailand for the year 1990 was constructed for this study on the basis of Input-Output (I/O) Tables (NESDB, 1993) and National Accounts of Thailand (NESDB, 1991). The original I/O table was a 180×180 matrix of order, which was converted to a 21×21 matrix for the study. The social accounting matrix and values of the various model parameters used in this study are available in Timilsina and Shrestha (2002).

Results

The carbon tax in the absence of the UCDM scheme causes welfare loss no matter how the tax revenue is recycled to the economy. Such a loss would be avoided under the UCDM depending on two factors: (i) the scheme of recycling the tax and the CER revenue to the economy and (ii) the price of CERs. It is interesting to note that the UCDM would cause welfare gain even at a very low CER price (US$2/t$CO_2$) when carbon tax- and CER- revenue is recycled to finance cuts in existing indirect taxes on non-energy goods. It would also do the same when the revenues are recycled to households through a lump sum transfer or used to finance cuts in existing labor tax but requires CER price greater than US$55/t$CO_2$.

In the absence of UCDM, GDP is found to decrease when tax revenue is recycled to household or used to finance cuts in indirect taxes on non-energy goods; whereas it is found to increase when the revenue is used to finance cuts in labor tax. Under the UCDM, GDP is higher than in the case of carbon tax alone in each scheme of revenue recycling.

In the absence CER sales, the carbon tax would cause trade balance to be negative (i.e., trade surplus) when the tax revenue is recycled to households and when it is used to finance labor tax cuts. The opposite (i.e., trade deficit) would result when the tax revenue is used to finance cuts in indirect tax rates of non-energy goods. The UCDM would further increase the trade surplus as the total exports would increase due to exports of CERs. As expected, trade surplus increases along with the CER price as the country gets higher CER revenue at higher CER prices. An interesting finding here is that the UCDM further increases the trade deficit despite the additional revenue from the export of CERs. The export of CER, in fact, would cause exports of other goods to decrease and imports to increase thereby indicating a phenomenon, which is similar to "Dutch Disease" discussed in several existing literature (e.g., Benjamin, 1994; Cordon 1982).

CO_2, SO_2 and NO_x emissions under UCDM are smaller than that in the absence of UCDM under the revenue recycling scheme 1, whereas the opposite is found under the revenue recycling schemes 2 and 3. Moreover, the emissions are found to increase with CER price in the latter cases. This clearly implies a rebound effect under UCDM when tax- and CER revenue is recycled to finance labor and indirect tax cuts.

Conclusions

The study first finds that whether or not the welfare losses of the carbon tax are offset under the UCDM depend on CER price and scheme of recycling tax- and CER- revenue to the economy. The UCDM would offset welfare losses of the carbon tax at a CER price as low as US\$2/tCO_2, if the revenue is recycled to cut existing indirect taxes on non-energy goods. When the revenue is recycled to households through a lump-sum transfer or used to finance labor tax cuts, CER price greater than US\$55/tCO_2 would be needed to offset the welfare loss of carbon tax. The study also shows that economic welfare increases with CER price under all revenue recycling schemes considered. GDP would decrease with the carbon tax when the tax revenue is recycled to households or when it is used to finance cuts in existing indirect taxes on non- energy goods. On the other hand, the GDP would be higher than that in the base case even at zero CER price when the tax revenue is used to finance cuts in existing labor tax. Like economic welfare, GDP would increase with CER price under each scheme of revenue recycling. The UCDM would also increase trade surplus when the tax- and CER- revenue is recycled to households or used to finance cuts in existing labor tax. On the other hand, the UCDM with revenue recycled to finance cuts in existing indirect taxes would result in an increased trade deficit and cause a phenomenon like 'Dutch Disease'. The percentage reductions of CO_2, SO_2 and NO_x from the base case would be higher under the UCDM than that under the carbon tax alone when the revenue is recycled to households as a lump-sum transfer. The opposite would be the case when the tax- and CER- revenue is recycled to finance cuts in existing labor or indirect taxes. The sensitivity analyses on key parameters show that the qualitative results of the study are robust.

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