

THE IMPACT OF TRADE STRUCTURE IN ENVIRONMENTAL CGE MODELLING: AN APPLICATION ON SINGAPORE

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Overview

Since the early 1990s, computable general equilibrium (CGE) model has become an important tool in analyzing energy and environment related issues. As a complex macroeconomic framework, the simulation results of CGE models are fairly sensitive to parameter values and structure specification. The literature has been discussing to improve the performance of CGE models by using parameter values that are econometrically estimated from historical data over a period, rather than calibrated based on one-year data (See, e.g., Beckman et al. [2011]). But model structure specification has received far less discussion. One representative is Van der Werf [2007], which carried out an empirical analysis on the nesting structure of production function using industry-level data from 12 OECD countries.

Particularly, analysis on the trade module specification is almost blank. For example, trade module in global models such as EPPA, G-Cubed and GREEN (as well as its successor ENV-Linkages) usually has quite flexible specification on imported goods. That is, imported goods can directly be consumed by households, used by firms as intermediate inputs and invested. Due to many reasons, trade module in most single-region CGE models simply adopts the standard Armington's assumption, which assumes that imported goods and the corresponding domestic goods are imperfect substitutes and need to be aggregated into "Armington composite goods" for consumption, intermediate use and investment. That is, imported goods and domestic goods cannot be directly consumed or utilized. So far, analysis on the two structures has not been seen in the literature. But with constantly increasing international trade in recent decades, the validity of the standard assumption is challenged, especially for economies with a high degree of openness (such as Singapore, Hong Kong, Shanghai, etc.).

This paper thus aims to investigate whether different trade structures would give quite different simulation results and policy implications. Two single-region CGE frameworks are considered: one explicitly assumes that imported goods can be directly consumed and utilized, and the other follows the Armington's assumption. Singapore data is used in calibration as its input-output table contains very detailed information on imports, including direct consumption, intermediate use and investment of imported goods. The paper is organized as follows: after the introduction, the second section describes the settings of the two CGE frameworks. The third section gives an overview of the data used and the hypothesis scenarios to be analyzed. The fourth section compares the simulation results under different frameworks. The last section discusses the implications of the findings.

Methods

Single-region computable general equilibrium model. The economy is divided into 9 non-energy sectors (i.e. Agriculture, Petrochemicals, Pharmaceuticals, Semiconductors, Other manufacturing, Construction, Wholesale & Retail Trade, Transport & Storage, Other Services) and 3 energy sectors (i.e. Petroleum & petroleum products, Gas and Electricity). In addition to market-clear conditions for commodities, labor and capital, several other assumptions are also made to close the model. First, ratios of saving and transfer payments to income are exogenous for the household and government. Second, foreign savings are fixed while the exchange rate floats freely. Third, prices of imports are exogenous while prices of exports are determined by domestic firms.

Results

Four hypothesis scenarios are analyzed under both frameworks: (1) domestic carbon tax on energy and energy-intensive sectors, (2) domestic carbon tax on energy and energy-intensive sectors with tax revenue refunded to households, (3) domestic carbon tax on energy and energy-intensive sectors with tax revenue refunded to firms and (4) externally imposed border-carbon-adjustment (BCA) on exports. The simulation results show that indicators such as GDP, aggregate consumption and government expenditure are sensitive to trade structure setting in the BCA scenario but not that sensitive in other scenarios. Indicators such as aggregate imports, aggregate exports and nationwide CO₂ emissions display obvious differences under the two frameworks. For example, given the same policy shock, emissions reduction is usually doubled under the framework that follows the Armington's assumption. At industry level, the differences are even more obvious for imports and exports.

Conclusions

The analysis in this paper generally shows that the assumption on imported goods can influence the impacts of external shock and policy shock to a large extent, especially at industry level. For open economies like Singapore, it is reasonable to expect that the first CGE framework gives a more precise forecast, as the setting is more close to the actual economic structure. Therefore, one important implication of this paper is that studies for open economies and especially for their individual industries need to be careful with the setting of trade structure. One assumption cannot be applied to all the economies. Besides, allowing direct consumption and utilization of imported goods makes the model more flexible. From the view of model development, it would be easier to extend a more flexible single-region model to a multi-region or global model, where international trade plays a more important role.

References

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