AN EMPIRICAL STUDY ON THE POSSIBILITY OF USING COPULAS AS AN ALTERNATIVE DESCRIPTION OF ENERGY-RELATED PRODUCTION TECHNOLOGY IN CGE MODELS

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Overview

This study reviews the critical problems of conventional computable general equilibrium (CGE) models for energy and climate change policy analysis, and proposes an alternative way of representing the production technologies in the computing structures. Literature shows that there exists an ambiguity in describing energy-related production activities, which usually brings about huge discrepancy in the long-term projection results among different CGE models. This phenomenon is rooted in the inefficiency of the traditional models in incorporating the microscopic information, which is not clearly overcome by any sectoral or regional disaggregation efforts within the model. In practical employment of CGE models, this matter usually surfaces as the uncertainty of parameter and nesting structure. In this sense, we aim to explore an alternative approach and provide a comparative assessment of its performance. As a solution to this problem, this paper introduces copulas, one of the multivariate statistics approaches. A copula is a function that combines a multivariate distribution function with its one-dimensional marginal distribution functions. A series of empirical results show that a copula model turns out to be successful in describing the dependence embedded in an energy-included multivariate joint distribution and producing more robust projection outcomes.

Methods

In order to provide a quantitative analysis on the performance of a composite input factor structure for depicting energy-related production functions, we focus on the constant elasticity of substitution (CES) function which is the most widely used specification in many economic models, including CGE models. Using the data of conventional quantities – labor cost, capital and value added – as well as energy use of the firms in Korea, we derive optimized CES functions for a disaggregated dataset. Then, we compare the performance in reproducing the dependence information. Next, we briefly introduce the basic theory of copula approach and provide an empirical assessment of its possibility: A candidate copula model – a two-level nested Gumbel copula model – is devised and a few experiments are performed to investigate its performance. Also, we apply the copula model to a pilot CGE model and check any improvement in the robustness of projection results.

Results

In the assessment of the performance of CES functions in reproducing the mutual dependence between disaggregated data groups, the comparison with the correlations of aggregate real data proves that the estimated CES function fails to reproduce the correlation information of the aggregate dataset. In another experiment with a copula model, the simulation results seem to well imitate the relations embedded in the real data. Despite a disagreement in the results of reproducing the dependence, a copula model produces more close correlation coefficient values. Also, a pilot CGE model equipped with a copula model in manufacturing sector shows more narrowed intervals of standard deviation in GDP projection than a CES function-based model.

Conclusions

We conclude that there is a loss of information with a CES function model and the traditional method is not appropriate for statistically depicting the microscopic relations between economic variables. Contrarily, despite the reliance on parameter numbers and nesting structures, a copula model turns out to be more successful in reproducing firms' production activities as well as improving the robustness of projection results than the conventional CES function. That is, the copula approach can effectively and robustly describe the relations embedded in an energy-related multivariate joint distribution, which is mostly difficult to handle in conventional economic models.