Economic modeling and the choice of model parameters: Case of land use modeling

Background, relevance, and contributions:
Numerical partial and general equilibrium models have been widely used for quantitative analysis of policy, economic, and environmental issues. These models typically use various behavioral parameters in their simulation processes. While the choice of these parameters is a crucial issue in both partial and general equilibrium modeling practices, the existing literature has more extensively examined this topic for the case of Computable General Equilibrium (CGE) models for two main reasons. First, these models have been more extensively and systematically used in quantitative analysis. Second, despite differences among CGE model, they follow a unique theoretical foundation that makes their parameterization more complex.

In general, there are three ways to select a parameter or a set of parameters in a modeling practice: i) relying on the experts' judgments; ii) applying the existing econometrically estimated elasticities; and iii) using a calibration process. The first approach is typically used due to the lack of evidence or data. The use of econometrically estimated elasticities is a common approach in economic modeling. However, there are several barriers against this approach in CGE modeling. Arndt et al. (2002) have highlighted several important barriers: a) lack of proper data to econometrically estimate required parameters; b) inconsistency between the existing estimates and models' requirements and structures; c) econometric estimates usually ignore structural changes over time; d) and finally, econometric estimates disregard the full set of general equilibrium constraints. For these reasons, alternative approaches have been developed and used by CGE modelers to directly infer required elasticities from actual observations (e.g., Arndt et al. (2002), Liu et al. (2004), Hillberry et al. (2005), etc.).

While alternative calibration approaches have been developed and widely used in CGE modeling, the existing literature in this area has not been fully developed and lacks important deficiencies. Here, we address two important items. First, the existing literature in this area has been mainly focused on the trade elasticities, the demand elasticities, and the rate substitution among inputs in production functions. Thus far, no major effort has been developed to determine the behavioral parameters that govern supplies of primary inputs such as land and resources in CGE modeling. Only a few preliminary efforts have been made in this area. For instance, see Ahmed et al. (2008), and Taheripour and Tyner (2013). Second, the existing calibration efforts commonly have determined their desired parameters assuming other model parameters are valid and given. This approach basically ignores interactions among the parameters of a model and their implications. This paper highlights these interactions and their implications.

Research methodology and modeling framework:
To accomplish the goal of this research, we begin with the work developed by Taheripour et al. (2020). These authors have extensively discussed the use of the Constant Elasticity of Transformation (CET) functions in land use modeling and concluded that: 1) the CET approach fails to maintain physical area of land in balance; 2) various arbitrary *ex post* approaches have been followed to solve the balancing issue; 3) and the *ex post* correction approaches affect the land use outcomes. These authors offered a new approach, called Modified CET (MCET), to solve the CET balancing issue endogenously and determine land allocation across uses without the need for *ex post* adjustments.

To highlight the role and importance of the choice of behavioral parameters and their interaction, we adopted a well-known CET-based CGE model, GTAP-BIO, which has been frequently used to assess induced land use changes due to biofuels. In particular, we use the latest version of this model, reported in Taheripour et al. (2017). Two sets of behavioral parameters mainly govern the changes in land use and land cover items in this model: regional land transformation elasticities and regional yield to price responses. The first set shapes the land supply side, and the second set governs yields and affects the demand for cropland.

In this paper, we first modify this model to follow the MCET approach mentioned above. We then assess the performance of the new model in assessing land use changes due to biofuels. The outcomes of this practice indicate that under the same set of parameters, the MCET approach projects smaller yield responses and more demand for cropland. We show that this observation is due to a shift in the land supply frontier induced by imposing the physical land constraint and an interaction effect between the land transformation elasticities and the yield to price responses. We developed several experiments to decompose and understand these effects.

Major findings:
A major finding is that compared to the old model, the new model, which preserves physical area of land in balance, projects more demand for cropland and smaller yield responses due to an expansion in demand for biofuels. To highlight this finding, consider Figure 1 which shows the percent differences between the two models' results for corn area induced by an expansion in demand for a corn ethanol-based jet fuel by 0.85 Billion Gallons Gasoline Equivalent (BGGE). This figure shows positive percent differences in the area of corn land by region (results of the new model over the results of the old model). This means more demand for land due to the same increase in the demand for a given biofuel. On the other hand, consider Figure 2 which represents negative differences between the two model results for corn yield.

Fig 1. Percent differences in corn area

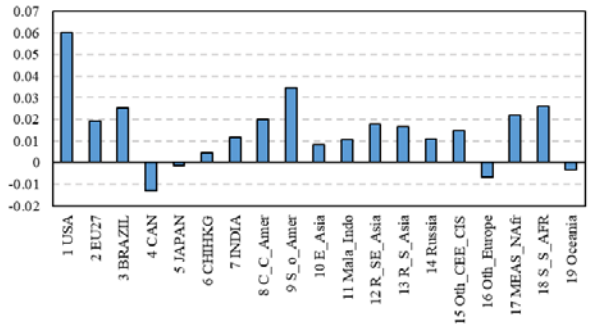
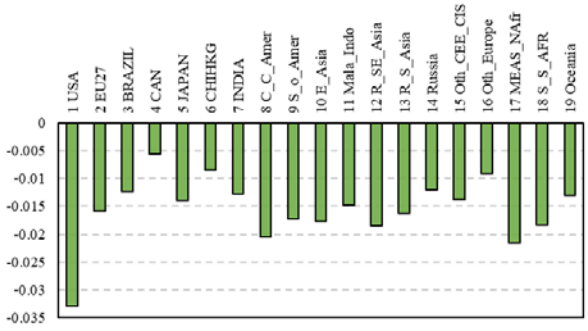


Fig 2. Percent difference in corn yiled



Using various calibration simulations, we show that one can restore the original CET-based model results using the new model. The calibration processes could target either the land transformation elasticities, the yield to price elasticities, or both.

Potential for generating discussions: The analyses provided by this paper will attract the biofuel stakeholders, policymakers, students, and our colleagues that follow the existing debates about the issue of modeling induced land use changes due to biofuels. The paper offers important findings and has the potential to generate lively discussion.

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