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

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Outline of this presentation

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Background and literature review (1)

- Numerical PE and GE models have been used for quantitative analysis of policy, economic, and environmental issues
- These models use behavioral parameters in their assessments
- The choice of these parameters is crucial issue and has been widely addressed in the literature
- Three ways to select a given parameter:
  - Relying on experts' judgments
  - Using the existing econometrically estimated values
  - Using a calibration approach
- Using the econometrically estimated parameters is preferred, but it has several barriers (Arndt et al., 2002):
  - Lack of proper data to econometrically estimate these parameters
  - Inconsistency between the existing estimates and models' requirements and structures
  - Estimated parameters usually ignore structural change
  - Econometric estimates disregard the full set of general equilibrium constraints
- Due to these issues, we often use various calibration or tuning approaches: Arndt et al. (2002), Liu et al. (2004), Hillberry et al. (2005), Ahmed et al. (2008), and Taheripour and Tyner (2013)

Background and literature review (2)

- While alternative calibration approaches have been developed and widely used, the existing literature in this area has not been fully developed and lacks important deficiencies:
  - The existing literature has mainly remained focused on the trade elasticities, household demand elasticities, and substitution among inputs on the supply side
  - No major effort has been made to determine the behavioral parameters that govern supplies of primary inputs such as land and resources
  - The existing calibration efforts commonly have determined their desired parameters assuming other model parameters are valid and given.
  - Interaction among model parameters has not been a focal point.
- This paper highlights and addresses these issues
  - We built on the work develop by Taheripour et al. (2020)
  - These authors have extensively discussed alternative CGE approaches in land use modeling

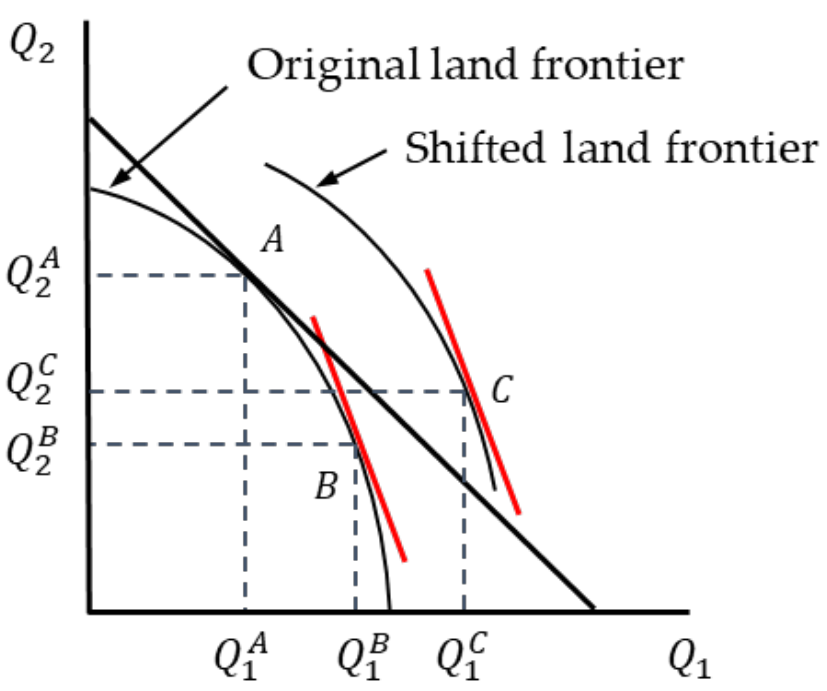
Background and literature review (3)

- Main approaches in modeling land use in CGE:
  - CET approach: This is a dominate approach and commonly has been used in the GTAP based models such GTAP-AEZ, GTAP-BIO, GTAP-BIO-W, GTAP-FCS, …
  - Extreme value distribution functions: Logit and Fréchet approaches are usually used in stylized CGE model
  - Other approaches such as land transformation matrices, cost of land conversion, and simple market clearing conditions
- Main messages from Taheripour et al. (2020) on CET approach:
  - CET approach considers heterogeneity in land quality and takes into account implicit costs of land conversion, but it fails to maintain area of land in balance
  - They offered a straightforward method, named MCET, to simply solve the balancing issues

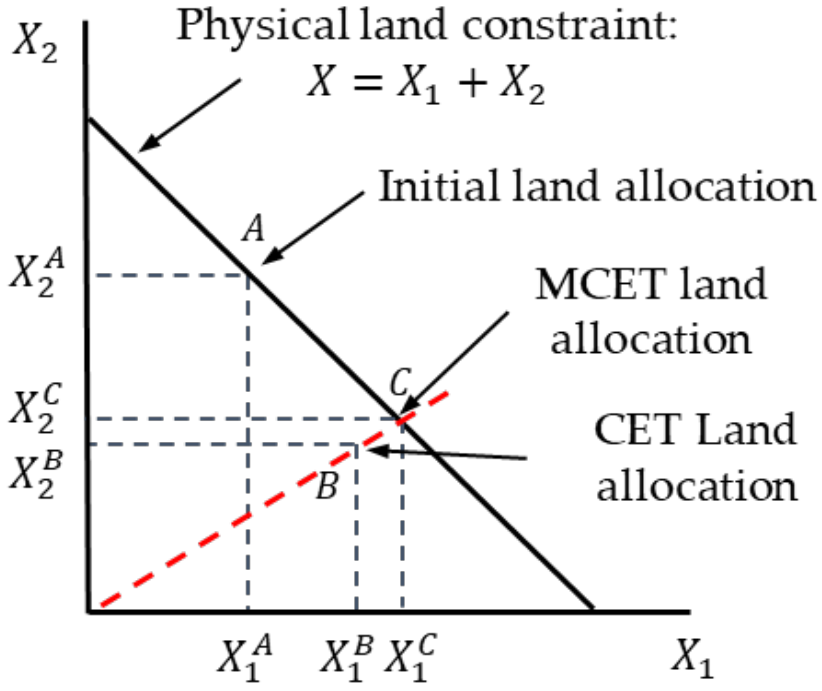
Research method

- To accomplish the goal of this research we implemented the following steps:
  - Adopted the MCET approach proposed by Taheripour et al. (2020)
  - Modified the GTAP-BIO-AVI model that followed CET approach to adopt the MCET approach. It has been used to assess induced land use changes due to aviation biofuels
  - The results of the original and modified models are compared with the original model parameters to highlight their differences
  - An iterative approach is invented to replicate the land use results of the old model with the new model by changing the land transformation elasticities and a set of parameters that govern crop yield
- The results of these steps help us to understand the role and importance of the choice of model parameters and their interactions

Theoretical background: Land allocation in CET and MCET approaches



Land allocation using value added



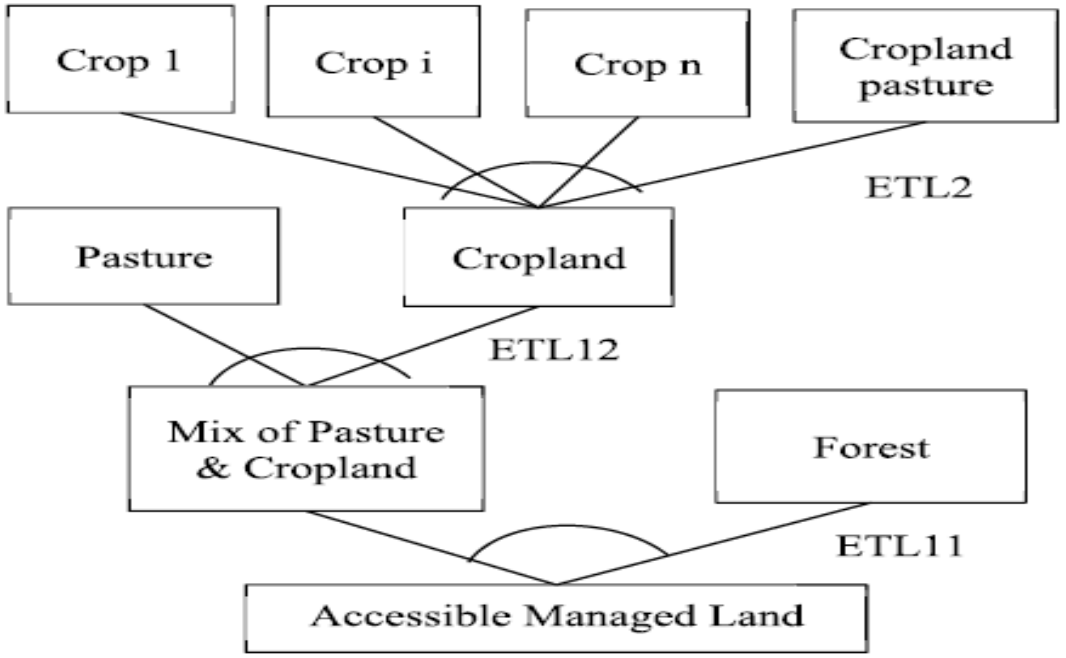
Physical area of land

Changes in land use due to an expansion in demand the crop produced on land type 1

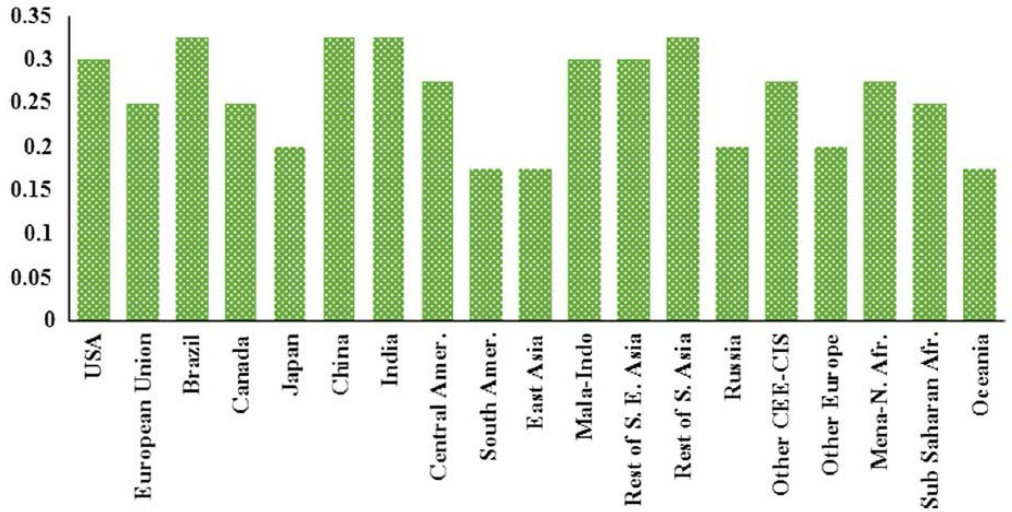
Model Background

- GTAP-BIO-AVI is an advanced version of GTAP BIO that augmented to trace production and consumption of aviation biofuel and their induced land use changes (Zhao et al., 2021).
- GTAP-BIO is an advanced version of GTAP-E. It has been frequently modified and used to assess Induced Land Use Changes (ILUC) due to biofuels and other environmental issues, e.g., Hertel et al. (2010) and Taheripour et al.(2017).
- These models use nested CET functions to allocate land across uses with a set of transformation elasticities tuned to FAO DATA
- These models use a set of regional parameter, YDEL, to govern yield to price response

Nested land supply structure: Taheripour and Tyner (2013)



Tuned YDEL parameters: Taheripour et al. (2017)



Examined experiments

- Using GTAP-BIO-AVI with CET and MCET structures, we examined the global land use implications of an expansion in corn jet fuel produced in the US by 0.85 BGGE under the following set of conditions:

Experiments	Model used	ETLs	YDELs
Experiment I	CET	Original	Original
Experiment II	MCET	Original	Original
Experiment III	MCET	Calibrated	Original
Experiment IV	MCET	Original	Calibrated
Experiment V	MCET	Calibrated	Calibrated

Calibration process

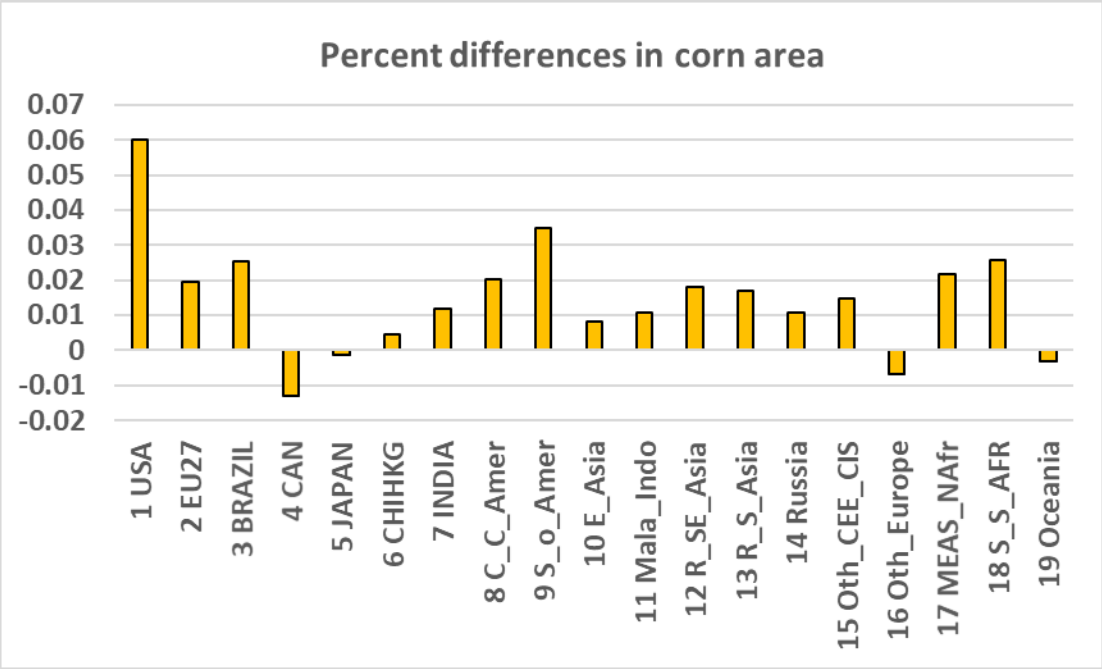
- For experiments III, IV and V we used the flowing calibration process to mimic the land use outcomes of the first experiment:
  - A program is developed to pick and assign various sets of parameters to the targeted parameters (ETLs and YDELs) and run the model for each set
  - In each run the R**oot Mean Square Error** (**RMSE**) for changes in land use and land cover is calculated using the following formula:

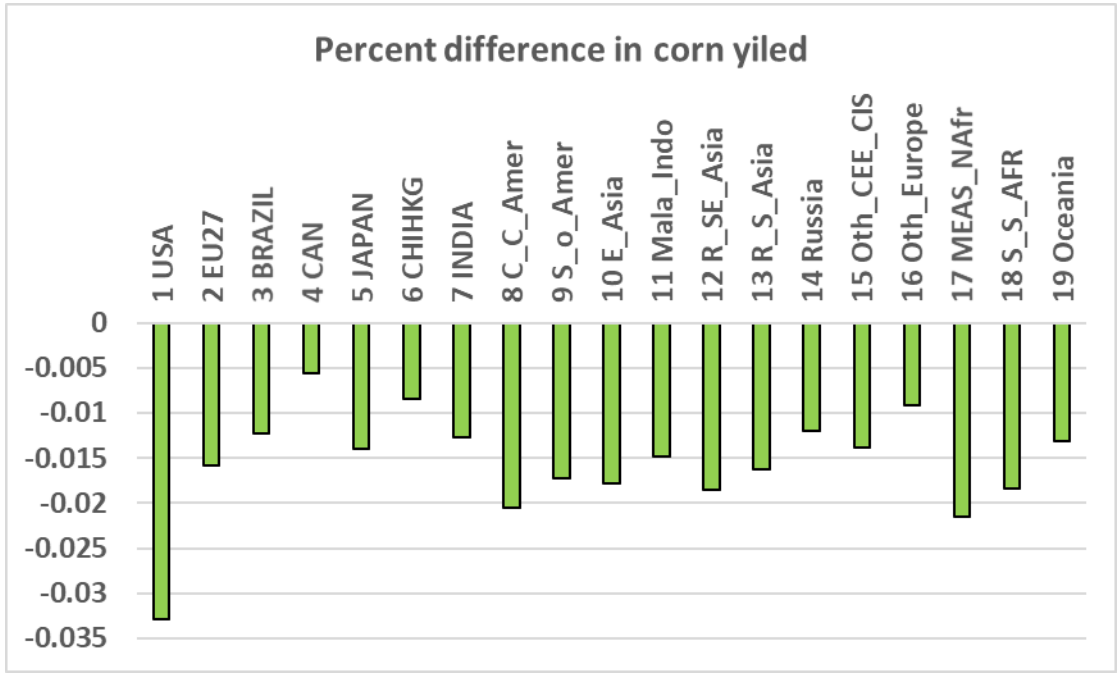
$RMSE_R = \sqrt{\frac{(L_i^R - L_i^{EXPI})^2}{N}}$, where Li is land type i, R show the running experiment and $EXPI$ represent Experiment I

  - A random scaler assigns a new value to each targeted parameter in each run
  - A set of primary runs for about 500 iteration has been examined over ETLs and the best one selected according to value of RMSE and then the following runs have been examined:
    - Experiment III: 100 runs for ETLs
    - Experiment IV: 100 runs for YDELs
    - Experiment V: 100 runs for both ETLs and YDELs
  - For each experiment, the run with the smallest RMSE was picked

Results (1)

- The main difference between the CET and MCET models:
  - MCET: More area, lower productivity
  - CET: Less area, higher productivity

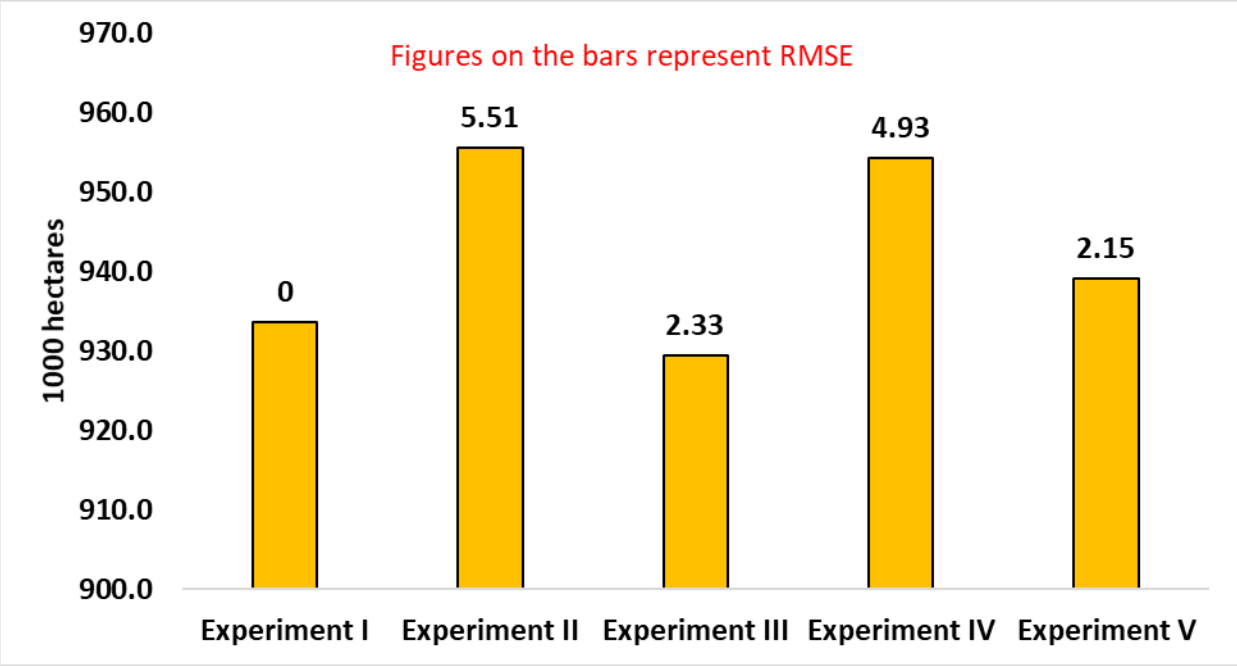




Percent difference show results of MCET over CET

Results (2)

- Changes in corn area of US across experiments:
  - MCET: Projects larger demand for land for feedstock and lower productivity with original parameters
  - Calibration of ETLs alone (Experiment III) could restore the CET results
  - Calibration of YDEL alone (Experiment IV) partially restore the results of CET
  - Calibration of both ETLs and YDEL provide closer results to the CET results (see RMSE values)

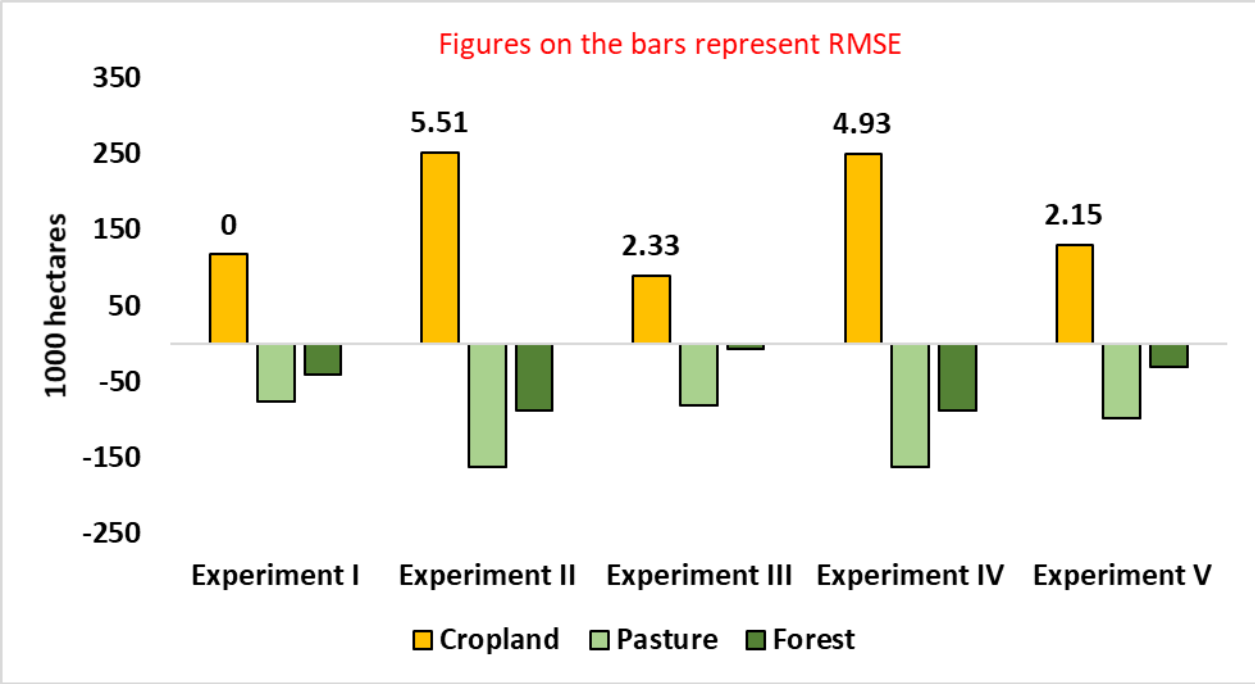


The results of experiments III, IV and V represent interactions between ETLs and YDEL

Change in area of US corn due to corn jet biofuel

Results (3)

- Change in land cover area across experiments:
  - MCET: Projects larger demand for land conversion and more deforestation with the original parameters
  - Calibration of ETLs alone (Experiment III) could fairly restore the CET results
  - Calibration of YDEL alone (Experiment IV) partially restore the results of CET
  - Calibration of both ETLs and YDEL provide closer results to the CET results (see RMSE values)



The results of experiments III, IV and V represent interactions between ETLs and YDEL

This suggest that ETL and YDEL should be recalibrated

Change in total global area of land cover item due to corn jet biofuel

Conclusions

- This research highlight the choice of model parameters
- A given set of parameters could generate different results across different models
- Model structure affect the choice of model parameters
- Recalibration is needed if we move from CET to MCET to get the same results
- A new method of calibration is provided
- The demand and supply side parameters could interact
- Proper calibration is needed for both sides

Thanks

Questions and Comments