Evidence-Based Improvement of GTAP Cropland Allocation Structure

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1. Introduction

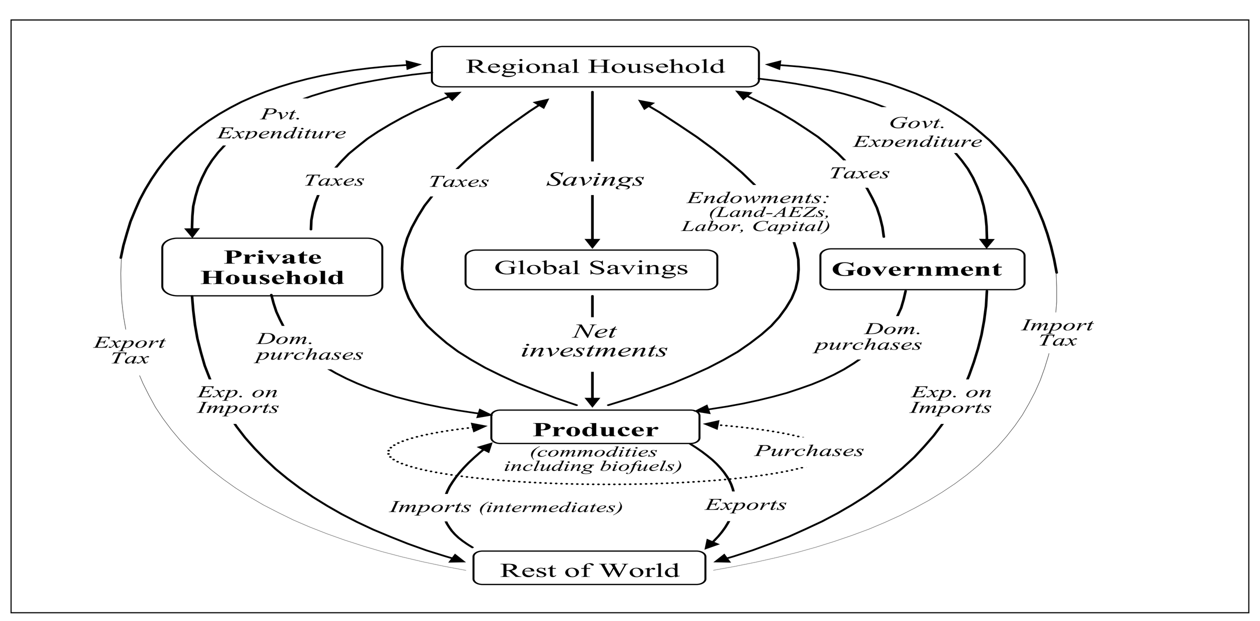
GTAP-BIO is a multi-region computable general equilibrium model which traces production, consumption and trade of a wide range of goods and services at a global scale. GTAP maximizes welfare while maintaining market clearing conditions and resource constraints at a country/regional level. This model has been widely used for quantitative analysis of various policy issues, such as trade, land use and energy.

The land use impacts of producing biofuels from cellulosic materials could be more complicated than corn ethanol. Currently, technologies for producing biofuels from cellulosic materials are not commercially available, so there is no market data on which to base the analysis, and there is little farmer experience in producing the needed feedstocks. For these reasons it is important to provide a comprehensive analytical framework to assess a wide range of alternative possible cases which may come about in the future.

2. Objectives

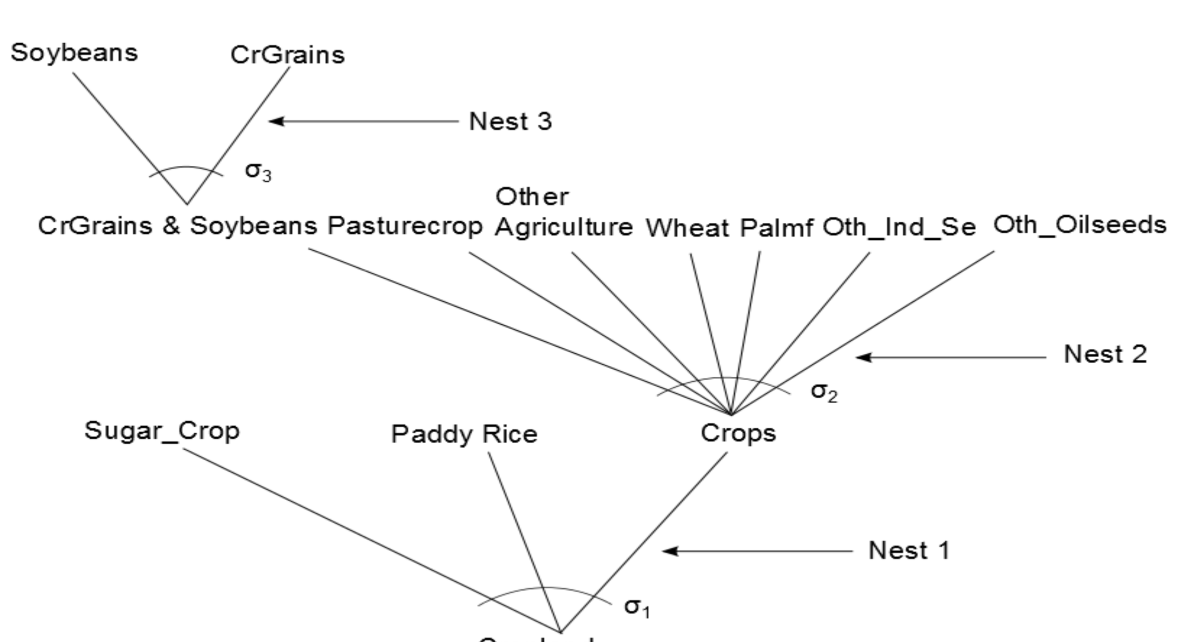
Based on the most recent observations on regional land use changes, this research provides new estimates on cropland allocation structure to access the land use changes in response to evolving policies and economic conditions.

3. An Overview of GTAP Model



4. Methodology

- A three-level CET function is used to allocate the cropland of each region among alternative crops.

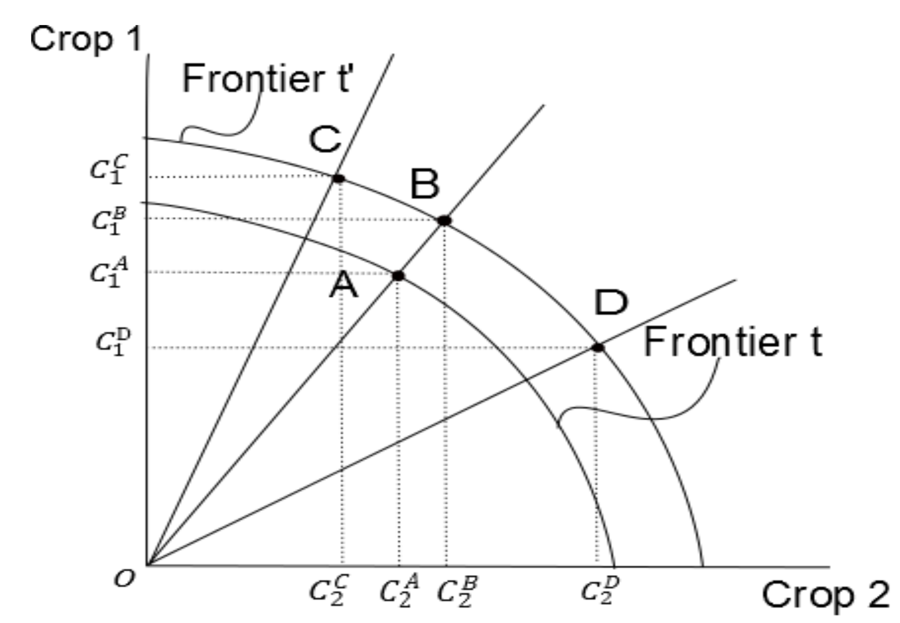


- Nest 1 allocates cropland among crops with limited area shifting over time.
- Nest 2 allocates cropland among crops with higher flexibility for switching.
- Nest 3 represents allocation of cropland between corn and soybeans.
- A tuning process that follows Taheripour and Tyner (2013) is used to obtain the elasticities of transformation (σ) in the new proposed structure.

5. Theoretical Background for Tuning Process

In response to changes in relative crop prices, two separate changes in each nest may occur:

- Movement of land from one nest to another
- Reallocation of land within each nest



- Point A is the initial land allocation between crops 1 and 2.
- Over the time, the cropland frontier shifts from t to t'.
- Three possible outcome:
  - At B: $OC_1^A/OC_2^A = OC_1^B/OC_2^B$, which relates to limited transformation elasticity.
  - At C: $OC_1^A/OC_2^A < OC_1^C/OC_2^C$
  - At D: $OC_1^A/OC_2^A > OC_1^D/OC_2^D$, which relates to more significant land transformation elasticity.

6. Data and Empirical Tuning

Harvested areas of major crops for 19 regions are obtained from FAO. Nest 1 and nest 3 contain few crops. The land transformation pattern is easily tuned according to the empirical observations.

- Examine the distribution of harvested area at nest 1 and 3. If the change in distribution is small given the change in relative prices, the land transformation is limited. Otherwise, the land transformation is at a larger scale.

New Values for Elasticities of Transformation for 19 regions

Region	σ_1^r	σ_2^r	σ_3^r
USA	-0.1	-1.01	-0.1
EU27	-0.1	-0.84	-0.1
BRAZIL	-0.3	-0.63	-0.3
CAN	-0.1	-0.24	-0.3
JAPAN	-0.5	-0.51	-0.1
CHIHKG	-0.1	-0.27	-0.3
INDIA	-0.3	-0.23	-0.3
C_C_Amer	-0.1	-0.34	-0.1
S_o_Amer	-0.1	-0.32	-0.1
E_Asia	-0.1	-0.75	-0.1
Mala_Indo	-0.1	-0.30	-0.1
R_SE_Asia	-0.1	-0.84	-0.1
R_S_Asia	-0.1	-0.32	-0.1
Russia	-0.1	-0.92	-0.3
Oth_CEE_CIS	-0.1	-0.80	-0.5
Oth_Europe	-0.1	-0.28	-0.1
MEAS_NAfr	-0.1	-0.28	-0.1
S_S_AFR	-0.1	-0.62	-0.1
Oceania	-0.1	-0.27	-0.1

6. Empirical Tuning cont.

The values of land transformation elasticities at nest 1 and nest 3 in combination with regional land transformation elasticities developed by Taheripour and Tyner (2013) for one level cropland frontier to determine the regional transformation elasticities for nest 2.

$$\sigma^r = \sum_{1}^{3} \alpha_i^r . \sigma_i^r$$

σ^r represents an aggregate measure of land transformation elasticity for cropland frontier of region *r*

σ^i represents the land transformation elasticity for nest *i* in region *r*

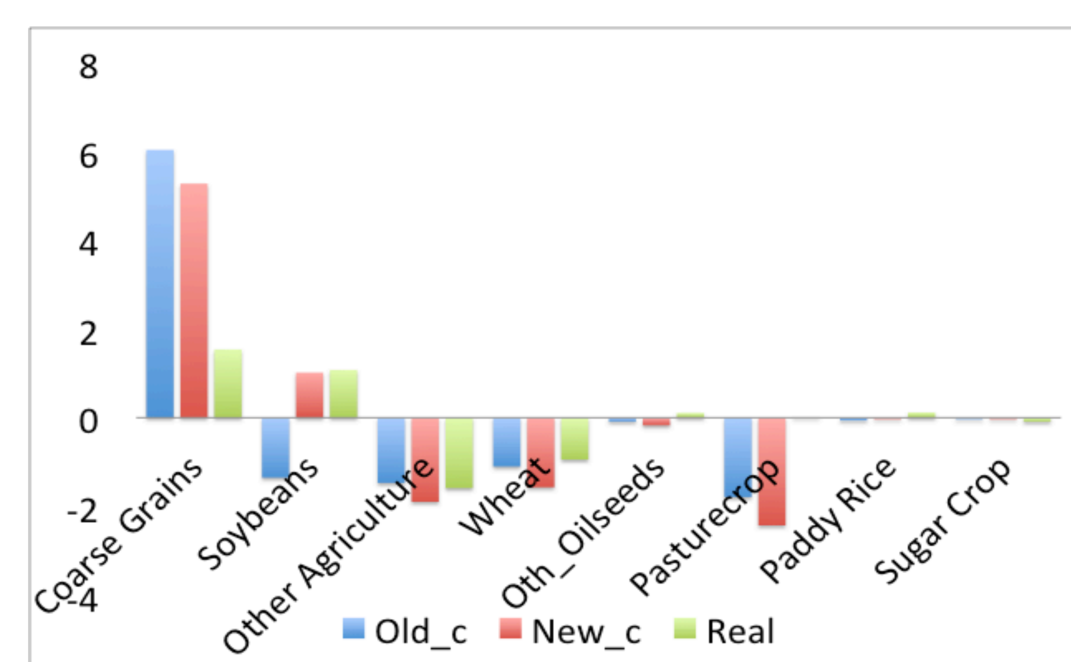
α^i shows the revenue share of nest *i* in total land revenue in region *r*.

7. Simulation Scenarios

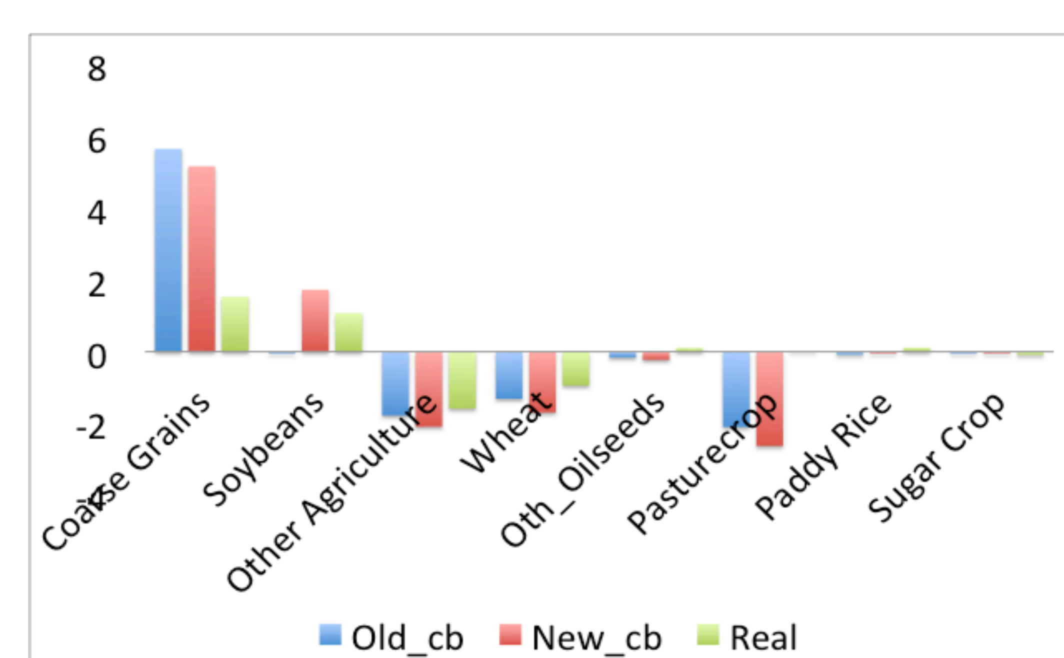
- An increase in corn ethanol production from its 2004 level (3.41 BG) to 15 BG, off of the 2004 database, the simulation results are denoted using subscript "c".
- An increase in corn ethanol production from 2004 level to 15 BG and in biodiesel from 2004 level to 1 BG, the simulation results are denoted using subscript "cb"

8. Results

US Cropland Changes in Model Results (corn ethanol) and Real Observation, unit: MH



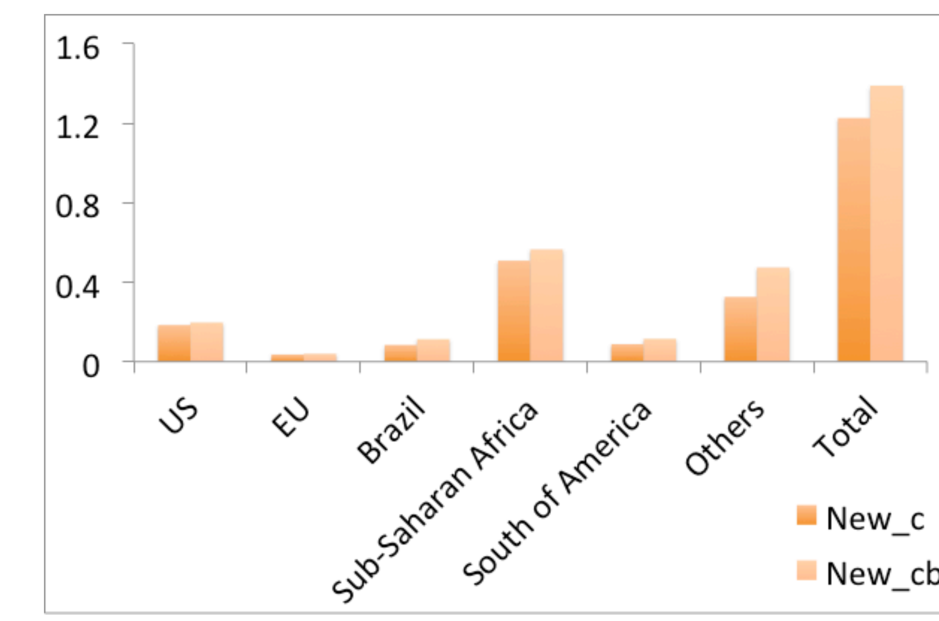
US Cropland Changes in Model Results (corn ethanol and biodiesel) and Real Observation, unit: MH



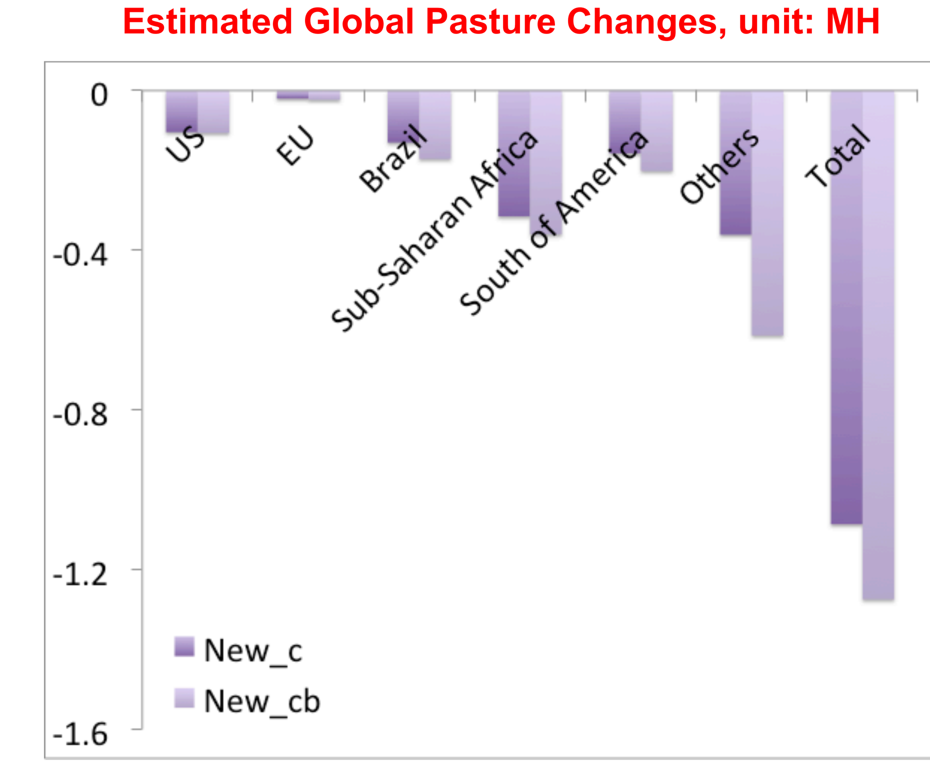
8. Results-cont.

Estimated Global Forest Changes, unit: MH

Estimated Global Cropland Changes, unit: MH



Estimated Global Pasture Changes, unit: MH



9. References

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