Oil Price Shocks and the U.S. Bioenergy Market: Assessing Demand and Land Use Impacts

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Introduction

- One rationale for expanding bioenergy production is improved energy security, e.g., reduced dependence on imported fossil fuels with greater domestic share of energy production
- Higher oil prices tend to make biofuels more competitive, but also increase the costs of production given the use of energy in production and transportation of bioenergy feedstocks
- Different feedstocks vary in their dependence on fossil fuels and will be differentially impacted by an increase in those prices
- Changing petroleum prices expected to alter the mix between transportation biofuels and bioelectricity
- In this study, we examine the effects of oil price shocks on demand for different types of bioenergy and implications for land use and net GHG emissions

Approach

- Apply recently updated FASOMGHG model to explore the implications of alternative global oil price scenarios for bioenergy use, land use, trade, and net GHG emissions.
- FASOMGHG is a forward-looking dynamic model of the forest and agriculture sectors that simulates the allocation of land over time to competing activities in both the forest and agricultural sectors and the associated impacts on commodity markets.
- Model also simulates environmental impacts resulting from changing land allocation and production practices, including detailed accounting for changes in net GHG emissions.
- To further explore international trade impacts and interactions between sectors, we are also applying the Applied Dynamic Analysis of the Global Economy (ADAGE) dynamic CGE model.

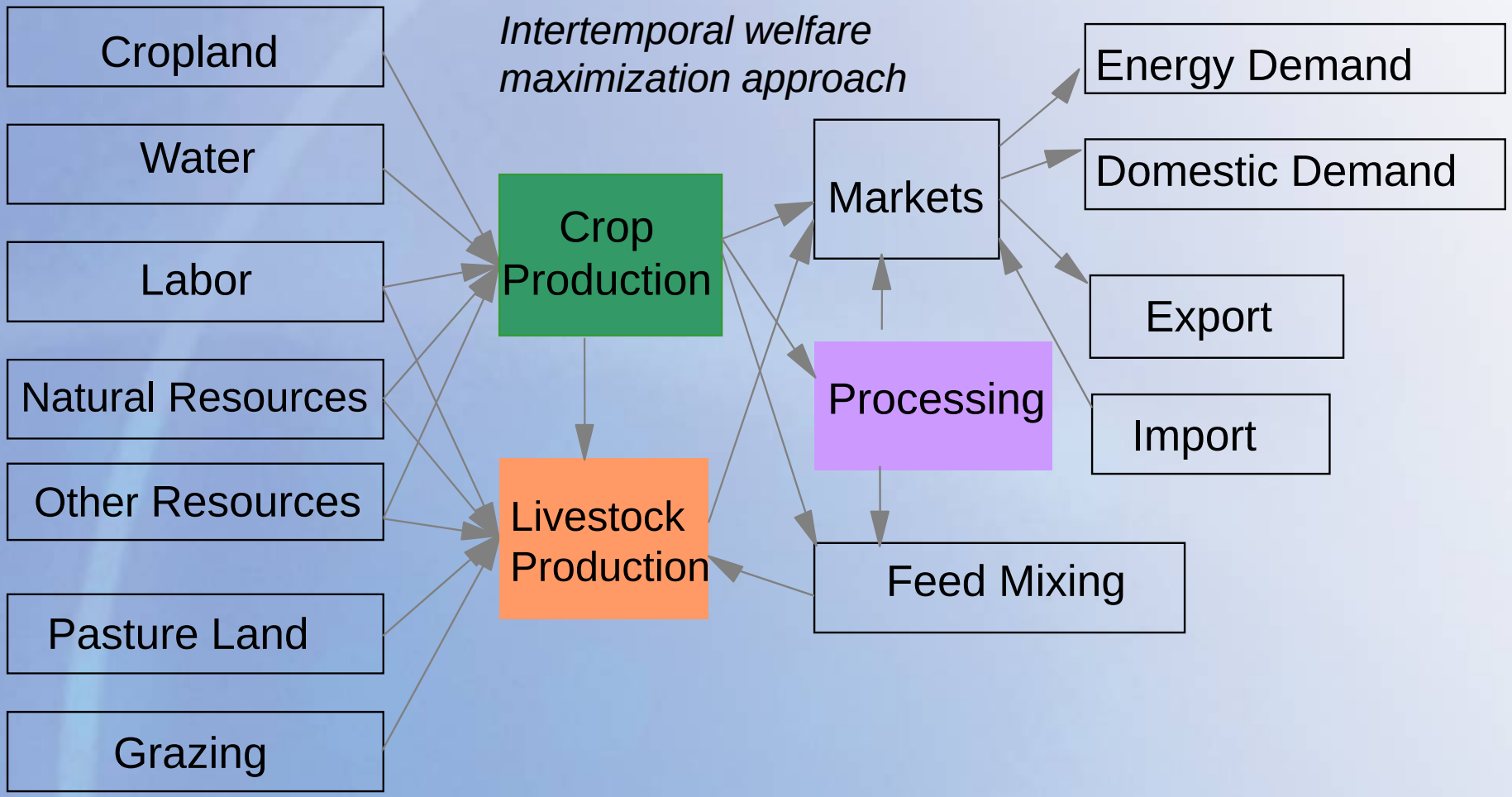
Impacts on Net Farm Income

- Higher production costs due to higher prices for fossil fuels, fertilizer, and other energy-intensive inputs
- Additional income opportunities with increased demands for agricultural biofuel and bioelectricity feedstocks
- Higher agricultural output prices as farm-gate commodity prices will likely rise in response to increased energy and energy intensive input costs, increased competition for land, and shifts in management towards reductions in energy-intensive production
- Previous study (Baker et al., 2010) found increase in net farm income under carbon policy, with larger increases at larger carbon prices

FASOM Model Structure

- Objective: Welfare Maximization
  - Land is allocated between activities (and combined with other inputs) based on relative rents (including GHG payments) and suitability to maximize intertemporal welfare
- Both Forestry and Agriculture, 10 Land Types
  - Forest – approximately 80 products from private timberland
  - Agriculture – crops and pasture
    - Over 70 primary and about 60 processed commodities, 20 processed feeds
  - Developed – Tracks conversion of forest, crop, and pastureland for development
- 3 GHGs — CO_2, N_2O, CH_4
  - Stocks and flows of GHGs for more than 50 sources and sinks
- 63 US regions (11 market regions) and international trade with 37 major trading partners
- Detailed Bioenergy Market
  - Forestry & agricultural dedicated and residue feedstocks
  - Tracks production of starch- and sugar-based ethanol, cellulosic ethanol, biodiesel, and bioelectricity

FASOM Agricultural Sector



FASOM Regions

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Model Scenarios

- Simulated a series of alternative price shocks for energy-intensive inputs between 10%-50%
- Cases with and without increases in biofuels along with the increases in fossil fuels
- Required RFS2 volumes as lower bound on biofuels production

Preliminary Findings

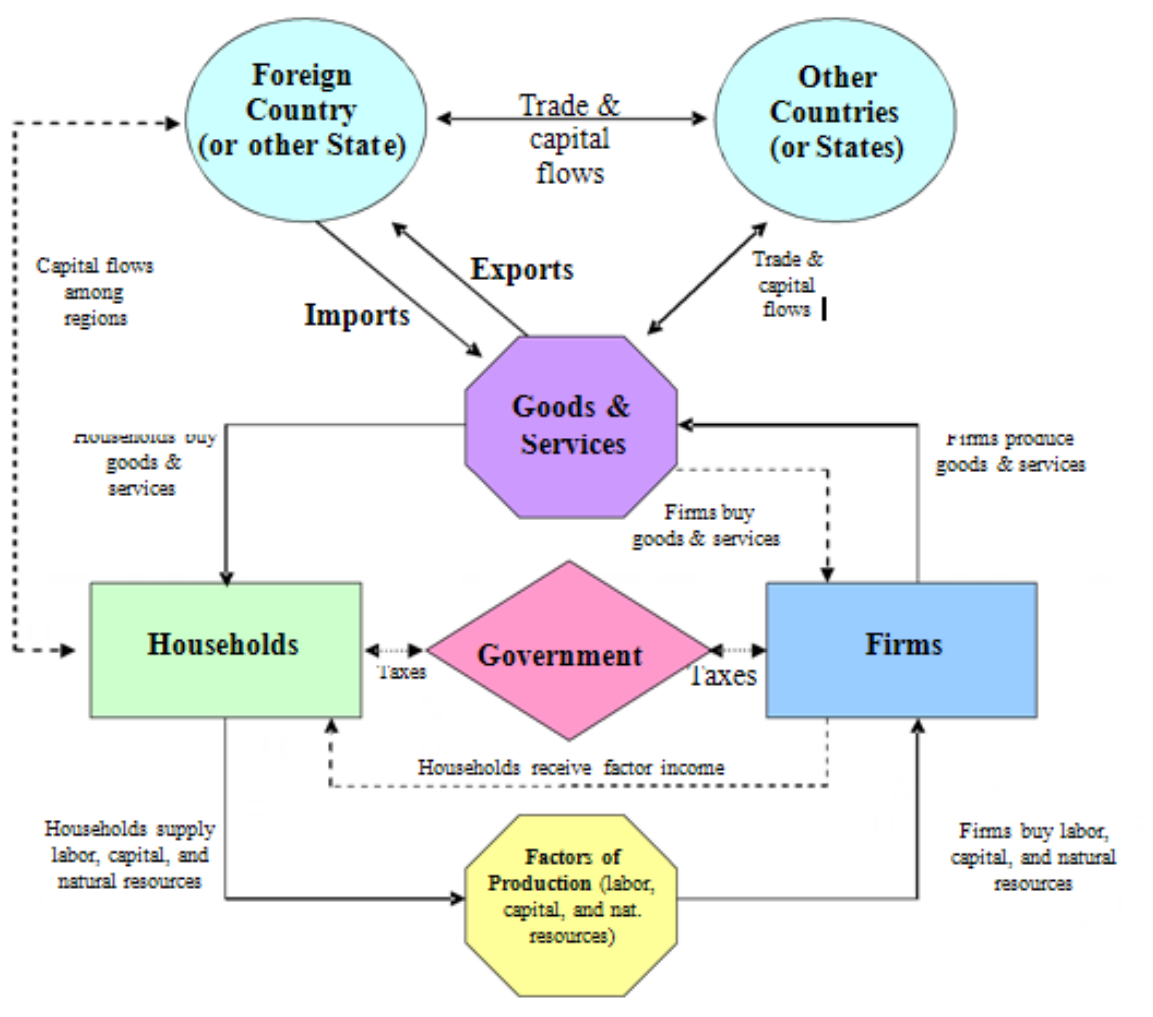
- Higher energy prices reduced share of crop ethanol produced using corn, bringing in more sorghum, barley, rice, and wheat
- Also, tends to reduce share of crop ethanol as there is a shift towards more cellulosic ethanol production (generally less energy-intensive feedstock production)
- Dampens bioelectricity response to carbon price as liquid biofuels become relatively more attractive with higher petroleum prices
- Reductions in net GHG with higher fossil fuel prices as agricultural producers adjust production practices and produce bioenergy using less fossil fuels

ADAGE Analysis

- In this study, we are also employing a recursive dynamic version of the ADAGE CGE model to enable comprehensive analyses of the key sectoral, economy-wide, and international implications of biofuels. The GTAP data base and baseline construction are key requirements of the model.
- First we explicitly incorporate detailed agriculture and biofuels sectors into the GTAP v7.1 data base, pertaining to the global economy in 2004.
- We update the entire data base for the base year 2010, based on secondary data sources (IEA, EIA, FAO, etc).
- We develop baseline projections on macro-economic variables, energy, biofuels, and technological change in agriculture for the 2010-2050 period.
- We augment the production and consumption structures to include interactions of various crops, byproducts, livestock, forestry, land use and land cover change, and biofuels.
- The model is set up to run biofuel policy scenarios under alternative approaches (biofuels as perfect & imperfect substitutes for petroleum).

Structure of the ADAGE Model

- *Applied Dynamic Analysis of the Global Economy*



Source: Ross (2008)

Key Features of ADAGE-Biofuels Model

- We adapted the existing ADAGE model (dynamic, forward looking, intertemporally optimizing CGE model focused on the energy sector) to add more detail on agriculture, bioenergy, and land use.
- Well developed energy and GHG modules with a focus on climate policy analyses (e.g., the electricity sector is differentiated by source; the transportation sector is modeled as explicit purchased and personal vehicle transportation).
- GHG accounting and abatement costs for 6 types of GHGs.
- Adding detailed biofuels, agriculture and land use sectors enables examination of interactions with these sectors and greater insights on sector and fuel specific implications.
  - Interactions between biofuels, bioelectricity, and other energy, transportation, and climate policy

Dynamics of ADAGE-Biofuels Model

- The dynamics in the ADAGE-Biofuels model are derived from:
  - Changes in the available effective labor supply from population growth and changes in labor productivity,
  - Capital accumulation through savings and investment,
  - Changes in stocks of natural resources,
  - Baseline production of biofuels under policy mandates, and
  - Technological change in the energy intensive, agriculture, and livestock sectors.

Developing the Biofuels Data Base

- We used the most recent GTAP database available (version 7.1) as the starting point for model development. This data base comprised 57 sectors and 112 regions, corresponding to the global economy in 2004.
- Broke biofuel feedstocks, biofuels, and byproducts out from existing sectors.
  - Feedstock crops: Corn, Soybean, Rapeseed/Canola, Palm oil, Sugarbeet, Sugarcane
  - Biofuels: ethanol (grain, sugar, cellulosic), biodiesel (soy, rapeseed, palm)
  - By-products: DDGS, vegetable oil meal
- Based on secondary data on production, market price, factor-wise costs of production (domestic and imported), utilization, international trade (bilateral exports and imports), and subsidies and tariffs on the new biofuels related sectors, from external sources such as FAO, UNcomtrade, IEA, EIA, etc.
- Cellulosic: Cellulosic biofuels (from corn stover, switchgrass, miscanthus) are directly incorporated into the model as production possibilities.

Preliminary Findings with Oil Shock

- Reductions in total transportation fuel usage with rising prices, but relatively large share of fossil fuels substituted with biofuels
- Increasing cropland area in all regions modeled with reductions in pasture and forest in all regions (except increase in forest in the ROW region)
- Increases in prices of biofuels and agricultural crops, generally in the range of 1%-10% depending on the scenario and size of the oil price shock

Future Research

- Further analysis of oil price and other energy shocks for level and mix of bioenergy production as well as net GHG impacts, looking at wider range of shocks and more combinations of impacted inputs to refine our results
- Application of expanded versions of both models vs. more aggregated versions for exploration
- Simultaneous modeling of climate impacts and energy market impacts on bioenergy potential and costs

More Information

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