Modelling the Consequences of Increasing Bioenergy Demand on Land and Feed Use

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Aim and method

- Taheripour et al. 2010, Birur et al. 2008, and Hertel et al. 2008 have introduced biofuels and their byproducts into the GTAP model.
- Aim of the paper:
  - Evaluation of the EU-RED
    - Impact on the EU supply chain of biofuel crops (grains and oilseeds) production and processing for food, feed and fuel purposes.
    - Effects of covering by-products on land use
- Method:
  - Simulation experiments based on an extended version of the Global Trade Analysis Project (GTAP) model:
    - Production of biofuels and its by-products
    - Substitution between different feed components including biofuel by-products.
The model

- **GTAP**: applied general equilibrium model based on neo-classical microeconomic theory
  - multi-regional
  - multi-sector
  - static

- **LEITAP extension of GTAP**:
  - land market modeling
  - capital - energy sources (including biofuels) substitution
  - biofuels and biofuels (feed) by-products production
  - feed components - feed by-products substitution
The model: Technology tree – Petrol industry

(Bio-)Petrol industry

- BDBP
- (Bio-)Petrol
- DDGS

Labour/Capital/Energy

- Labour
- Capital/Energy

Other inputs

Energy

- Non-Electric
- Electric

Non-coal fuels

- Coal

Gas

- Fuel

Oil seeds

- Fossil oil
- Ethanol

- Woody crops
- Sugar
- Grains
The model: Animal feed - nested structure

Feed

Grassland (roughage)  Concentrated feed and its raw components

High energy feed  High protein feed  Other raw components of concentrated feed

Wheat  Other grains  DDGS  BDBP  Oil seeds  Other compound feed
The database (1/2)

- Version 6 of the GTAP database - worldwide data for 2001
  - bilateral trade, transport and protection data characterizing economic linkages among regions
  - individual country input-output databases which account for intersectoral linkages
  - aggregation 36 regions (EU countries and most important countries and regions outside EU) and 25 sectors (16 agri-food sectors; 5 energy sectors)
The database (2/2)

- Data base adjustments to model the biofuels and biofuel policy:
  - Modification of intermediate input of grain, sugar and oilseeds in the petroleum industry to reproduce 2004 biofuels shares in the petroleum sector.
  - Implementation of biofuel by-products (Dried Distillers’ Grains with Solubles – DDGS and oilseeds meals – BDBP).
    - Constant conversion ratio between grains and oilseeds quantities used to produce biofuels and resulting by-products production
    - Implementation of intermediate inputs of by-products in the feed production for the livestock sectors.
The simulation scenarios

- Two model version:
  - with and without by-products in bioenergy sector

- Two scenarios:
  - Reference (Ref) scenario without EU RED
  - EU-RED with a 10% blending share for transportation fuel by 2010

- Common scenario assumptions:
  - Macro-economic assumptions (technical progress, population growth, labor and capita availability, associated GDP growth)
  - Update of policy changes
General simulation results

- Biofuels Directive stimulates the demand for biofuel crops and sugar in the EU biofuel industry.
- Demand for other agri-food products remains similar to the level observed in the Reference scenario because:
  - small price effects of RED – apart from the directly affected crops
  - relative small cross-effects of the RED on other agri-food products due to the low income and price elasticities for agri-food products
- RED results in a 0.23 percentage points lower GDP growth in EU countries in 2007-20 compared with the Reference scenario,
  - equivalent to almost 24 billion EUR in 2001 prices.
- Inflationary effect induced by extra demand for biofuel crops is mitigated by the production increase encouraged by higher biofuel crops prices.
Land use and output prices in EU in 2007 – 2020, BFD less Reference (%)

...an upward pressure on land prices (19% EU and 4% world) agri-food prices (3.1% EU and 0.8% world) and harvested area (2.2% EU and 0.8% world), but biofuel crops area in EU 27% up whereas pasture 4% down.
… high domestic prices and declining exports for biofuel crops (50% in BFR compared with Ref) of biofuel crops in the BFD scenario have a negative impact on agri-food exports

… other crops and sugar exports are significantly lower (by 13% and 15% respectively) in the BFD scenario compared with the Ref scenario.
EU agri-food import growth by destination: 2007-2020, BFD less Reference (%)

...BFD boosts agri-food imports compared with Ref (biofuel crops 2 times, agri 12% and food 4%);
...additional biofuel crops and sugar imports are mainly used as an intermediate input in the petrol sector.
EU agri-food exports and import value (mil 2001 USD) per group of counties in 2020, BFD less Reference, in mill. $

...high Income countries and Central and South America contribute most to additional EU biofuel crops imports (about 90% in 2020) while African countries contribute almost 45% of the total sugar imports.

...EU trade balance in agri-food products deceases by 22 billion USD as the result of the BFD.
Growth of agricultural production, %, 2007-2020
Change in agricultural land price, 2007-2020, with both types of models, BioF minus Ref, in percent.
Impact of by-products in global land use expansion (1)

- Without by-products:
  - 2.0 % biofuel share
  - 41.04 million ha
- With by-products:
  - 3.1% biofuel share
  - 40.16 million ha
  - By-products compensate for 0.9 million ha
    - 0.7 million ha in low income countries
    - 0.2 million ha in Brazil
Impact of by-products in global land use expansion (2)

- If biofuel shares in transportation are the same in model BP and noBP
- By-products availability reduce global land use for agriculture by 2.9% or 22.5 million ha
… grains and oilseeds (the biofuel crops) are replaced by compound feed and especially by feed byproducts (share of the compound feed increases from 69% in the Ref to 75% in the BFD) in 2020 … byproducts share increases from 1.5% to 9.5% and biofuel crops share decreases from almost 14% to 7%.
Summary of Renewable Energy Directive impact

- **Direct effect:**
  - demand stimulation for biofuel crops and sugar
  - biofuel crops harvested area production and imports increase and the EU agri-food exports and trade balance deteriorate
  - inflation of EU prices of these commodities by 25% and 19% respectively but in total agri-food prices increase only by 3.1% for the EU and 0.8% at world level
  - use of biofuel crops in the EU petrol sector increases by almost 10 times

- **Indirect effects:**
  - land use changes from pasture to crops
  - significant increase of biofuel production byproducts and therefore...
  - substitution of biofuel crops in animal feed by biofuel byproducts
  - consequently small impact on meat production