Farm Foundation and ERS Workshop

Global Biofuel Developments: Modeling the Effects on Agriculture

CARD Ethanol Model: An Approach to Modeling Ethanol Markets and Scenario Analyses

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CARD

Outline

- Description of the CARD Ethanol Model
  - U.S. ethanol model
  - Brazilian ethanol model
  - China, EU-25, India models
  - Japan, South Korea and the Rest of the World
- Summary Results of Some Scenario Analyses
  - Removal of trade and domestic distortions in the U.S.
  - Price shocks (crude oil price, corn price, sugar price)
  - Long-run equilibrium analysis

Outline of CARD Ethanol Model

- Non-spatial multi-market model
- Behavioral equations for production, consumption, ending stocks and net trade
- Solves for a representative world ethanol price
- Domestic ethanol prices linked to world price through price transmission equations
- Incorporates linkages between agricultural commodity markets and energy markets

U.S. Ethanol

- Energy Policy Act of 2005
- Federal Tax Credit
- Trade Policy
  - Import tariff and duty
  - CBI agreement
- Ethanol, Corn and Crude Oil Link
- Expanding Production Capacity

U.S. Ethanol Model

- Fuel Ethanol demand
  - A derived demand from the cost function for refiners blending gasoline with additives including ethanol
  - $C = C(P_{Ethanol}, P_{CrudeOil}, Policy, Q_{GasolineSupply})$
  - $C = \tilde{C}(P_{Ethanol}, P_{CrudeOil}, Policy) * Q_{GasolineSupply}$
  - $Demand\ for\ fuel\ ethanol = \partial C / \partial P_{Ethanol}$
  - $E_{Fuel} = \frac{\partial C}{\partial P_{Ethanol}} = Q_{GasolineSupply} * \left(\frac{\partial \tilde{C}}{\partial P_{Ethanol}} \right)$

U.S. Ethanol Model

- Fuel Ethanol Demand
  - $\frac{\partial \tilde{C}}{\partial P_{Ethanol}} = f(P_{Ethanol} - Taxrebate, P_{CrudeOil}, Mandate, RFS)$
  - $Q_{GasolineConsumption} = g(P_{Gasoline}, P_{Ethanol}, Taxrebate, GDP, Population)$
  - In equilibrium $Q_{GasolineSupply} = Q_{GasolineConsumption}$
  - $E_{F*} = \frac{\partial C}{\partial P_{Ethanol}} = f(P_{Ethanol} - Taxrebate, P_{Gasoline}, Mandate, RFS)$
    $*g(P_{Gasoline}, P_{Ethanol} - Taxrebate, GDP, Population)$

U.S. Ethanol Model

- Fuel Ethanol Demand
  - At the equilibrium of the gasoline market, $\partial \tilde{C} / \partial P_{Ethanol}$

    can be interpreted as the share of fuel ethanol in total gasoline

    consumption $E_{F*} / Q_{GasolineConsumption}$

- Total Ethanol Demand = Fuel Ethanol Demand + Residual Ethanol Demand

U.S. Ethanol Model

- Fuel Ethanol Production
- *Production = h (Net Revenue, (Production Capacity))*
- $$Net\ Revenue = \pi^{NET} = \gamma_E \cdot P_{Ethanol} + (s_{WM} \cdot ((\gamma_{GF} \cdot P_{GF}) + (\gamma_{GM} \cdot P_{GM}) + (\gamma_{CO} \cdot P_{CO}))) + (s_{DM} \cdot (\gamma_{DDG} \cdot P_{DDG})) - P_{Corn} - m \cdot P_{NaturalGas}$$
- $(Production\ Capacity)_t = (Production\ Capacity)_{t-1} * (1 + Growth\ Rate\ of\ Capacity)$
- $$Growth\ Rate\ of\ Capacity = g_t = \begin{cases} k(\pi_{t-1}^{NET}, E(D_E)) & if \quad \pi_{t-1}^{NET} > 35¢\ per\ bushel \\ 0 & Otherwise \end{cases}$$

U.S. Ethanol Model

- Trade Equations
- Trade Policy Parameters:
  - *In quota tariff rate $t^i = 0$*
  - *Out-of-quota tariff rate t^o = 2.5% plus 54 cents per gallon*
  - *Tariff rate quota (CBI) = 60 million gallons or 7% of consumption, whichever is greater*
  - *Transportation cost = tc = 11 cents per gallon*

  - *US Imports = Imports from CBI + Imports from Other*

U.S. Ethanol Model

- Trade Equations for CBI

$$M_{CBI} = \begin{cases} Capacity & if \quad P_E^{US} > \theta \cdot (P_E^W \cdot (1+\tau^A) + tc) \\ \alpha + \beta \cdot \left(\dfrac{P_E^{US}}{P_E^W \cdot (1+\tau^A) + tc} \right) & if \quad P_E^{US} > \phi \cdot (P_E^W \cdot (1+\tau^A) + tc) \\ M_{CBI} = 0 & Otherwise \end{cases}$$

- $t^A = t^i \; if \; M_{CBI} \leq TRQ$
- $t^A = t^o \; if \; M_{CBI} > TRQ$

U.S. Ethanol Model

- Trade Equations for Other Imports

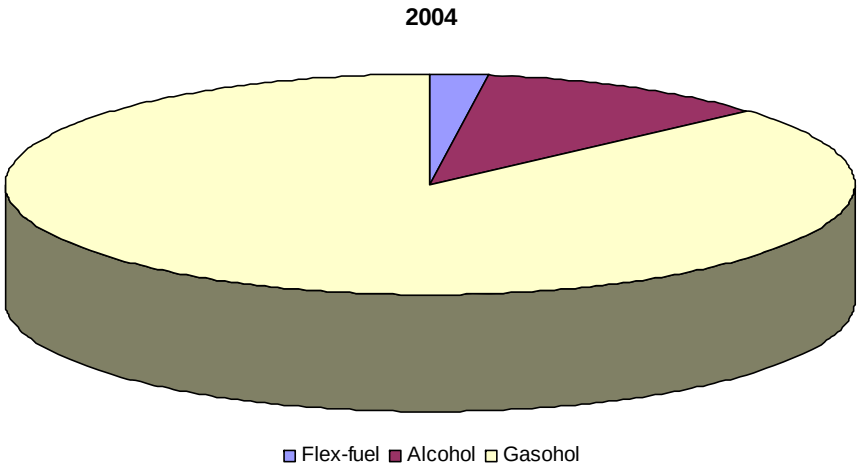
$$M_{Other} = \begin{cases} 0 & if \quad P_E^{US} < \phi \cdot (P_E^W \cdot (1+\tau^o) + tc) \\ (Demand - Supply) & Otherwise \end{cases}$$

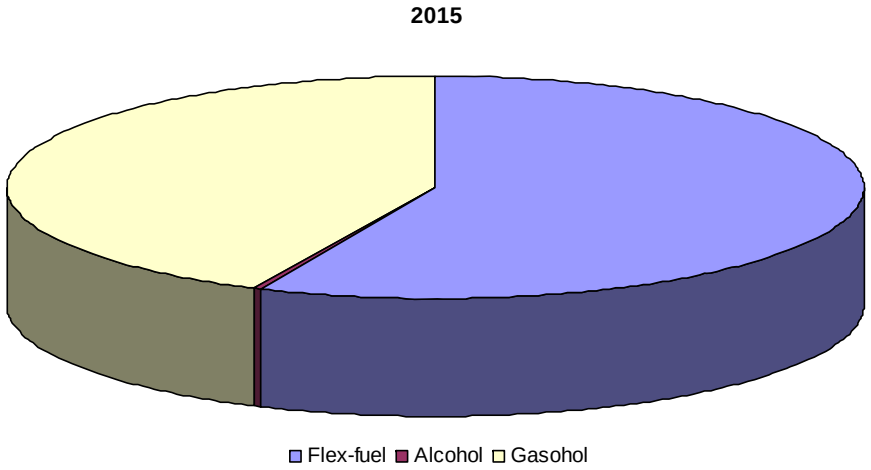
- Price-switching mechanism
  - When tariff is prohibitive, the domestic price is solved endogenously
  - When the tariff is not prohibitive, the domestic price is determined through a price transmission equation

Brazilian Ethanol

- Mandate on Ethanol Mix with Gasoline
- Lower Excise Tax on Ethanol Use
- Ad valorem Duty
- Tax Incentives on Ethanol and Flex-fuel Vehicles
- Sugar and Ethanol Link

Share of Brazilian Vehicle Fleet





Brazil Ethanol Model

- Fuel Ethanol Demand
  - Anhydrous and hydrous demand
  - $C^{Anhydrous} = f(P_{Ethanol}, P_{Gasoline}, InteractionTerm, GDP, Population, Blend)$
  - $C^{Hydrous} = g(P_{Ethanol}, P_{Gasoline}, InteractionTerm, GDP, Population, FlexfuelCars)$
  - $InteractionTerm = FlexfuelCarsRatio * P_{Gasoline}$

Brazil Ethanol Model

- Ethanol Production
  - From cane producers profit maximization in the Brazilian sugar model
  - $AHA_t = h(AHA_{t-1}^{Cane}, P_{Sugar}, P_{Ethanol}, P_{AlternativeCrop})$
  - $SugarcaneProduction = AHA_t^{Cane} * Yield_t$
  - *Share of Sugarcane in Ethanol Production = j (Relative price of Ethanol to Sugar)*

Brazil Ethanol Model

- Ethanol Production
  - *Sugarcane in ethanol production = Share of sugarcane in ethanol production *Total sugarcane production*
  - *Ethanol production = Sugarcane used in ethanol production* Conversion rate*
- Stocks
  - *Ethanol Ending Stocks = k ($P_{Ethanol}$, Beginning stocks)*
- Net Trade
  - *Net Exports = Production + Beginning Stocks – Consumption – Ending Stocks*

Other Country Models

- EU-25, China, India
  - Ethanol Consumption or Disappearance
  - Ethanol Production
  - Change in Stocks (EU-25)
- Japan, South Korea and Rest of World
  - Net Trade Equations
- ROW closes the model.

Scenario Analyses

- Removal of U.S. Import Tariff
- Removal of U.S. Volumetric Ethanol Excise Tax Credit (VEETC)
  - ***Removal of U.S. Ethanol Domestic and Trade Distortions: Impact on U.S. and Brazilian Ethanol Markets***
- Price Shocks (World crude oil, U.S. corn, world sugar)
  - ***An Analysis of the Link between Ethanol, Energy, and Crop Markets***
- Long-run Equilibrium Analysis
  - ***The Long-Run Impact of Corn-Based Ethanol on the Grain, Oilseed, and Livestock Sectors: A Preliminary Assessment***

http://www.card.iastate.edu/publications

Extensions to the Model

- Fuel Ethanol demand
  - Fuel ethanol demand in the U.S. model to be split into three components
    - Additive Market
    - E-10 Market
    - E-85 Market
- Links to the U.S. and International Livestock and Dairy Sectors
- Biodiesel

THANK YOU