Impacts of biofuel promotion policy in India: An assessment using a dynamic CGE model

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Outline of the presentation

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Research objectives

This research aims to assess economic and social impacts of 20% biofuels blending mandate by 2017, using forward-looking dynamic CGE model that can model transitional dynamics of the economy. We start from a simple version of the model, then later incorporate important issues gradually. The current simple version can address:

- **Welfare impacts:** Equivalent variation (EV) represents overall welfare impacts.
- **Nationwide economic impacts:** Changes in GDP as well as sectoral outputs
- **Food-fuel competition over land:** land factor based on AEZ is modelled.
- **Social impacts:** Changes in commodity prices and wage rates will imply impacts on the poor.

The following important issues are left for the later stage of the research.

- **Environmental impacts:** GHG emissions, water use and air and water pollution are not assessed.
- **Impacts through international linkages:** we start from single country model for India with only one Rest of the World region as the trade partner.
- **Poverty impacts:** income distribution and unemployment issues are not assessed.

Biofuels expectations in India

Expectations for BF: Addressing two pressing problems in India

- Meeting rapidly increasing energy demand (annual growth rate of 4.8% for the next decades). Crude oil imports may cost 10% of national GDP.

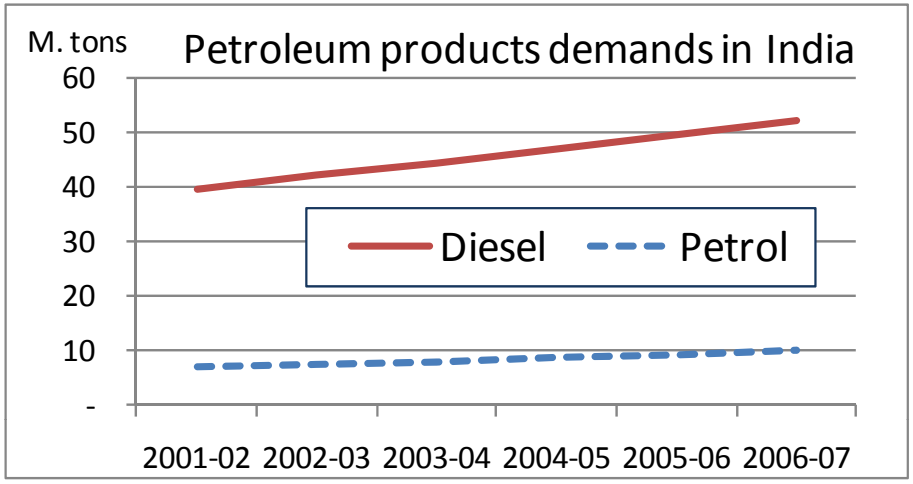
  ➡ Both ethanol and biodiesel would address this issue.

- Stimulating rural development for poverty alleviation.

  ➡ Non-food based biodiesel would address this issue.

In India, diesel consumption is 5 times larger than petrol.

➡ Higher expectation for biodiesel.



Source : Indian Petroleum & Natural Gas Statistics, 2000-01

Biofuels promotion nationwide policies in India

National Biodiesel Mission (Planning Commission of GOI, 2003)

- To meet 20% of diesel demands by biodiesel from non-edible oil seeds on marginal land (focusing Jatropha curcas), by 2011-2012.
- Also, to meet 5% of petrol demands by bio-ethanol, by 2011-2012 .

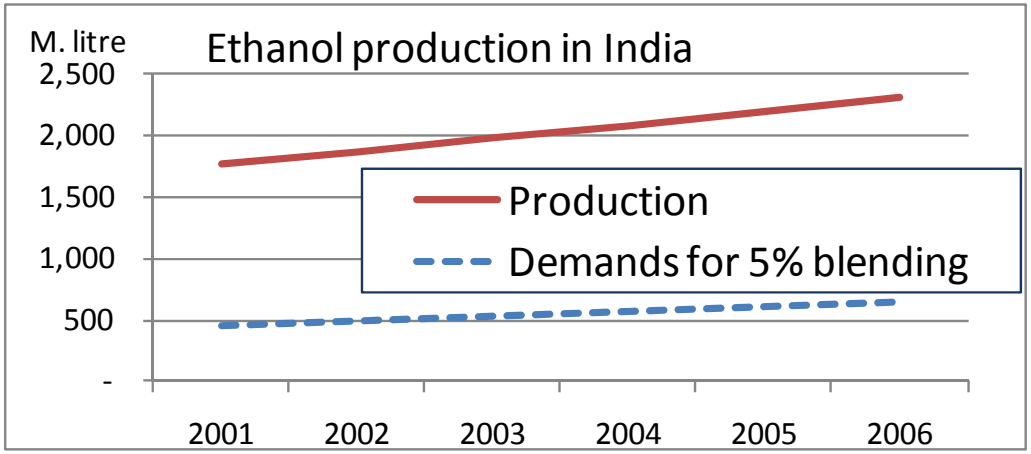
National Policy on Biofuels (the Cabinet approved in Sep. 2008)

- Demand side: 20% blending mandate for both diesel and petrol with biodiesel and bio-ethanol, respectively, by 2017.
- Rural development: Biodiesel must be from non-edible oil seeds on marginal land. Cultivation of fuel crops on fertile irrigated lands will not be encouraged. Imports of oil from other crops will not be permitted.
- Supply side: Minimum purchase price for biofuels and minimum support price for feedstock will be set to encourage biofuel and fuel crop production.
- This policy invites severe criticism, and the Prime Minister asked a Group of Ministers (GOM) to review the policy again in Nov. 2008.

Current biofuels situation in India

Bio-ethanol

- 9 states have implemented 5% ethanol blending mandate since 2005.
- India is one of major ethanol producers (in 2005, India was 4th largest producer).
- Currently, ethanol production is large enough for 5% blending.
- India is the largest sugar consumer in the world. ➡ Food-fuel competition.



Source :http://www.ethanolindia.net/sugarind.html (production)
Indian Petroleum & Natural Gas Statistics, 2000-01 (demands)

Biodiesel

- No reliable data of biodiesel production. Most likely very low level.

Needs for potential impact assessment of biofuel policy

Review of national policy on biofuel policy must be based on assessment of following potential policy impacts:

1. Social welfare impacts
   - Equivalent variation (EV)
2. Economic impacts
   - GDP, sectoral outputs, etc.
   - Terms of trade and international competitiveness
3. Social impacts
   - Commodity prices, e.g. food, energy, etc.
   - Employment generation
   - Income distribution, poverty reduction
4. Environmental impacts
   - Water use and land use
   - GHG emissions
   - Air and water pollution

Modelling analysis tries to cover these impacts.

Literature review: Modelling biofuels in CGE models

Increasing number of BF policy assessment studies employ computable general equilibrium (CGE) models. CGE models have advantages in reflecting inter-sectoral and inter-regional economic linkages which are important for BF policy.

Treatment of biofuels can be classified as follows:

1. Implicit intermediate inputs (Dixon et al. 2007, Banse et al. 2008, etc.)
   - Energy crops enters commodity production as substitutes of fuels.
   - No BF trade, no BF final consumption.
2. Explicit disaggregation of biofuel sectors (Birur et al. 2009, etc.)
   - Biofuels are treated as commodities.
   - Additional data are required for disaggregation.
3. Explicit disaggregation with latent technology (Kretschmer et al. 2008, etc.)
   - Biofuels which are not recorded in the base year are treated as latent technologies in the dynamic setting. After several years, biofuels appear as new commodities.

Literature review: Disaggregation of biofuel sectors

Once data is available, explicit disaggregation of biofuel sectors is advantageous in several aspects, e.g. addressing trade related impacts and better representation of BF technologies. This approach is now mainstream.

Taheripour et al. (2007) GTAP-BIO database

- The pioneering work. 3 biofuel sectors (biodiesel, corn-base ethanol and sugar cane-base ethanol) are disaggregated in GTAP ver. 6 database (base year: 2001).
- Birur et al. (2008) conducted policy simulation using customised GTAP model for this database (GTAP-BIO model).
- Recent version disaggregate land (factor input) into 18 Agro-Ecological Zones (AEZ). This is important to model food-energy competition over land use in detail.

Valin et al. (2009)

- Based on GTAP ver. 7 (base year: 2004), they elaborate (1) biofuel related sectoral disaggregation comparing with GTAP-BIO, and (2) land use related GHG emissions.

Literature review: Modelling dynamics in CGE models

So far, BF-extended CGE models employ either static approach or recursive dynamic approach. No forward-looking dynamic model is available.

Static approach

- Time dimension is not appeared in the model. Rigorously speaking, the simulation corresponds to steady-state equilibrium.
- Most GTAP model studies with GTAP-BIO database employs static approach, but giving policy shock corresponding to base year and target year (e.g. 2001-2008).

Recursive dynamic approach

- For each time step (say, 1 year), macroeconomic shocks (e.g. GDP growth, factor endowment growth) during the period are given to static CGE model to update database.
- It can simulate policy shocks on the database corresponding to target year, but solution implicitly assumes steady-state equilibrium.

To assess BF policy in India, **forward-looking dynamic model** is desirable to reflect rapid changes in BF demands and production.

Model specifications

Database: India Social Accounting Matrix (SAM) based on GTAP-BIO database (base year: 2001, indeed, Global SAM is already constructed)

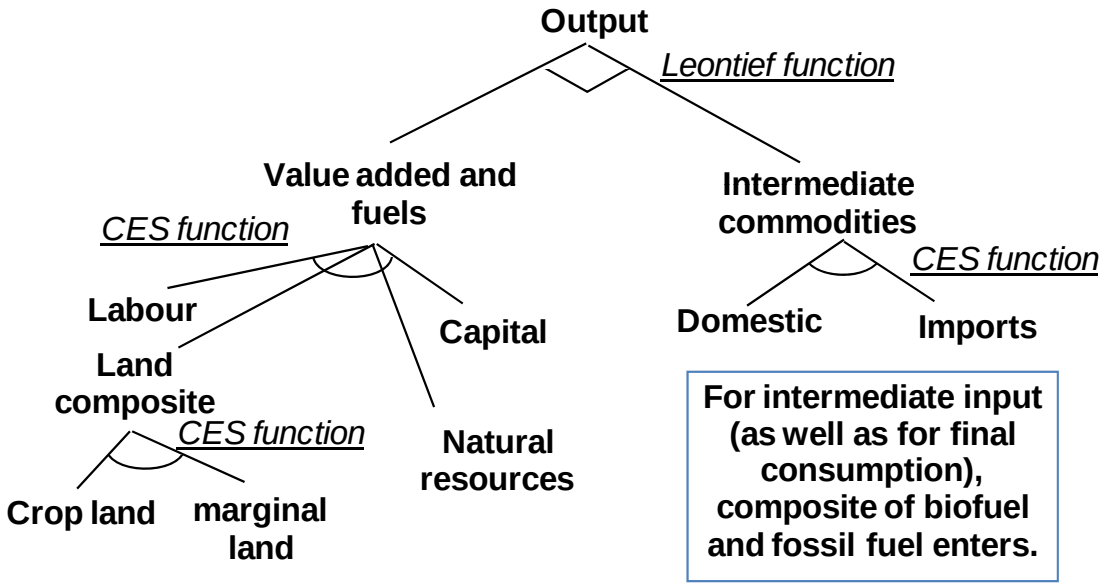
- 6 sectors: food crops, energy crops, biofuels, fossil fuels, fuel products, others.
- 5 factors: labour, capital, crop land, marginal land, natural resources. Crop land and marginal land are aggregated from AEZ data.

Model consists of behavioural equations of 3 actors (household, production sectors, and the government).

- Households maximise utility with endogenous saving decisions.
- Production sectors maximise profit given production technologies (production functions).
- The government is assumed to be budget neutral. It collects taxes, provides subsidies and invests in marginal lands amelioration for energy crop cultivation.

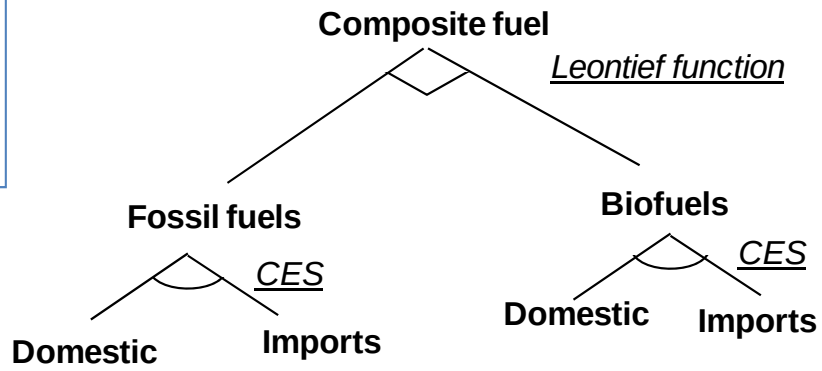
Production structure: introduction of biofuels

All "real" sectors



For intermediate input (as well as for final consumption), composite of biofuel and fossil fuel enters.

Composite fuel (imaginary sector)



BF blending mandate is reflected as I-O coefficient between biofuel and fossil fuel

Policy simulations

Policy scenarios

- Biofuel blending mandate is set to gradually reach 20% in 2017.
- Scenarios with and without biofuel imports are prepared.
- Scenarios with and without economic incentives to biofuels in terms of subsidy to energy crop and/or biofuels and tax on fossil fuels are prepared.

Assessment indicators

- Social welfare indicator: EV
- Economic indicators: GDP, imports and exports, capital stock in the target year
- Social indicators: Commodity prices, wage rates

Simulation procedure

- Time step: 1 year
- Simulation period: 2001 - 2020

Expected policy implications

The simulation results will address the following policy relevant questions:

- Which biofuel policy scenario(s) will improve social welfare?
- Whether biofuel promotion will contribute to rural development, judging from changes in commodity price, wage rates and sectoral outputs?
- How severe the food-fuel competition over land will be?
- How effective the economic incentives (subsidies, tax) will be?
- What will happen in India if biofuel imports will be allowed?

Important questions to be addressed by future research include:

- Is biofuel policy environmentally sustainable considering water shortage in India?
- Whether biofuel policy will improve pro-poor income distribution and employment generation?
- How biofuel policy will affect GHG emissions in India?
- What will be the international impacts of Indian biofuel policy?

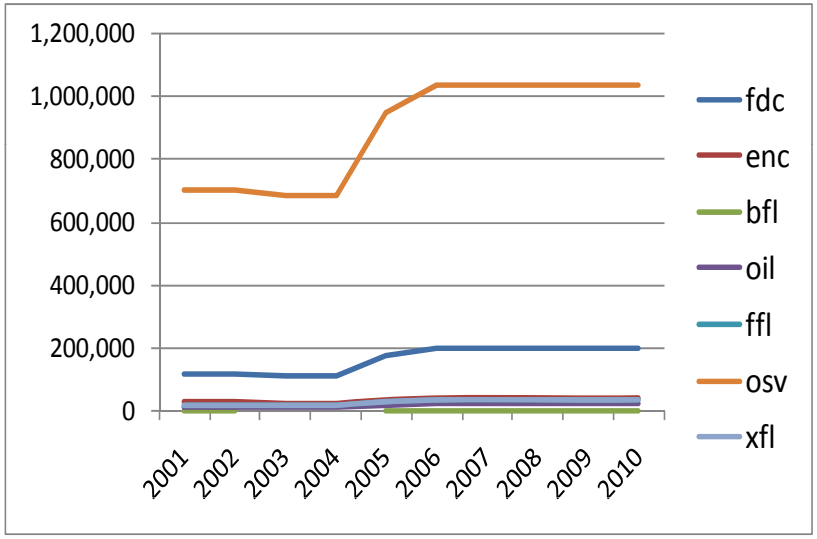
Preliminary results

Stability of the model

- The current version is very unstable, reporting large fluctuation of consumption levels, price levels. Need more work to get analysis results.

Difficulty to meet blending target

- Fixing quantity between two goods (biofuel and fossil fuel) is challenging. When TFP for all sectors are endogenised, TFP growth of the biofuel sector becomes very large (like more than 1000%).



Ex. Household consumption level

Much more work is necessary even to set up "simple version ".

Way forwards

Incorporate environmental impacts

- Water will be introduce into the model, with rainfed agriculture vs. irrigated agriculture distinction. Water issue is crucial for sustainability of BF policy.
- Database will be disaggregated to have more detailed energy sectors.
- Fossil fuel volume data in the GTAP data sets will be introduced.
- Pollution emission factor of fossil fuels will be introduced.

Incorporate international linkages

- Model will be extended to multi-regional CGE.
- Global SAM is already constructed

Incorporate poverty impacts

- SAM will be disaggregated to several classes of households.
- Unemployment will be introduced through some sort of wage rigidity.
- Whether rural-urban migration can be introduced or not is unclear.

Thank you for your attention.

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