

Land Use analysis of Biofuel

Mandates: A CGE perspective with MIRAGE-Biof

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Land Use analysis of Biofuel Mandates: A CGE perspective with MIRAGE-Biof

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MIRAGE

- Computable General Equilibrium
- Development started in 2001 in CEPII, Paris
- Initial focus on trade issues
- Multi country, Multi sector: Global model
- Dynamic recursive
- Main source of data: GTAP database
- Numerous extensions: Exist version that allows trade modeling at the product level, FDI etc.
- **GAMS** based

Why Land Use is important?

- Starting point: Trade liberalization
 - Agriculture is the most protected sector
 - Large tariff heterogeneity
 - Land is a production factor ! Mobility & Supply
 - Trade liberalization = Efficiency gains = Reallocation of production among sectors
 - Role of Land Mobility: perfect (e.g. most of LINKAGE simulations WB) or imperfect (MIRAGE): x2 gains for developing countries
- **Beyond trade liberalization:** role in the baseline → relative prices between agriculture and the rest of the economy
- First implementation in MIRAGE (at the 'country' level):
 - Imperfect land substitution: CET
 - Isoelastic land supply
- And then Land Use related emissions

One challenge: data

- Different databases
 - FAO, IIASA, M3
 - Not harmonized (within datasets / between datasets)
 - Poor quality of time series
 - Multi cropping
 - Problems on croplands, pasture, suitable land
 - Information on protected lands
- Consequences on yields, land availability, estimation

MIRAGE-BIOF

ILLUSTRATIVE RESULTS

EU Biodiesel Imports

Feedstocks Imports

LUC (decomposition)

Trade Policies Effect

LUC vs Emissions

LUC – Constant Food vs Endogenous Food

...Alternative approach for measuring the disappearing food

Assessing Non Linearity

Production pattern

Land Use pattern: Ha by 1E3GJ

Feed prices

Extension vs Intensification

Monte Carlo Analysis: LUC, grCO₂/MJ

Distribution LUC grCO₂/MJ

Cropland Ha

Modeling issues

BIOFUELS

Main Features

- Global CGE MIRAGE – assume perfect competition
- Improvement in demand system (food and energy) - done in previous works
- Improved sector disaggregation
- New modeling of Ethanol sectors
- Land market and land extensions at the AEZ level
- Co-products (ethanols and vegetal oils)
- New modeling of fertilizers
- New modeling of livestock (extensification/intensification)

Disaggregation (Sectors)

Sector	Description	Sector	Description	Sector	Description
Rice	Rice	SoybnOil	Soy Oil	EthanolW	Ethanol - Wheat
Wheat	Wheat	SunOil	Sunflower Oil	Biodiesel	Biodiesel
Maize	Maize	OthFood	Other Food sectors	Manuf	Other Manufacturing activities
PalmFruit	Palm Fruit	MeatDairy	Meat and Dairy products	WoodPaper	Wood and Paper
Rapeseed	Rapeseed	Sugar	Sugar	Fuel	Fuel
Soybeans	Soybeans	Forestry	Forestry	PetrNoFuel	Petroleum products, except fuel
Sunflower	Sunflower	Fishing	Fishing	Fertiliz	Fertilizers
OthOilSds	Other oilseeds	Coal	Coal	ElecGas	Electricity and Gas
VegFruits	Vegetable & Fruits	Oil	Oil	Construction	Construction
OthCrop	Other crops	Gas	Gas	PrivServ	Private services
Sugar_cb	Sugar beet or cane	OthMin	Other minerals	RoadTrans	Road Transportation
Cattle	Cattle	Ethanol	Ethanol - Main sector	AirSeaTran	Air & Sea transportation
OthAnim	Other animals (inc. hogs and poultry)	EthanolC	Ethanol - Sugar Cane	PubServ	Public services
PalmOil	Palm Oil	EthanolB	Ethanol - Sugar Beet		
RpSdOil	Rapeseed Oil	EthanolM	Ethanol - Maize		

Disaggregation (Regions)

Region	Description
Brazil	Brazil
CAMCarib	Central America and Caribbean countries
China	China
CIS	CIS countries (inc. Ukraine)
EU27	European Union (27 members)
IndoMalay	Indonesia and Malaysia
LAC	Other Latin America countries (inc. Argentina)
RoOECD	Rest of OECD (inc. Canada & Australia)
RoW	Rest of the World
SSA	Sub Saharan Africa
USA	United States of America

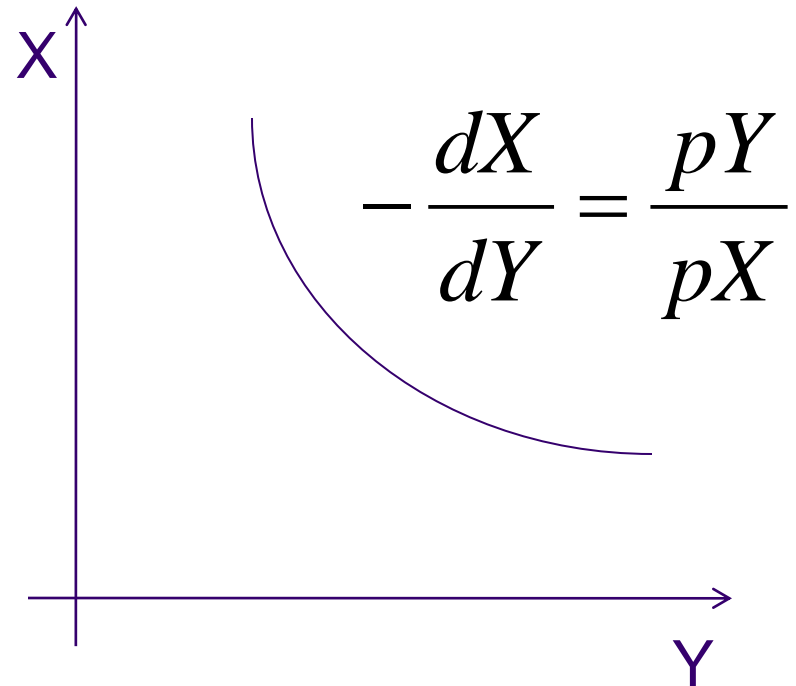
But: Land markets at the AEZ level

Major Efforts on Data: from Values to Quantities

- Improvement from GTAP7
 - Split for fertilizers and fossil fuels
 - Disaggregation with specific procedure for Maize, Soybeans, Sunflower seed, Palm fruit, Rapeseed + relevant Oils + Co-products
 - Production targeting (FAO) for all relevant crops
 - Creation of a “harmonized” price database for calibration
 - Case of co-products
 - Creation of Ethanol and Biodiesel (2008 trade and production structure).
 - Correction of some I-O data (e.g. China)
- Land use (AEZ GTAP database 2001 → 2004, + consistency with FAO and M3)
 - Correction for Sugar cane AEZ in Brazil

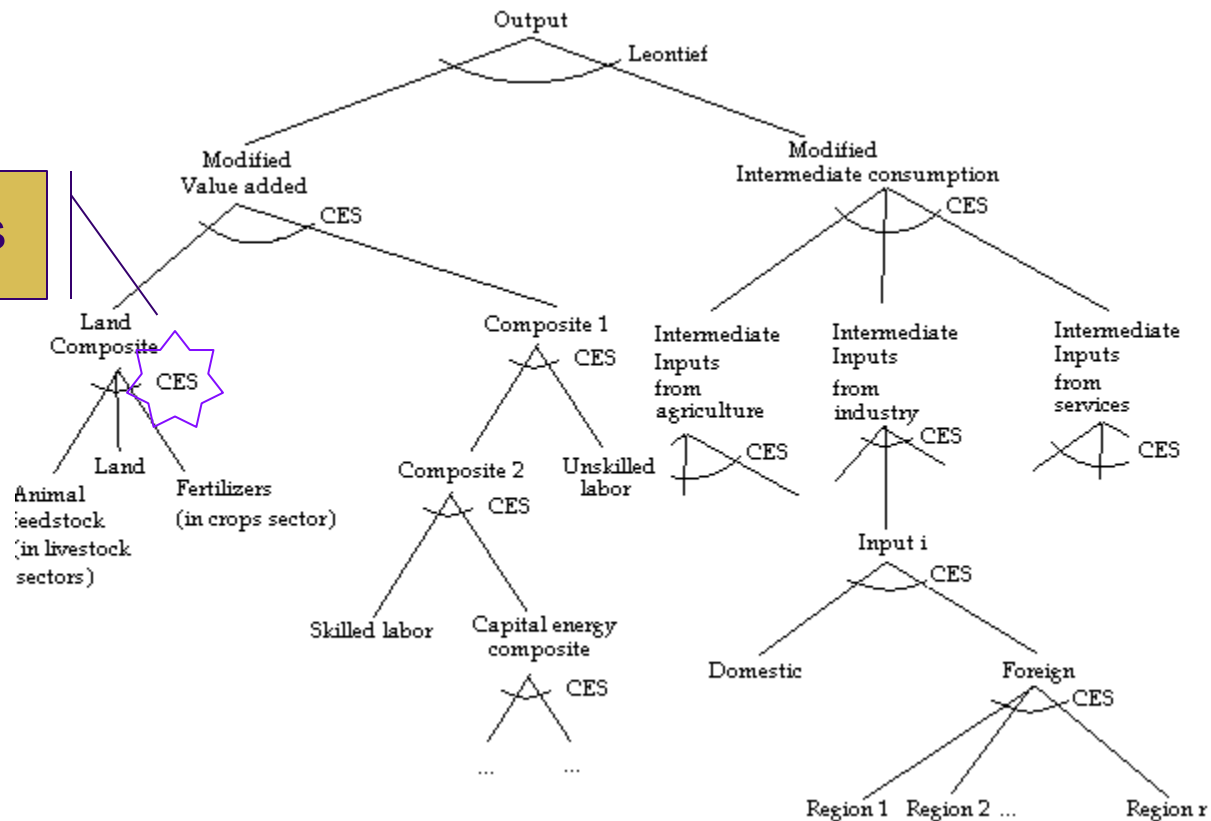
General Remarks

- CGE:
 - A world of value and prices
 - But rarely “real” prices
 - Calibration issue
- Here, physical linkages are crucial
 - Substitution effects
 - Transformation effects
- Limits of CES and CET
 - Constraints on the choice of elasticities



Production Tree for an Ag. Sector

Changes

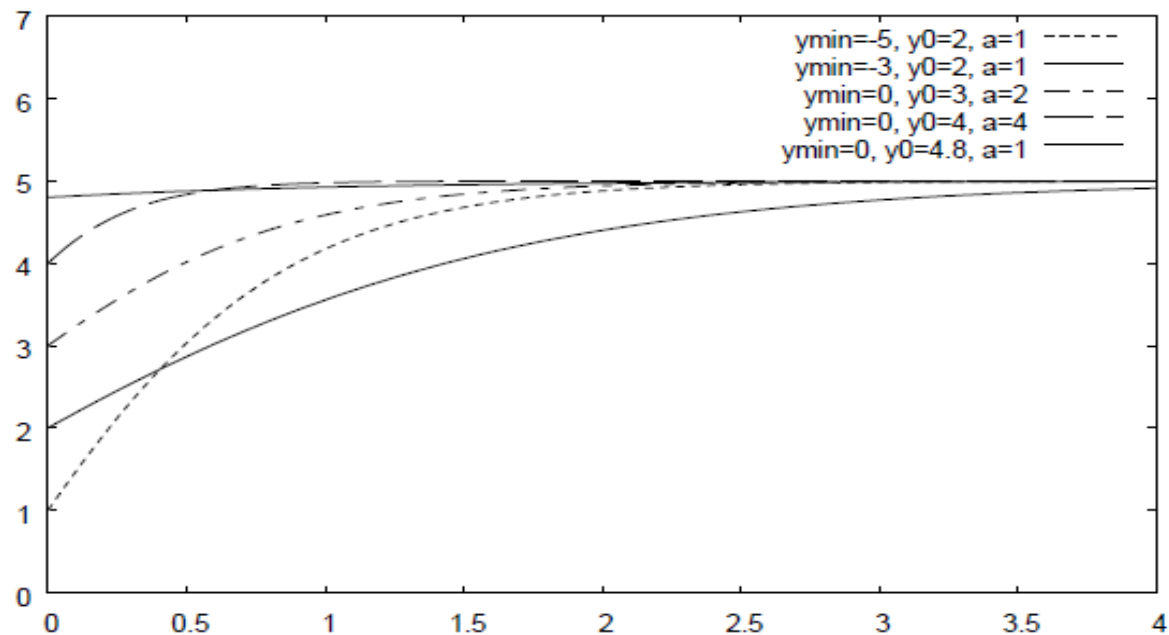


Yield Changes in the Model

- Exogenous technology: TFP in agriculture
- Endogenous effects:
 - Factor accumulation:
 - More capital and labor by unit of land
 - Fertilizers

Fertilizers

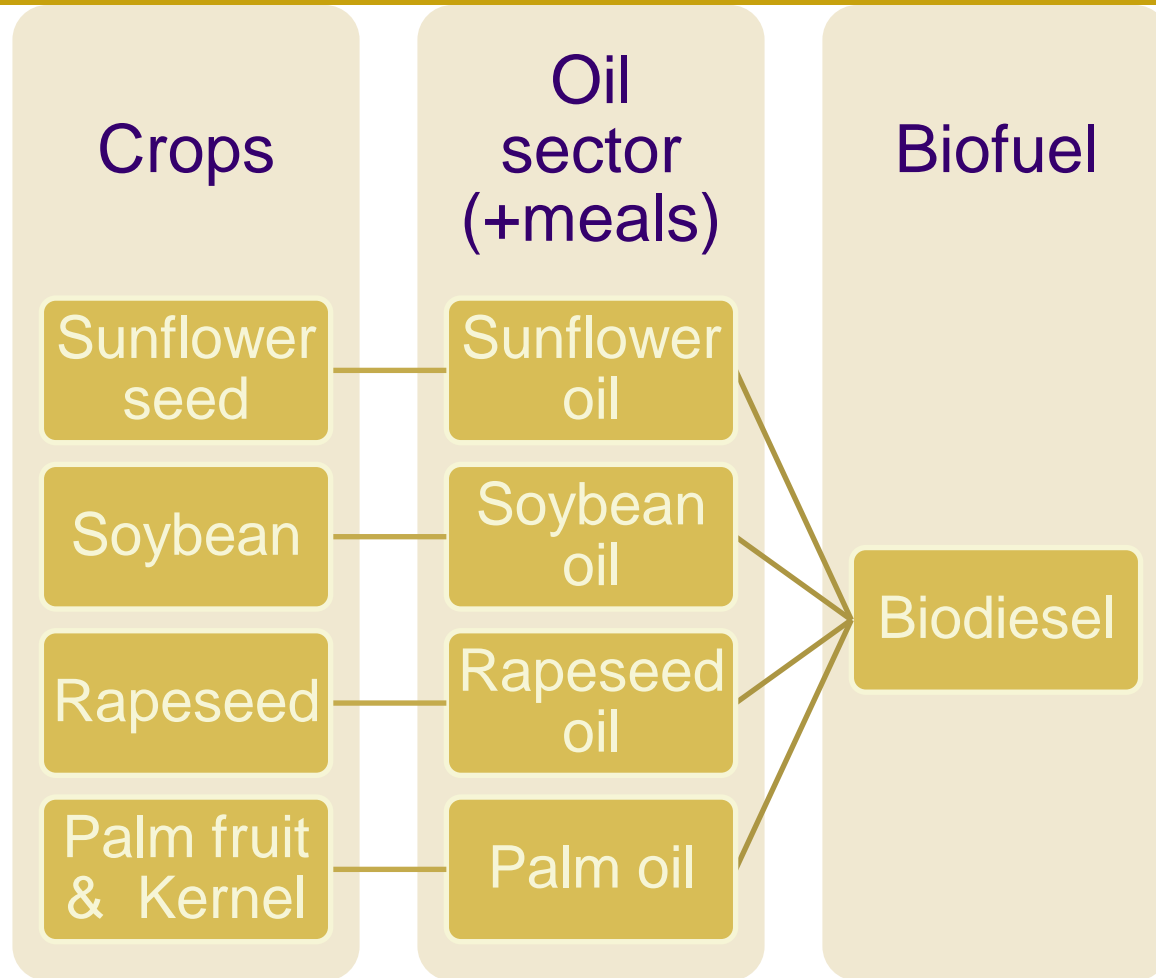
- Price elasticities calibrated from the IMPACT model
- Logistic approach for yield effects



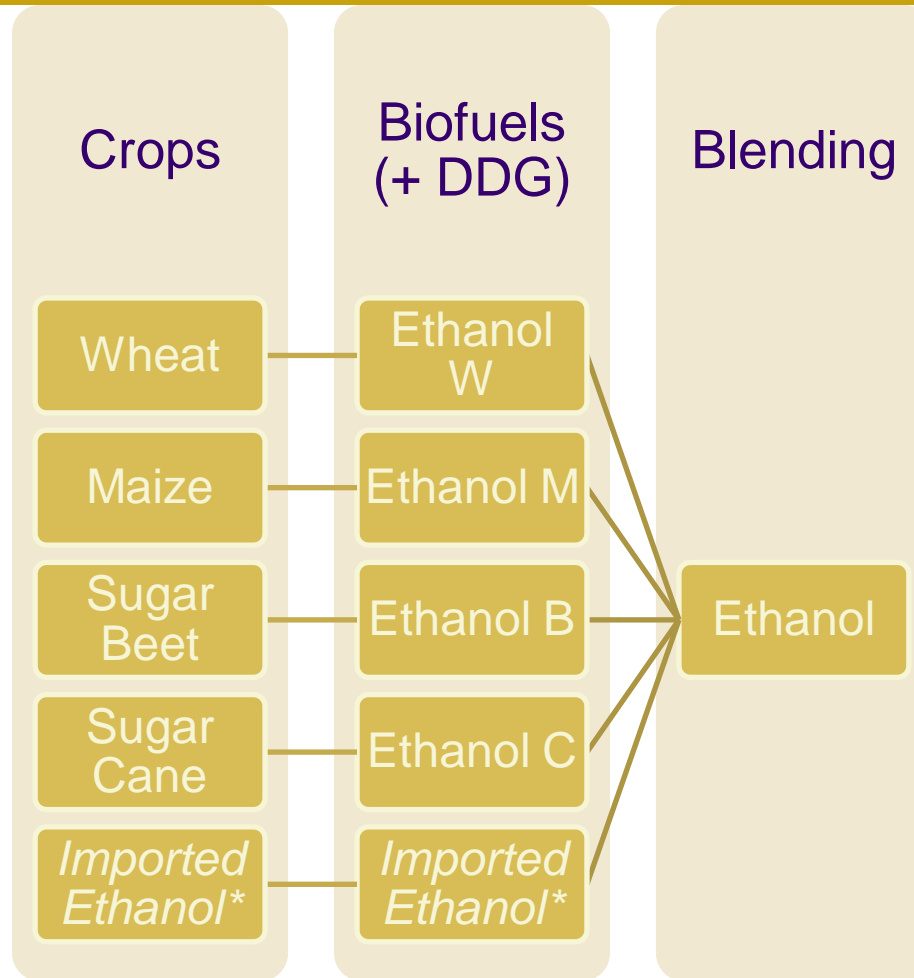
Defining a Relevant Baseline

- Macroeconomic targets
 - Growth
 - Oil prices
 - EU fuel consumption for Road transportation
- Technology and yields
 - Ludena and al.
 - EU specific case
- Policies
 - Trade policies
 - Ag policies
 - Biofuel policies

Biodiesel Production



Ethanol Production



Modeling issues

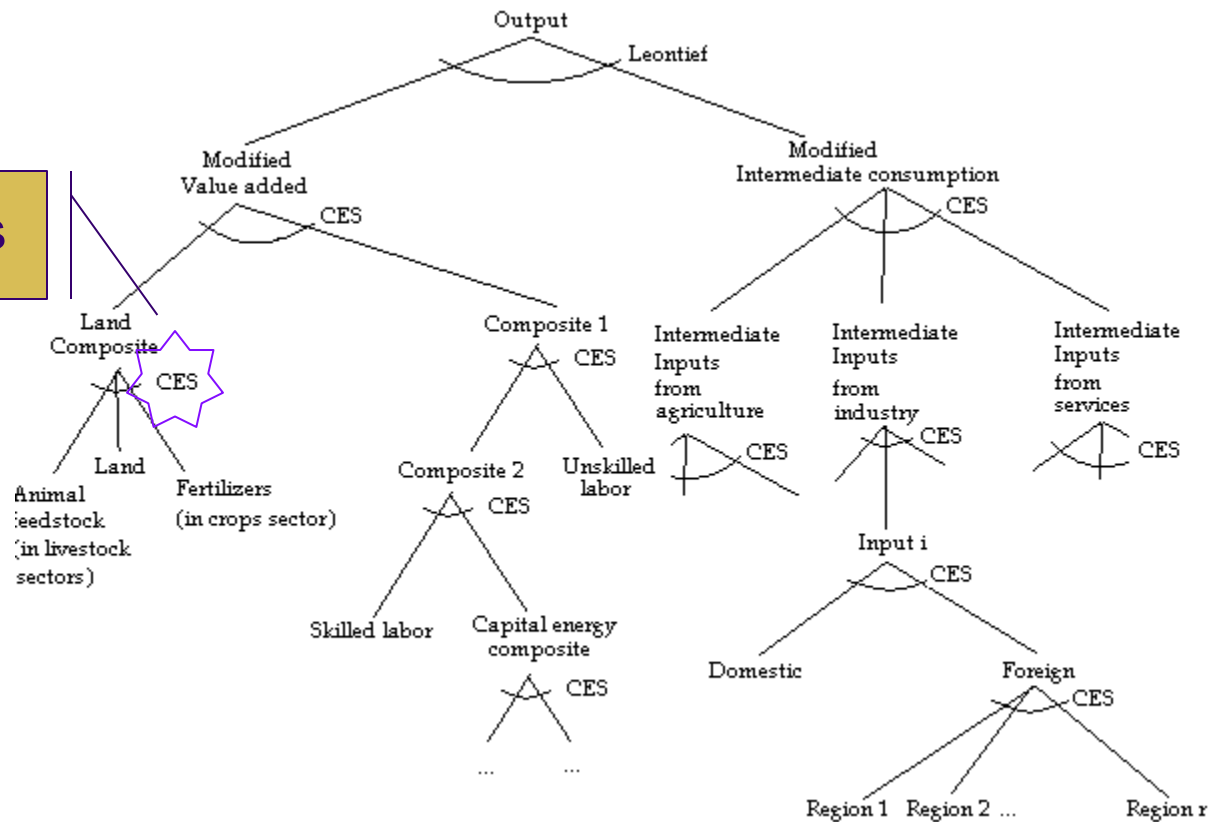
DEMAND OF LAND

In MIRAGE

- Two components
 - Endogenous (what is important in our model)
 - Exogenous (urbanization trend, non economic program related to forestry)

Production Tree for an Ag. Sector

Changes



Livestock Sector and Intensification

Traditional approach

- Feedstock → Intermediate consumption
- Intermediate consumption & Value Added (including Land) complementary
- Increase in feedstock prices → Increase in production cost → Decrease in demand → Decrease in production → Decrease in Land Use

Intensification approach

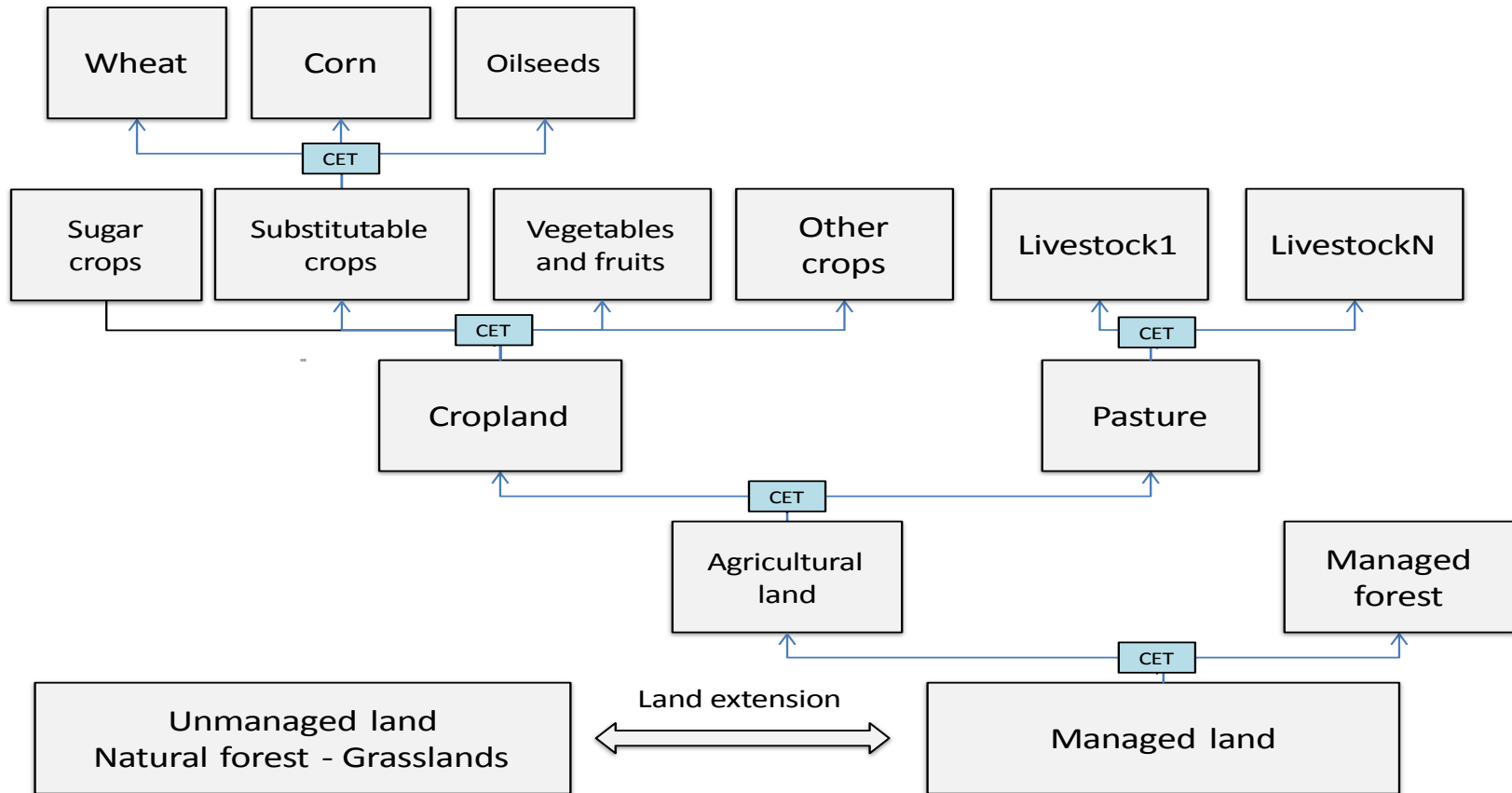
- Like fertilizers
- Ratio price of land/price of feedstocks → Producer choice
- Increase in price of feedstock → Substitution effect = Intensification + Overall price effect = reduction in production → Overall, potential increase in Land use

+ Limitations in the interactions between pasture land and crop lands ($P_0/P_1/P_2$)

Modeling issues

SUPPLY OF LAND

Land Markets – at the **AEZ** Level



Land Extension Allocation

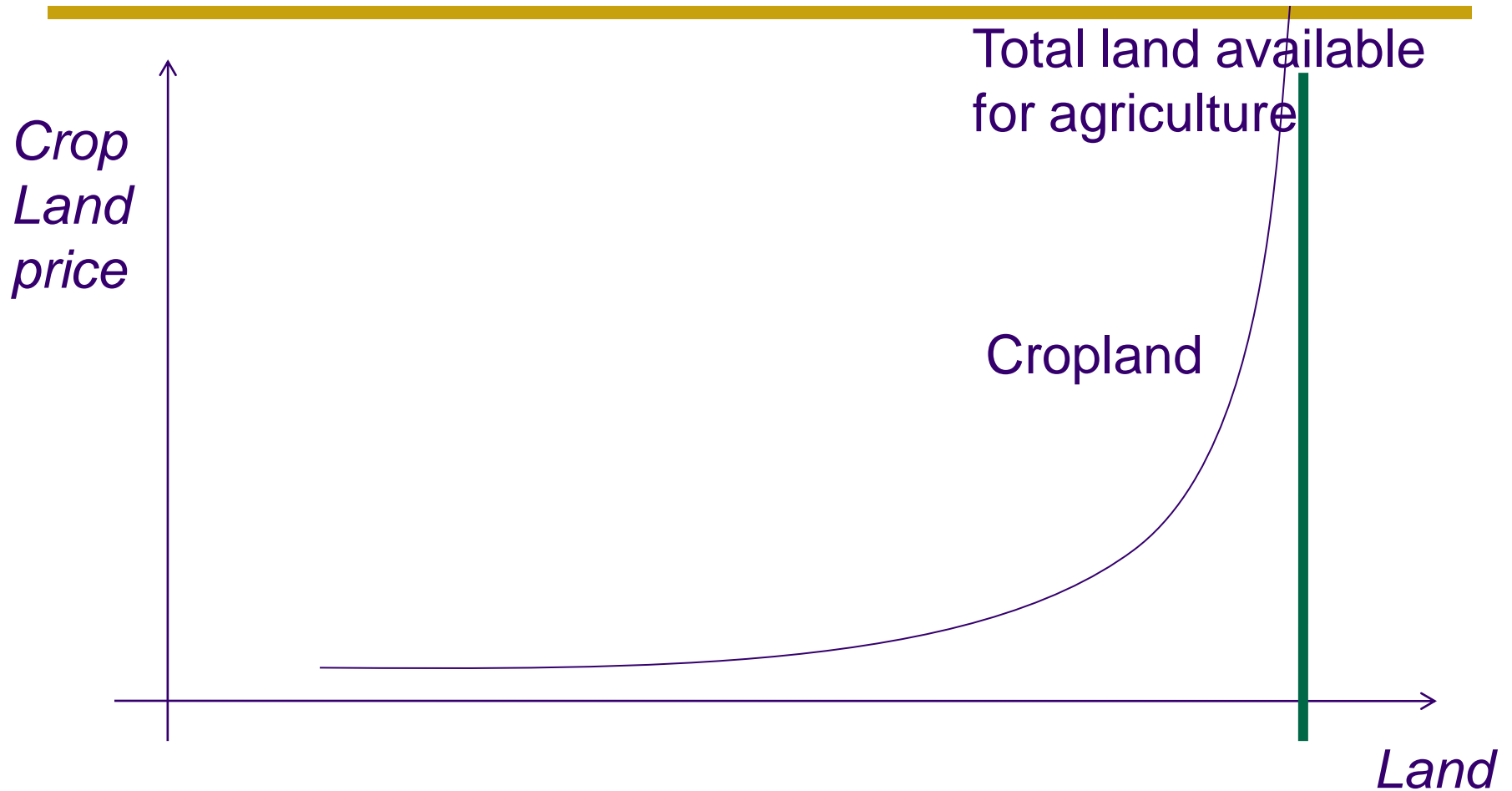
from Winrock Intl. – EPA report

	Forest Primary	Other	Savannah & Grassland
Argentina	0.0%	24.7%	23.3%
Brazil	16.3%	11.2%	48.5%
CAMCarib	30.4%	10.7%	42.9%
Canada	7.8%	42.5%	16.1%
China	2.2%	27.3%	26.0%
CIS	5.6%	33.3%	26.7%
EU27	0.4%	23.5%	30.9%
IndoMalay	51.7%	7.0%	31.0%
LAC	10.8%	14.3%	33.8%
Oceania	0.0%	32.6%	22.5%
RoOECD	0.0%	18.8%	45.8%
RoW	3.7%	36.9%	16.7%
SEasia	20.4%	21.5%	33.8%
SouthAfrica	5.1%	28.4%	22.2%
SouthAsia	0.0%	32.4%	23.9%
SSA	13.0%	16.7%	41.7%
USA	2.5%	21.1%	23.7%

Methodology

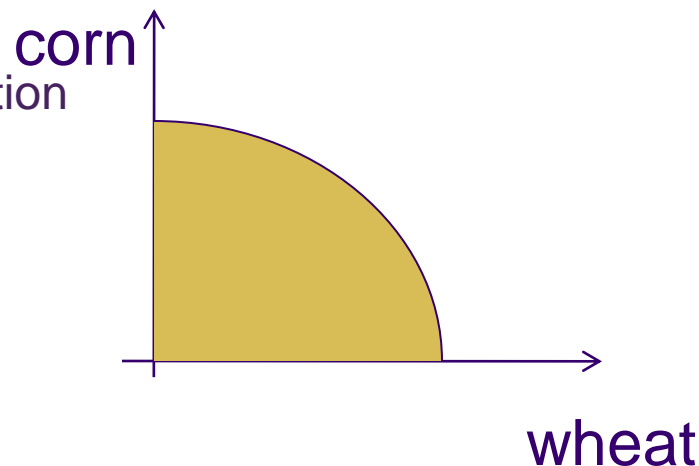
- Amount of land extension: land supply based on cropland price
- Evolution of the elasticity
- Where the land is taken:
 - Ad Hoc coefficients: Winrock
 - Limitations
 - Done at the AEZ level
 - RAS procedure to consider land availability constraint at the AEZ level

Technical issue: Land Extension



Technical issues: land substitution (1)

- CET function: concavity
 - Aimed to capture imperfect transformation
 - Adjustment costs / stylised facts
 - Changes in productivity
- Nested CET: consequences of concavity
 - $\sum (i, \text{Land}_i) \neq \text{CET}(\text{Land}_I)$
 - In the model / out of the model rescaling
 - In MIRAGE: in the model
- CET:
 - Good in static
 - More problematic in dynamics:
 - Adjustment costs based on calibration year.
 - Recalibration issue



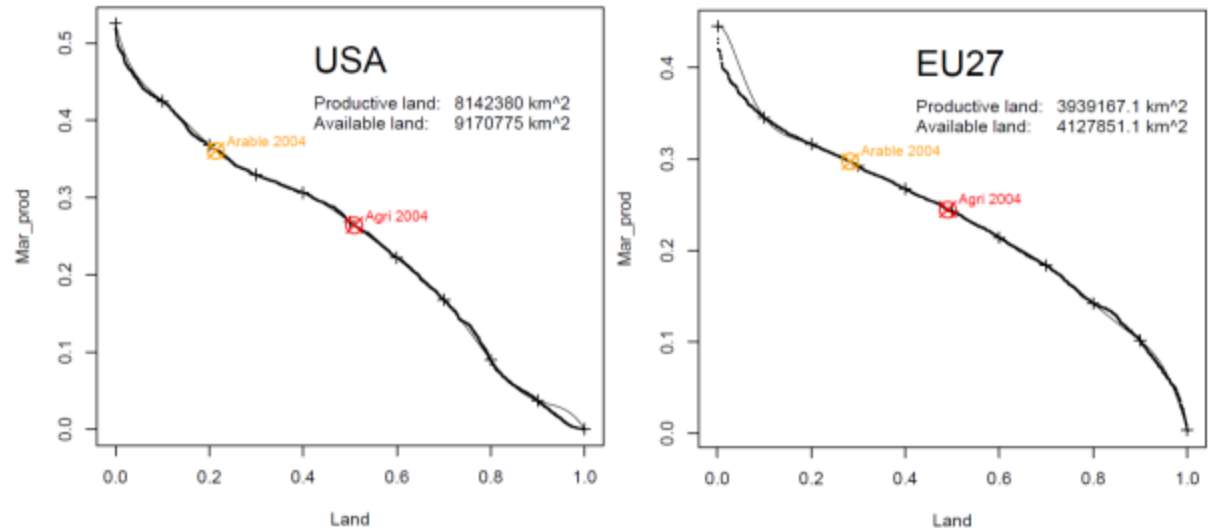
Technical issues: land substitution (2)

- CET: Which elasticities?
 - Poor estimates in the literature
 - In many cases, indirect estimates
 - Past estimates / future behaviour: the role of policy reform
- Ongoing researches:
 - Crop rotation and crop complementarities
 - Alternative functional form: from nested CET to CRESH (or better, more flexible functional form).
 - Conversion costs: problem of expectation and fixed costs

Technical issue: Productivity of new land

- Initially:

Figure 22. Example of marginal productivity profiles introduced in the model



based on IMAGE model. Interesting, complex, but seems not very robust (very complex issue: short term/long term)

- Now: fixed marginal productivity in terms of average productivity : 0.5 for everyone, 0.75 for Brazil

Sensitivity Analysis

- Numerous parameters with uncertainties
 - Different values for elasticities
 - Marginal productivity
 - Etc
- Test different closure of the model
- Monte Carlo simulations