Trade-led Growth in Times of Crisis
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Advances in Use of CGE analysis for Trade Policy Making

Paper title:

Role of Technology-induced Productivity in Tackling Food and Fuel Trade-offs: Tale of Twin Crisis

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Plan of the presentation

- Motivation/Objective
- Issues: Macro Lens View
- Causes of high food Prices
- Food versus Fuel Debate
- Suggested Policy Reponses
- **Paper Focus**: Alternate Technology and N-S and S-S cooperation, also Domestic assimilation factors (insufficient dissemination, training, etc.. in the deficient economies)
- A Stylized model of Technology and Adoption Factors
- GTAP CGE model and its augmentation
- GTAP V7 Database, Parameters
- Simulations, Results
- Policy Insights
- Preliminary work: needs detail further work along Birur, Hertel et al. (2008). For example, Database pertains to 2004, lack several elements of prod & trade.
- Future, further extension needed

Issues and Primary objective

- Export bans, Surge in Demand, Supply slump, Climate and *Energy Crisis*, Oil prices
- Alternative Fuel, esp., DD for Biofuel, land-use changes, *Food – Fuel competition*,
- *Food self-sufficiency*, Balancing Food security and Energy Security
- Low yields and productivity due to underinvestment in agrl research, biotech…

- Policy responses for Tackling the Crisis –
- Trade reform and others..
- More Fundamental: from the perspective of sustainable growth and development under global integration.
- GTAP: Birur et al. (2008), Hertel (2008), Arndt et al (2009), Tyner and Taheripour (2008)...GTAP applications with extensions. Does not consider this aspect of Policy Response— see Patil, Tran, and Giselrød (p. 1189, 2008), FAO, 2008; UNEP, 2009; Riley, Tilman et al 2009.

Emerging trends: World Food Scenario [1]

Table 2. Basic facts of the world cereal situation (*million tonnes*)

	2007/08	2008/09	2009/10	Change: 2009/10 over 2008/09 (%)
PRODUCTION[1]				
Wheat	610.9	683.8	655.2	-4.2
Coarse grains	1 082.5	1 142.7	1 093.1	-4.3
Rice (milled)	441.0	459.1	460.2	0.2
All cereals	**2 134.5**	**2 285.5**	**2 208.5**	**-3.4**
Developing countries	1 206.9	1 240.1	1 239.9	0.0
Developed countries	927.5	1 045.5	968.6	-7.4
TRADE[2]				
Wheat	112.8	128.6	114.0	-11.3
Coarse grains	129.5	111.9	112.0	0.0
Rice	30.0	31.0	30.6	-1.4
All cereals	**272.3**	**271.5**	**256.6**	**-5.5**
Developing countries	84.4	68.8	64.7	-6.1
Developed countries	187.9	202.7	191.9	-5.3

Decline in production in food crops/ cereals

Source: GIEWS, FAO, July 2009

Emerging trends: World Food Scenario [2]

Year	Population (Billion)	Output (Million T)	Per capita availability (kg)
1950 - 1951	2.5	631	248
1960 - 1961	3.1	824	272
1970 - 1971	3.8	1079	286
1980 - 1981	4.5	1429	321
1990 - 1991	5.3	1768	334
2000 - 2001	6.1	1843	301
2007 - 2008	6.6	2075	314

Source: UN Population Division and FAO Statistics.2009.

Table 2. Trends in Yield of Cereals-Kg per Hectare in Major producing Nations in 2007.

Country	Yield of Rice	Yield of Wheat
US	7,694	2,825
China	6,265	4,455
India	3,124	2,619
Nigeria	1,440	1,127

Source: As in table I.

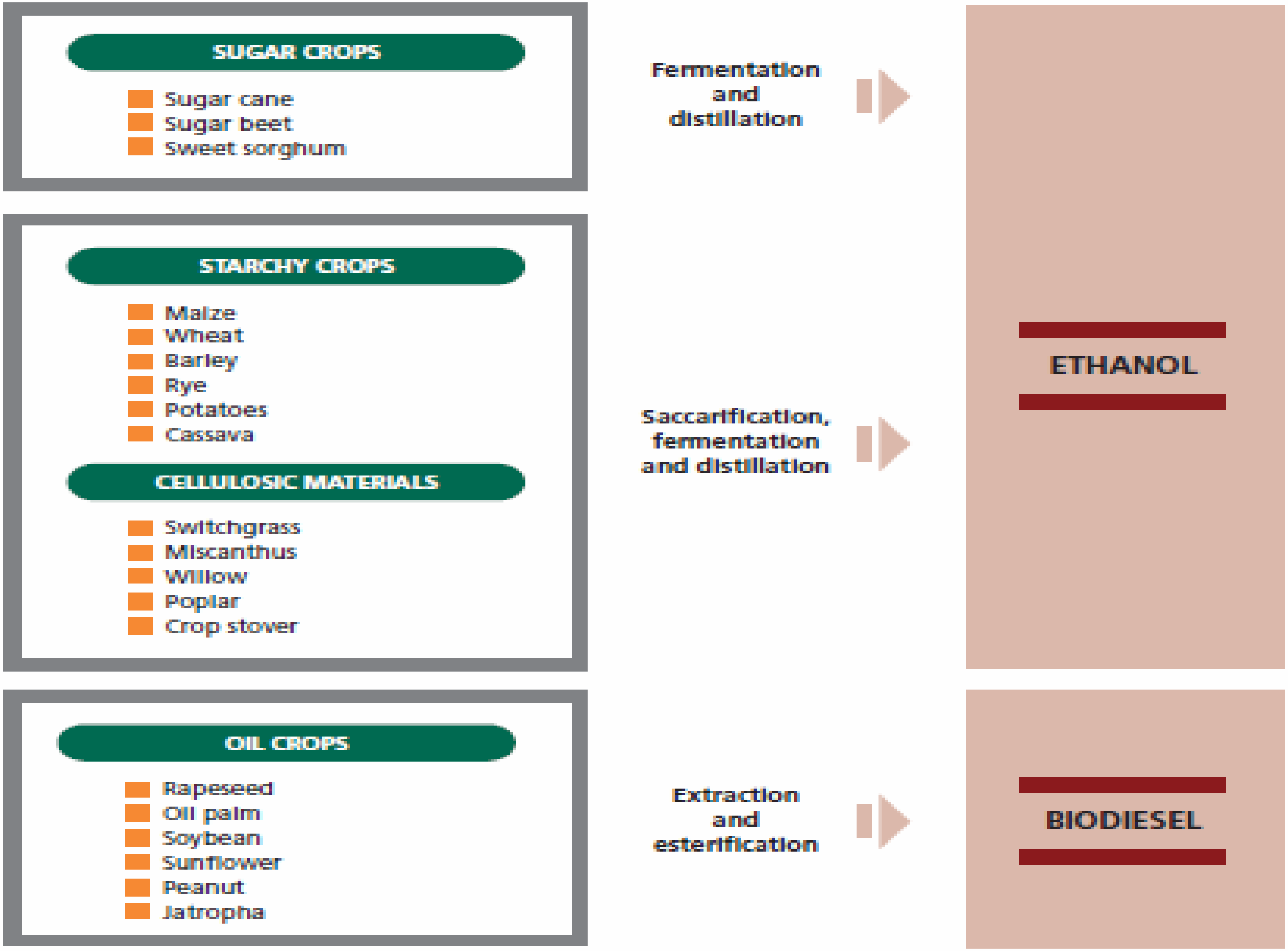
Yields differ across DCs and LDCs

UN (2006) projects world population to increase to 8.3 billion in 2030 and it will grow about as fast as cereal yields

Rising commodity prices, hike in import costs and food import bills FAO, 2008. Globally, 29% increase in spending on food imports in 2007. due to rising prices of imported cereals, veg oils—major biofuel feedstocks

22 African countries are identified as most vulnerable due to high fuel, cereal prices, and undernourishment.

Conversion of agricultural feedstocks to liquid biofuels. Source: Figure 6 (FAO, 2008).



Source: FAO.

Trade-offs: Fuels and Food

- Reshaping the nature of linkages between agriculture and energy output markets as crops provide feedstocks
- Competing use of finite resources. Increasing competition for natural resources, such as, land, esp in the Short-run
- Price incentives: Crops redirected to biofuel production, or, food-oriented land converted into bioenergy production
- **IFPRI Rosegrant et al (2008), GTAP: Tyner and Taheripour (2008).**

- Biofuel yields per hectare vary across feedstocks, land, countries
- Differences in conversion efficiency, production technology, crops yields.
- Different land requirement
- Debatable effect on commodity markets, land use changes and environment
- **GTAP:** Birur, Hertel, Tyner (2007, 2008), Hertel, Taheripour et al..(2007, 2008)

Modern Bioenergy: Brief Taxonomy

Sources: UNEP, Intl .Panel for Sustainable Res. Mgmt (Oct 2009) Towards sustainable production: Assessing Biofuels and FAO (2008): State of Food and Agriculture, Biofuels: prospects, risks and opportunities

- Energy carriers derived from biomass(feedstocks) such as food crops, fibres, organic wastes, energy crops, ..used for transport, electricity and heating
- Types: Liquid (bioethanol and biodiesel), Biogas, Solid (fuelwood, charcoal)
- **Source-wise**: processed

- First generation based on conventional technology: ethanol and biodiesel from--grains, sugar cane, sugarbeet, maize, corn, wheat, soybean, sunflower, jatropha, etc
- Second generation biomethanol, mixed alchohol from non-food: lignocellulose, switchgrass, Miscanthus
- **Next generation sophisticated tech. (Algae and others !)" UNEP (2009), Science (2008, 2009), Stern (2009), The Economist (July, Aug 2009)— Oilgae from Algae, Bio-propanol, butanol**

Food, Fuel, Energy: Three-pronged crisis

- *REFERENCE: “Beneficial Biofuels—The Food, Energy, and Environment Trilemma”*
- *in Science (August 2009). David Tilman, Jonathan A. Foley, Jason Hill, et al. “Undesirable impacts of biofuels done wrong !” (p. 270)*

❑**The best biofuels.** The search for beneficial biofuels should focus on sustainable biomass feedstocks that *neither compete with food crops nor directly or indirectly cause land-clearing and that offer advantages in reducing greenhouse-gas emissions, productivity in food and biomass.*

❑The best biofuels make good substitutes for fossil energy. .. more than *500 million tons of such feedstocks could be produced* annually in the United States

Towards sustainable Production Technology for Biofuels

- A more sophisticate approach to developing biofuels: *Science (p 44, 2008), UNEP Report (Oct, 2009), Stern (2008, 2009), Sachs (2008).*
- Credible studies show that with plausible technology developments biofuels could supply some 30% of global demand in an environmentally friendly way *without affecting* food production. *Koonin (Science, 311, 2006).*
- "Advanced biofuels must be developed from dedicated energy crops, separately and distinctly from food."
- **Non-food Feedstocks,** Algae (Oilgae), Microalgae (Couveia and Oliviera 2009, Patil et al. 2008, The Economist 2009) on non-arable land, non-potable water, not seasonal, daily harvestable, not-displacing food crops cultures.

Complementary Technologies and flows

- "*Dramatic improvements in <u>policy and technology </u>are needed to reconfigure agriculture and land use to gracefully meet global demand for both food and biofuel feedstocks*". –John Riley et al (Science, Aug 2009), FAO 2009.
- Bioinformatics based Genome Sequence of first and second generation fuels, for alternative feedstocks with better energy yields**. FAO, 2008/2009, WDR Ch 7, 2008***, 2009; FAO, 2009; UNEP Report (Oct, 2009).*
- Genetic improvements<u>, modern HYV technology and transgenic techniques: </u>*Better seed* for maintaining and increasing soil organic matter in croplands to make nutrients available. (Benin: HYV seeds **NERICA** (New rice for Africa). per unit land area, per unit fertilizer input (not increasing much in its level of usage), per unit water consumed.
- Own, research/innovative capability.
- *North to South, South to South,* for example, UN Asia Pacific Centre for Agricultural Engineering and Machinery (**UNAPCAEM**)

Technology: Prior Study

Literatures abound with role of <u>*general-purpose-technology*</u> <u>(GPT) and other kinds of technological break-through</u> like bio, nanotechnology, (Linstone, 2004), (Darby and Zucker, 2003) and biotechnology (Evenson and Santaniello, 2006), Kahn and Zaks (June 2009, Centre for S-A-G-E, UWM).

- <u>World bank's WDR 2008, CH 7:</u> cross-cutting nature of "advances in bio and information sciences.." (pg. 158). And, GEP (2008).
- Application across all fields: spilling over via linkages.
- Stern (2009), Borlaug (2008), Sachs (2008), Tilman and Riley (2009), Romer ..
- One study in the context of Food crisis: Nouve and Wodon (Oct 2008) World Bank: CGE model for Mali: <u>impact of TFP</u> productivity increase of <u>*domestic*</u> rice production and Import Tax cut.
- Much *larger positive impact for TFP changes* than tax cut.
- *Does not consider such linkages and does not look into Bioenergy, Tech flows and associated enabler factors.*

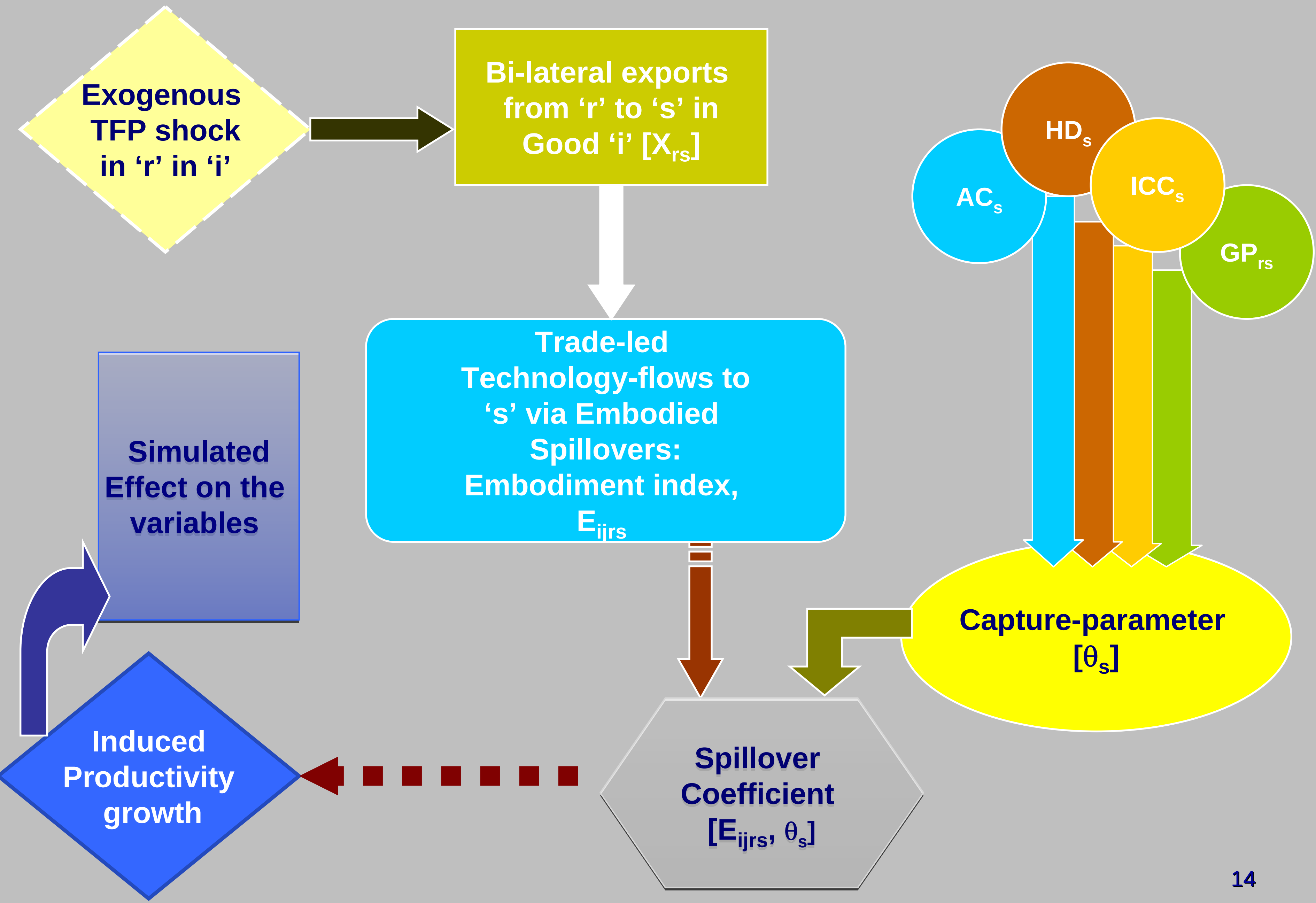
Mode of Access to Foreign Productivity Growth

- **Embodied technology transmission via trade**— WDR (1999, GEP 2008); Hoekman and Javorcik (2006); Schiff (2003, 2004), Keller (1999, 2000, 2004); Eaton et al. (1996/97, 2001); Spence Report (2008), Das (2008). Coe, Helpman and Hoffmaister (1996, 2008), Lederman et al. (2003), De Ferranti et al. (2003),
- **Bussolo and O'Connor (2002):** '*technology seldom works in vacuum; it is embedded in social system....'* **Stiglitz (2003, 2006):**

- ***Main Focus*****:** Role of Absorptive Capacity (AC), Governance parameter (GP), Technological Achievement (ICC), Social Acceptance (SA) and Structural Congruence (SC) in harnessing Technology. —Cohen et al. (1989, 1990), WDR (1999/2000), Meijl and Tongeren (1998, 2000),), Evenson (2007), Lucas (2009), Romer (1998, 2007, NBER 2009). Kauffman and Mastruzzi (2005/2008/2009), etc.

All the related equations and formulae are in the paper; not reported for parsimony of space and time.

Flow Chart for Transmission Mechanism



AC and SCI: What are they?

Human Capital: education/literacy propels a new spurt of growth Ability or key competencies to perform tasks of varying complexity.

- WDR (1999, 2002, 2005); Navaretti and Tarr (2000); Winters et al. (2003); Schiff (2003, 2004); Dollar and Kraay (2001), Lucas (2009), Romer (2009), Keller (2000, 2004).

Absorptive Capacity (ACs): (human capital induced skill-intensity) – acquiring certain competencies, recipient's ability to identify, procure and use the transmitted tech (Stern 2007, 2009; Evenson, 2006).

$$AC_{HIE} > AC_{RIE} > AC_{LMIE}$$

HDI: *Structural homogeneity, closely related to innovation capability and human resource development determining social acceptance of foreign tech*- Linneman (1966), Rauch (2001), Dasgupta (2009), Liu and San (2006). [Eq 2]

GP, ICC and SCI parameters

- **Governance Parameter (GP):** *governance and institutional quality. Better GP enhances favorable investment climate, affinity based on network, trust and integration, trade facilitation, -*
- Schiff and Wang (2004), Groot et al.(2004),Kaufmann and Kraay (2003, 2009), and GEP, WDR (World Bank 2008 linking tech and institution, p. 158), Spence Report (2008).

- **Innovation Capability Congruence [Eq.1]-**based on UNCTAD Innovation Capability Index [WIR (2005)]- multi-dimensional measure of technology capability, R&D, and human capital.

- **Structural Congruence (SCI):** technological capability, achievements in creation, diffusion, and use of new ideas— [Eq. 4 and 4a]

- ***All the related equations and formulae are in the paper; not reported for parsimony of space and time.***

Current Implementation: GTAP Framework

- GTAP—multi-regional, multi-sectoral *CGE* Model— analyses the issue in global context. Technology spillover context of Food-Fuel. None so far

	Table 1	Sectoral and Regional Aggregations adopted for the Simulation			
	Regions and Elements			Sectors and Descriptions	
1	USA	USA	1	CrGrains	Cereal Grains
2	CAN	Canada	2	Rice	Paddy and Milled Rice
3	EU29	EU27+2	3	Wheat	Wheat
4	Brazil	Brazil	4	Oilseeds	OilSeeds
5	Japan	Japan	5	Sugarcan	Sugarcane,Sugar beet
6	ChiHkg	China, Hong Kong	6	Livestock	Cattle,Animalpdts, Milk, Wool
7	India	India	7	Forestry	Forestry
8	LAEEX	Latin American EnergyExporters	8	Ethanol1	Ethanol1 (corn-based)
9	RoLAC	Restr of American & Caribbeans	9	Ethanol2	Ethanol2 (Sugarcane-based)
10	EEFSUEX	aggregated region 10	10	Biodiesel	Biodiesel
11	RoE	aggregated region 11	11	Voln	Vegetable oils & fats
12	RoHIA	Rest of High Income East Asia	12	Ofdn	Other Food Products nec
13	MEASTNAEX	Middle-East and North Africa	13	Crpn	Chemical, rubber, plastic pdts
14	SSAEX	Sub-Saharan Africa	14	ICT	IT sector
15	RoAFR	Rest of Africa	15	ProcLiveS	Meat, Dairy Products
16	IDN	Indonesia	16	OthAgri	Other Agricultural Goods
17	MYS	Malaysia	17	OthPrimS	Other Primary, Fishery& Mining
18	Oceania	Oceania incl Australia, New Zeala	18	Coal	Coal
19	THL	Thailand	19	Oil	Crude Oil
20	PHL	Philippines	20	GasDist	Natural gas and distribution
21	RoSAsia	Rest of South Asia	21	Oil_Pcts	Petroleum, Coal Products
22	VNM	Vietnam	22	Electricity	Electricity svc
23	RoESEA	Rest of East and South East Asia	23	Egy_IntIn	Energy-intensive Industries
			24	Oth_Ind_	OtherIndustry and Services

Source: This is based on 23x24 Aggmap.Txt file based on author's aggregation of augmented GTAP Version 7 database

Illustrative Simulation Experiments:

Competition for inputs between biofuel and food *can be alleviated* by tech changes, two such are: Second or Next generation biofuel tech and Agricultural biotech (Hochman et al 2008, Zilberman, 2009)

Three types of simulations:

[i] (identifiers: BtGrain, BtRice, BtWheat)-spillover of 10% TFP-enhancement in 3 BT sectors—grain, rice and wheat with 'agro-chemical inputs' augmenting technical change in USA plus clients' *own indigenous technology* (uniform 5% for LDCs)

[ii] (identifier: ItBtAgChem) -*simultaneous* TFP augmentation in ICT and intermediate 'agro-chemical inputs' augmenting technical change in agro/biotechnology-intensive sectors in USA

[iii] (identifier: GPTFuel)-we consider spillover of next generation Bt, agro-fuel technology by simulating 10% TFP-shock in ICT conjointly with 5% TFP-enhancement in BT-led agro-fuel technology in USA

Sectoral Effects [1]

Higher TFP in sector intensive in Hi-Tec prods. $ava_j = \gamma_j(\bullet).\ ava_{HI\text{-}TECH}$

Results for Scenario 2: Biotech induced TFP

Table 6: Simulated impact on Output supply and supply prices of selected agricultural and fuel sectors under the designated scenario ItBtAgChem as described in Section 6* alongwith the embodied spillover coefficients.

Supply Price	CrGrains	Rice	Wheat	Oilseeds	Ethanol1	Biodiesel	Voln	Ofdn	Crpn	OthAgri
USA	-1.08	-0.87	-1.22	-1.12	-0.43	-0.93	-0.82	-0.54	-0.67	-0.65
CAN	-1.53	-2.49	-1.61	-1.59	-0.59	-1.27	-1.27	-1.20	-1.14	-1.34
EU29	-1.50	-1.53	-1.46	-1.48	-1.37	-1.41	-1.45	-1.46	-1.41	-1.47
Brazil	-1.44	-1.51	-1.41	-1.40	-1.54	-1.47	-1.47	-1.54	-1.44	-1.47
ChiHkg	-1.31	-1.41	-1.35	-1.30	-1.42	-1.41	-1.41	-1.42	-1.43	-1.36
India	-1.48	-1.48	-1.53	-1.44	-1.57	-1.51	-1.51	-1.57	-1.47	-1.48
LAEEX	-2.43	-1.93	-1.28	-1.07	-1.83	-1.51	-1.39	-1.82	-1.09	-1.01
RoHIA	-1.20	-1.60	-1.19	-1.23	-1.47	-1.38	-1.38	-1.48	-1.37	-1.64
MEASTNAE	-1.37	-1.41	-1.48	-1.21	-1.34	-1.31	-1.31	-1.34	-1.25	-1.37
SSAEX	-1.33	-1.37	-1.30	-1.33	-1.36	-1.35	-1.35	-1.36	-1.36	-1.35
RoAFR	-1.46	-1.53	-1.48	-1.51	-1.48	-1.48	-1.48	-1.48	-1.45	-1.48
THL	-1.06	-1.22	-1.32	-1.06	-1.39	-1.33	-1.33	-1.39	-1.38	-1.38
PHL	-1.21	-1.39	-1.30	-1.13	-1.47	-1.38	-1.38	-1.47	-1.51	-1.47
RoSAsia	-1.43	-1.43	-1.42	-1.38	-1.41	-1.41	-1.41	-1.41	-1.39	-1.42
VNM	-1.07	-1.19	-4.00	-1.14	-1.20	-1.23	-1.23	-1.21	-1.26	-1.15

Output Supply	CrGrains	Rice	Wheat	Oilseeds	Ethanol1	Biodiesel	Voln	Ofdn	Crpn	OthAgri
USA	1.06	-0.25	-0.31	0.54	1.83	2.11	0.76	1.52	0.68	1.29
CAN	2.58	5.09	2.55	2.43	3.29	3.36	2.88	3.23	2.85	3.25
EU29	1.06	1.00	1.12	1.28	1.34	1.46	1.53	1.47	1.72	1.31
Brazil	0.49	0.25	0.60	0.90	0.39	0.50	0.87	0.40	0.95	0.41
ChiHkg	0.26	0.13	0.09	0.20	0.22	0.30	0.41	0.32	0.57	0.19
India	0.04	0.06	0.07	0.12	0.13	0.06	0.45	0.21	0.46	0.11
LAEEX	1.04	1.17	0.11	0.48	0.46	0.78	0.84	0.73	0.60	0.67
RoHIA	0.43	0.47	0.21	0.19	0.66	0.61	0.62	0.71	0.82	0.60
MEASTNAE	0.21	0.34	0.53	0.19	0.37	0.39	0.42	0.38	0.25	0.32
SSAEX	0.14	0.23	-0.01	0.26	0.19	0.18	0.32	0.36	0.22	0.28
RoAFR	0.20	0.62	0.41	0.56	0.22	0.27	0.57	0.43	0.60	0.45
THL	0.53	-0.01	-0.28	0.31	0.44	0.38	0.32	1.10	0.81	0.45
PHL	0.26	0.23	0.21	0.63	0.25	0.67	1.20	0.60	0.79	0.36
RoSAsia	0.26	0.19	0.39	0.26	0.24	0.21	0.33	0.47	0.50	0.24
VNM	0.19	0.10	23.14	-0.13	0.37	0.25	-0.13	0.48	0.01	0.25

As expected, ex post Prices (and output) of food and fuel sectors fall (and rise).

Importance of Innovation can't be overstated for ensuring secure and affordable food supply

Simulation Results: Economy-wide Impact

Table 4: Values of economy-wide embodiment-indexes, spillover coefficients and capture-parameters in four Scenarios *

Regions / **Scenarios ↓**	**USA**	**CAN**	**EU**	**Brazil**	**Japan**	**ChiHkg**	**India**	**LAEEX**	**EEFSUEX**	**RoHIA**	**MEASTN AEX**	**SSAEX**	**RoAFR**	**THL**	**PHL**	**RoSAsia**	**VNM**
Row 2							**Spillover Coefficient (γirs/γir)**										
BtGrain	0.394	0.53	0.14	0.0004	0.681	0.0011	0.002563	0.4435	0.0013	0.283	0.15088	0.009	0.02	0.003	0.01	0.05657	0.001455
BtRice	0.426	0.49	0.22	0.0027	0.252	0.0006	0.000012	0.0799	0.00477	0.168	0.00573	0.013	0.041	0.002	0.02	0.00047	0.000001
BtWheat	0.257	0.32	0.2	0.0089	0.468	0.1632	0.000001	0.4229	0.00316	0.299	0.12002	0.115	0.057	0.14	0.2	0.12937	0.026569
ItBtAgChem	0.573	0.67	0.26	0.0444	0.133	0.0292	0.023912	0.1753	0.01001	0.134	0.06108	0.029	0.04	0.05	0.05	0.04439	0.020431
Row 3							**Structural Congruence (SCIrs)**										
		1	1	0.584	1	0.576	0.325	0.602	0.632	0.98	0.37	0.097	0.171	0.56	0.49	0.1536	0.3157
Row 4							**Capture-Paramete (θ_r)**										
		0.61	0.62	0.0033	0.526	0.0548	-0.0143	-0.111	-0.1481	0.309	-0.0478	-0.008	-0.032	0.04	-0.07	-0.02931	-0.04336

*Values shown relate to the base period computation from the global database.

Uneven Impact*—role of Capture-parameter,* Economy-wide indexes of Technology Capture depending on the constellation of factors.

Higher θ magnifies spillover with Trade-embodiment —DCs, RIE compared to LMIE; but for few countries with low capture-parameter, spillover is high due to high trade-embodiment.

For RIEs--when GP, ICI high, SCI is high and θ is high for RIE.

For LMIE, Low θ but Trade-embodiment magnifies Spillover

Sectoral Results: Algae-based biofuel TFP shock

Table 8: Embodied Spillover Coeffcients and Simulated impact on output supply and supply prices of selected agricultural and liquid bio-fuel sectors under the designated scenario GPTFuel as described in Section 6* in the text.

	CrGrains	Oilseeds	Sugarcane	Ethanol1	Ethanol2	Biodiesel	Voln	Ofdn	Crpn	OthAgri	Oil_Pcts	Egy_IntInd
Supply Price												
USA	-1.99	-2.10	-2.02	-0.79	-1.34	-1.77	-1.93	-1.44	-1.38	-1.89	-1.76	-2.27
CAN	-3.04	-3.20	-3.67	-1.20	-2.28	-2.54	-2.54	-2.41	-2.28	-2.72	-2.15	-2.71
EU29	-2.94	-2.91	-2.88	-2.68	-2.75	-2.76	-2.83	-2.86	-2.76	-2.89	-1.86	-2.83
Brazil	-2.82	-2.75	-2.87	-3.01	-2.78	-2.87	-2.87	-3.01	-2.82	-2.88	-2.09	-2.98
ChiHkg	-2.57	-2.55	-2.58	-2.78	-2.80	-2.76	-2.76	-2.78	-2.80	-2.67	-2.03	-2.80
India	-2.89	-2.83	-2.87	-3.06	-2.86	-2.95	-2.95	-3.06	-2.86	-2.90	-1.89	-3.10
LAEEX	-4.81	-2.16	-2.16	-3.61	-2.16	-2.99	-2.75	-3.61	-2.16	-2.06	-2.46	-2.24
EEFSUEX	-2.66	-2.57	-2.59	-2.70	-2.49	-2.62	-2.63	-2.70	-2.49	-2.70	-1.67	-2.56
RoHIA	-2.40	-2.46	-4.00	-2.92	-2.68	-2.69	-2.69	-2.92	-2.69	-3.26	-1.88	-3.00
MEASTNAE	-2.70	-2.39	-2.84	-2.64	-2.47	-2.57	-2.58	-2.64	-2.45	-2.70	-1.77	-2.54
SSAEX	-2.63	-2.64	-2.66	-2.69	-2.66	-2.67	-2.67	-2.69	-2.66	-2.66	-1.96	-2.66
RoAFR	-2.88	-2.98	-2.87	-2.90	-2.83	-2.91	-2.91	-2.91	-2.83	-2.91	-1.87	-2.86
RoSAsia	-2.80	-2.73	-2.88	-2.81	-2.73	-2.76	-2.76	-2.81	-2.72	-2.79	-1.96	-2.69
Output Supply												
	CrGrains	Oilseeds	Sugarcane	Ethanol1	Ethanol2	Biodiesel	Voln	Ofdn	Crpn	OthAgri	Oil_Pcts	Egy_IntInd
USA	2.07	1.11	2.18	3.61	2.69	4.15	2.04	3.30	1.44	2.18	3.64	3.93
CAN	5.19	5.13	5.74	6.56	6.68	6.61	5.49	6.30	5.74	6.13	6.92	5.23
EU29	2.09	2.53	2.69	2.66	2.96	2.88	2.98	2.89	3.39	2.51	2.77	2.44
Brazil	0.96	1.76	0.55	0.76	0.47	0.95	1.65	0.76	1.84	0.71	0.93	2.30
ChiHkg	0.51	0.40	0.37	0.43	0.42	0.55	0.74	0.60	1.09	0.34	0.58	0.13
India	0.08	0.24	0.10	0.25	0.14	0.11	0.85	0.39	0.89	0.20	0.31	0.72
LAEEX	2.13	1.03	1.18	0.93	1.03	1.54	1.66	1.44	1.20	1.03	2.43	0.58
EEFSUEX	0.23	0.47	0.19	0.31	0.13	0.30	0.42	0.34	0.42	0.22	0.42	-0.12
RoHIA	0.91	0.56	1.19	1.31	1.42	1.20	1.20	1.40	1.58	1.17	1.37	1.75
MEASTNAE	0.44	0.37	0.63	0.74	0.60	0.78	0.76	0.75	0.47	0.60	0.80	-0.81
SSAEX	0.28	0.55	0.48	0.40	0.27	0.37	0.57	0.74	0.44	0.49	0.48	0.93
RoAFR	0.41	1.11	0.57	0.44	0.48	0.53	1.07	0.84	1.19	0.82	0.43	1.29
RoSAsia	0.52	0.53	0.45	0.49	0.50	0.43	0.63	0.93	0.96	0.45	0.57	-0.29

- As conjectured, production of food and fuel sectors rise and price falls.

Results: Next generation Biofuel

Table 7: Simulated macroeconomic effects of 5% TFP-shock in ICT sector, 5% TFP shock in BT crops and agro-fuel sectors in USA for selected regions under GTPFuel scenario as described in Section 6.#

USA	CAN	EU	Brazil	Japan	ChiHkg	India	LAEEX	EEFSUEX	RoHIA	MEASTN AEX	SSAEX	RoAFR	THL	PHL	RoSAsia	VNM	RoESEA
Region-wide index of Technical Chage																	
6.91	10.37	4.13	0.60	1.74	0.32	0.26	1.96	0.12	1.57	0.81	0.35	0.52	0.57	0.56	0.53	0.27	0.89
Real GDP at Factor Cost																	
4.01	7.50	2.81	0.43	1.37	0.35	0.23	1.79	0.20	1.39	0.67	0.29	0.38	0.53	0.51	0.48	0.31	0.83
Terms-of-trade																	
0.50	-0.11	-0.07	-0.33	-0.77	0.00	-0.55	0.15	0.55	-0.33	0.78	0.18	0.14	-0.11	-0.20	-0.06	0.44	0.10
Real Income																	
4.49	8.27	3.15	0.43	1.47	0.34	0.11	2.02	0.41	1.36	1.13	0.39	0.48	0.62	0.43	0.49	0.74	1.05
Regional Export Price Index																	
-2.29	-2.57	-2.84	-2.99	-3.40	-2.92	-3.11	-2.51	-2.20	-3.15	-2.03	-2.54	-2.62	-2.96	-3.14	-2.76	-2.36	-2.74
Regional Import Price Index																	
-2.78	-2.46	-2.77	-2.67	-2.65	-2.93	-2.58	-2.66	-2.74	-2.82	-2.79	-2.71	-2.75	-2.85	-2.94	-2.70	-2.80	-2.84
Regional Exports (volume)																	
0.25	3.87	2.48	4.16	4.79	2.16	4.46	3.02	0.98	2.42	1.26	1.48	2.12	1.92	1.37	3.16	0.87	0.75
Regional Imports (volume)																	
5.49	6.97	2.62	-0.66	-0.06	0.06	-0.80	1.89	0.01	0.80	0.22	-0.10	-0.53	-0.36	-0.13	-0.04	0.27	0.16
CPI , Index of Prices paid and received for tradeables (respectively in consecutive rows below)																	
-1.62	-2.58	-2.87	-3.12	-3.42	-2.90	-3.19	-2.32	-2.45	-3.22	-2.34	-2.61	-2.82	-2.97	-3.06	-2.78	-2.20	-2.61
-2.78	-2.46	-2.77	-2.67	-2.65	-2.93	-2.58	-2.66	-2.74	-2.82	-2.79	-2.71	-2.75	-2.85	-2.94	-2.70	-2.80	-2.84
-2.29	-2.57	-2.84	-2.99	-3.40	-2.92	-3.11	-2.51	-2.20	-3.15	-2.03	-2.54	-2.62	-2.96	-3.14	-2.76	-2.36	-2.74

Source: Author's simulations. Except welfare and trade balance results, these values are for % changes of level variables from their base-case values.

- All the regions benefit, but differences are mainly due to extent of relative trade-embodiment and also, differences in the adoption parameters

Policy Recommendations:

- Addressing the pressing problem of sustainability and security—food and fuel –in a way that optimizes environmental & economic benefits via relieving upward pressure on food prices.
- Balancing biofuel production and food security, for sustainable development, to address adverse consequences of land-use changes ; renewable fuel production by exploiting multiple feedstocks (biomass, other energy crops like jatropha, switchgrass, oilgae..) and
- Alterative technologies for beneficial biofuels *so that minimal or no or less intense competition* with food production
- New technologies for boosting yields (productivity) in food – Agricultural Biotechnology as a Complimentary tech
- Also, enabling factors to overcome the country-specific constraints need to be developed. Education, human capital, infrastructure, social capital, governance, etc.

Policy Recommendations:

- North-South and South-South Technical cooperation (e.g., *UNAPCAEM* Technical Cooperation Initiatives UN-ESCAP) is necessary for technology flows and adoption in laggard countries
- Trade liberalization is part of a set of enabling policies that can facilitate crisis management.
- Domestic enabling factors *plus* Global / Regional integration or cooperation to harness the benefits of new technology
- Building Adaptive Capacity through agricultural research and extension services. Education/Literacy. Building investment climate conducive via Rural infrastructure
- Behind the border constraints, apart from policy-induced barriers, need to be addressed

Policy relevance: some quotes

- *"[A] demand-induced problem also calls for rapid expansion in food production, which can be done through more global cooperation."* ***Amartya Sen (May 28, 2008), New York Times.***

- ***Alexander Mueller of the FAO***: boosting yields in Africa, addressing a '*general mismatch of supply and demand*'.

- ***Gerald Nelson et al. , IFPRI(2009):*** *'yield declines are so great that only another round of technological change—a new Green Revolution would be enough to offset them. ..the technology to double or triple many crop yields exists in labs…the problem is to get it into the fields*…G20 meeting promised to put more taxpayer money into research and other help for agriculture."

Policy for action

- Integrated analysis/Synergistic approach is needed for enumerating science and technology policy and compare the alternatives for balancing food-fuel-environment trilemma.
- Needs to consider the tying of ecological and food price effects of plausible scenarios for biofuel incentives/expansion.
- Multi-disciplinary tasks needing collaboration around the world.
- Opportunities and challenges for Food-Fuel Policy is Global as these will have ramifications across borders, esp., Developed vis-à-vis Least-Developed/Developing nations.

Thank you

Give a man a fish, and you can feed him for a day. Teach a man to fish, and you can feed him for a lifetime – Chinese Proverb

Limitations of time:

Next slides are **extras**

if needed for explanation

thanks

Conclusions

- Global Trade in Hi-Tech increased
- Trade-mediated Technology Transmission
- Differential regional impact due to Capture-parameter
- Reduces food-fuel prices but 'not the only contributory factor'
- Developing Socio-Institutional Factors and Absorptive capacity facilitates by creating a favourable 'growth climate'.
- These are instrumental in channelizing and encouraging adoption of promising new inventions
- Differential sectoral impacts.
- Regions with higher productivity and assimilation do better

Future Directions..

- Factor-augmenting tech change-e.g., skill bias (Caselli & Coleman, AER 2006)
- Dynamic Implementation (Walmsley et al., various issues in GTAP).

Emerging trends: World Food Scenario [3]

TABLE 11

Import bills of total food and major food commodities for 2007 and their percentage increase over 2006

COMMODITY	WORLD		DEVELOPING COUNTRIES		LDCs[1]		LIFDCs[2]	
	2007	Increase over 2006	2007	Increase over 2006	2007	Increase over 2006	2007	Increase over 2006
	(US$ million)	*(Percentage)*	*(US$ million)*	*(Percentage)*	*(US$ million)*	*(Percentage)*	*(US$ million)*	*(Percentage)*
Cereals	268 300	44	100 441	35	8 031	32	41 709	33
Vegetable oils	114 077	61	55 658	60	3 188	64	38 330	67
Meat	89 712	14	20 119	18	1 079	24	8 241	31
Dairy	86 393	90	25 691	89	1 516	84	9 586	89
Sugar	22 993	–30	11 904	–14	1 320	–25	4 782	–37
Total food	812 743	29	253 626	33	17 699	28	119 207	35

[1] Least-developed countries (see footnote 13).

[2] Low-income food-deficit countries. FAO classifies countries as low-income food-deficit on the basis of three criteria: their per-capita income; their net food trade position; and a "persistence of position", which postpones the "exit" of an LIFDC from the list, despite the country not meeting the LIFDC income criterion or the food-deficit criterion, until the change in its status is verified for three consecutive years. For a detailed description of the criteria and a list of LIFDC countries, see: http://www.fao.org/countryprofiles/lifdc.asp.

Source: FAO, 2008a.

Emerging trends: World Bioenergy Scenario [1]

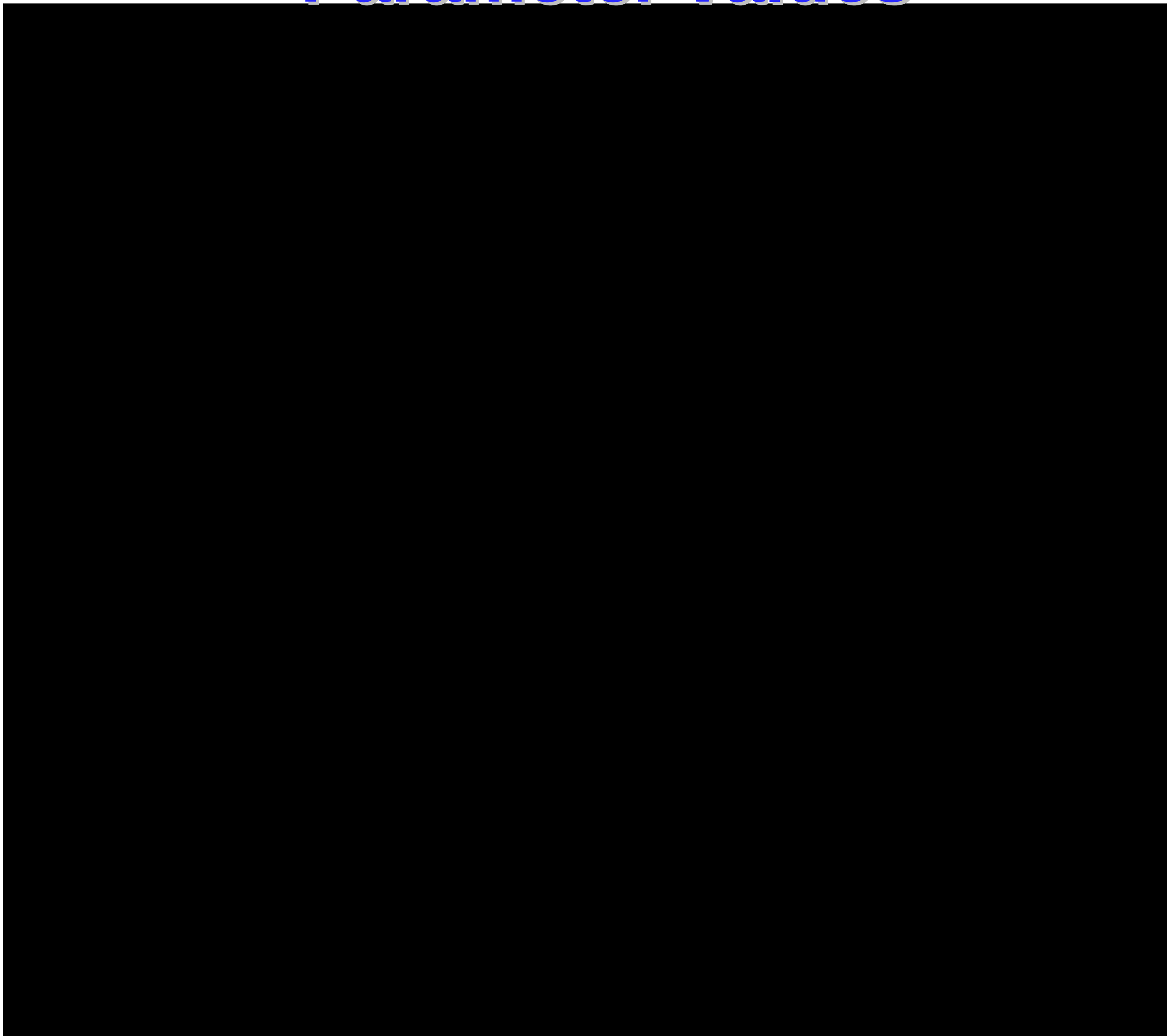
Biofuel production by country, 2007

COUNTRY/COUNTRY GROUPING	ETHANOL		BIODIESEL		TOTAL	
	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)	(Million litres)	(Mtoe)
Brazil	19 000	10.44	227	0.17	19 227	10.60
Canada	1 000	0.55	97	0.07	1 097	0.62
China	1 840	1.01	114	0.08	1 954	1.09
India	400	0.22	45	0.03	445	0.25
Indonesia	0	0.00	409	0.30	409	0.30
Malaysia	0	0.00	330	0.24	330	0.24
United States of America	26 500	14.55	1 688	1.25	28 188	15.80
European Union	2 253	1.24	6 109	4.52	8 361	5.76
Others	1 017	0.56	1 186	0.88	2 203	1.44
World	**52 009**	**28.57**	**10 204**	**7.56**	**62 213**	**36.12**

Note: Data presented are subject to rounding.
Source: based on F.O. Licht, 2007, data from the OECD–FAO AgLink-Cosimo database.

Source: FAO, 2008

Parameter values



Technology Transmission Mechanism

Specifications for Technology flows involve:-

•Sectoral Trade-Embodiment Index (input-specific trade intensity)

• Spillover Coefficients (domestic and trade-induced spillover)

-exogenously specified *Capture-parameter*, $\theta \in [0, 1]$

- **θ_s = AC_s .HD_{rs}. [GP_{rs}. ICC_s**, r is the Source of Technological change, HIE, Specifying the Parameters in the base-case data

Governance Parameter: $GP_{rs} = \min [1, GP_s/GP_r]$ **(3)**

ICC_s: degree of technological proximity

$ICC_s = \min [1, TC_s/TC_{threshold}]$ **(1)**

Social Acceptance Parameter: $HD_{rs} = \min [1, HD_s/HD_r]$ (2)

Structural Congruence (SCI_{rs}) $= ICC_s.HD_{rs}$

(4a)

Structural Incongruence (SAP_{rs}) $= GP_{rs}.HD_{rs}$

Model of Technology Spillover

Indexes: i = Unique Source Sector, j = using Sectors
r = Source region HIE, s= Recipients

. Embodiment Index for Destination 's'

$$E_{ijrs}=F_{irjs}/M_{ijs} \qquad i\neq j,\ r\neq s \qquad (6)$$

. Spillover Coefficient for 's'

$$\gamma_{ijrs}(E_{ijrs},\theta_s) = E_{ijrs}^{1-\theta s} \qquad (7)$$

- Spillover Equation for 's'

$$ava(j, s)=\gamma_{ijrs}(\bullet).\ ava(i, r)\ \ [r\neq s] \qquad (11)$$

- Spillover Equation for Source 'r'

$$ava(j, r)=\gamma_{ijr}(\bullet).\ ava(i, r) \qquad (11')$$

Intermediate-augmenting Tec $af_{ijs} = E_{ijrs}^{1-\theta_s} af_{ijr}$ **(12)**

Induced innovation in agro-chemical inputs equation: **(13)**

Technology Spillover: Bioenergy

Indexes: i = Unique Source Sector, j = using Sectors
r = Source region HIE, s= Recipients

- Spillover Equation for 's'

$afall(i, j, s) = \gamma_{ijrs}(\bullet).\ af(i, j, r)\ \ [r \neq s]$ (12a)

- Spillover Equation for Algae–based technical change's'

$af(k, l, s) = \gamma_{ijrs}(\bullet).\ afall(k, j, r)$ (13a)

'k': plant based algae sector,
i = ICT,
l = other agro-based sectors for bio-fuel:

Simulation Results: Economy-wide Impact [2]

Table 3: Simulated macroeconomic effects of 5% TFP-shock in ICT sector, 10% TFP shock in BT crop sectors and 5% in agro-chemicals in USA with 5% TFP shock in respective BT-crops in LDCs on for selected regions under designated scenarios described in Section 6.#

Regions / Scenarios ↓	USA	CAN	EU	Brazil	Japan	ChiHkg	India	LAEEX	EEFSUEX	RoHIA	MEASTN AEX	SSAEX	RoAFR	THL	PHL	VNM
1 Region-wide index of Technical Chage																
BtGrain	1.48	18.92	12.46	10.05	20.86	5.03	10.13	11.38	0.06	3.31	2.12	0.28	0.34	-0.04	0.15	0.02
BtRice	1.01	18.02	13.81	5.06	13.82	5.07	10.40	6.32	0.29	1.51	0.09	0.23	0.60	0.23	0.53	0.50
BtWheat	0.75	15.41	13.49	5.15	17.26	7.12	10.20	11.49	0.25	3.37	1.81	1.39	0.84	1.62	2.88	0.44
ItBtAgChem	2.73	5.17	2.08	0.31	0.89	0.16	0.19	1.42	0.26	0.71	0.47	0.16	0.28	0.27	0.42	0.21
5 Regional Export Price Index																
BtGrain	-2.38	-2.66	-2.38	-2.61	0.07	-1.89	-2.59	-2.47	-2.52	-2.14	-3.04	-2.42	-2.52	-2.13	-1.50	-2.19
BtRice	-1.62	-1.81	-1.37	-1.73	-0.92	-1.38	-1.84	-1.47	-0.96	-1.54	-0.84	-1.27	-1.21	-1.69	-1.33	-1.49
BtWheat	-2.17	-2.26	-1.96	-2.17	-0.49	-2.03	-2.25	-2.06	-1.62	-2.00	-1.85	-2.12	-1.79	-1.81	-1.67	-1.73
ItBtAgChem	-1.15	-1.30	-1.45	-1.53	-1.75	-1.50	-1.60	-1.28	-1.13	-1.62	-1.04	-1.29	-1.34	-1.51	-1.61	-1.20
6 Regional Import Price Index																
BtGrain	-2.24	-2.26	-2.29	-2.26	-2.30	-1.83	-2.41	-2.25	-2.27	-1.80	-2.24	-2.37	-2.31	-1.82	-1.76	-2.08
BtRice	-1.39	-1.52	-1.36	-1.37	-1.37	-1.36	-1.21	-1.54	-1.36	-1.25	-1.42	-1.47	-1.39	-1.24	-1.33	-1.31
BtWheat	-1.92	-2.04	-1.92	-1.92	-1.93	-1.72	-1.81	-2.04	-1.89	-1.59	-1.94	-2.00	-1.94	-1.63	-1.69	-1.84
ItBtAgChem	-1.42	-1.25	-1.42	-1.36	-1.35	-1.50	-1.32	-1.35	-1.40	-1.44	-1.42	-1.38	-1.40	-1.46	-1.50	-1.43
7 Regional Exports (volume)																
BtGrain	4.57	3.45	2.21	4.05	-11.78	1.56	3.27	3.26	1.02	2.79	2.76	1.44	2.08	2.85	1.05	1.48
BtRice	3.27	3.02	1.56	2.78	-2.16	1.24	3.06	1.80	0.57	2.45	0.58	0.88	1.26	2.01	0.87	1.14
BtWheat	4.52	2.72	1.95	3.39	-6.73	3.13	3.33	2.25	0.88	3.30	1.85	1.90	1.57	1.18	1.24	1.24
ItBtAgChem	0.05	1.88	1.25	2.13	2.46	1.10	2.29	1.54	0.50	1.23	0.64	0.76	1.08	0.99	0.70	0.44
8 Regional Imports (volume)																
BtGrain	0.38	5.27	1.17	-1.10	13.04	-0.28	-0.83	5.98	-0.38	2.02	0.76	-0.23	-0.81	-0.76	0.09	-0.05
BtRice	0.19	5.18	2.40	-0.98	4.02	0.01	-0.52	0.81	0.09	1.69	-0.13	0.00	-0.03	-0.53	0.13	0.26
BtWheat	-0.24	3.34	2.07	-0.79	8.81	1.28	-0.65	5.22	0.09	2.78	1.00	0.87	0.13	1.34	1.06	0.31
ItBtAgChem	2.80	3.54	1.32	-0.35	-0.06	0.02	-0.43	0.94	0.00	0.40	0.09	-0.06	-0.29	-0.20	-0.08	0.13

Source: Author's simulations. Except welfare and trade balance results, these values are for % changes of level variables from their base-case values (post-