Climate Change and Food-Fuel-Finance Linkage

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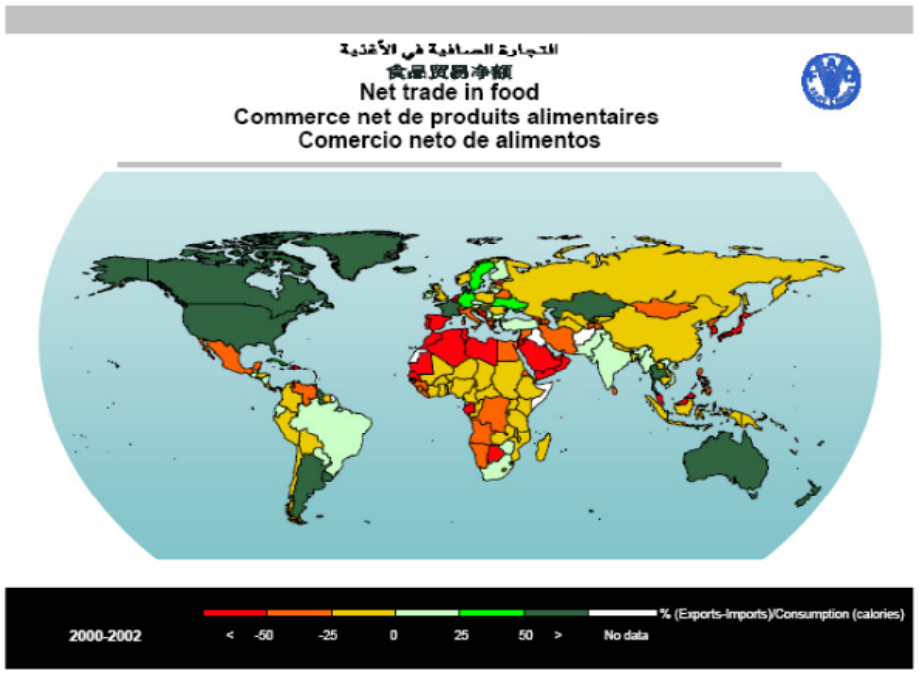
(1) The Global Status of Thailand's Agricultural Exports



Thailand: Main Agricultural Productions

	Rice	Cassava	Sugar cane	Rubber	Palm
% per total arable land	53.85%	5.68%	5.06%	12.51%	2.20%
No. of families involved	4,150,400	480,484	200,000	1,259,002	108,386
% Share in the World market	34.91% (No.1)	70% (No. 1)	9.61% (No. 2)	42.54% (No. 1)	0.99 % (No. 3)

Source: Office of Agriculture Economics, Thailand (Statistics of 2009)

Ratios of Domestic Consumption per Export of Major Crops (million tons)

	2005	2006	2007	2008
Rice	10.46/7.50	10.78/7.49	11.21/9.20	11.10/10.22
Sugar cane	3.70/4.63	4.20/6.52	6.50/5.79	9.65/4.04
Cassava	2.02/3.03	2.28/2.24	2.07/4.42	1.08/5.00
Palm	0.82/0.19	0.95/0.30	0.87/0.43	0.99/0.50

Thailand exports more than a half of its main crops' production (except Palm oil).

Source: Office of Agriculture Economics, Thailand (Statistics of 2008)

Average Growth of Domestic Supply and Domestic Demand of Main Crops

	Supply	Demand
Rice (1962-2007)	2.88%	1.20%
Sugar cane(1966-2007)	10.19%	6.18%
Cassava(1966-2007)	7.72%	3.89%
Palm(1966-2007)	18.93%	5.56%

The key driving force of excess supply for exports is the growth rate of supply, which has been much greater than that of demand in the past 40 years.

Source: Office of Agriculture Economics, Thailand (Statistics of 2007)

(2) Characteristics of World Agricultural Markets

(2) Characteristics of World Agricultural Markets

(2.1) Supply Side: Most markets are dominated by 3-5 big exporters.

	Rice	Cassava	Sugar	Rubber	Palm Oil
Top-5 Exporters	1.Thailand 2.Vietnam 3.India 4.Pakistan	1.Thailand 2.Vietnam 3.China 4.Indonesia 5.Brazil	1. Brazil 2. Thailand 3. Australia 4. EU 5. Guatemala	1. Thailand 2. Indonesia 3. Malaysia 4. Vietnam 5.Cambodia	1. Indonesia 2. Malaysia 3. Thailand 4. Papua New Guinea 5. Jordan
Market Share of Top-5 Exporters	74.75%	86.23%	67.32%	80%	94.94 %

Source: FAO (Statistics of 2008)

(2) Characteristics of World Agricultural Markets

(2.2) Demand Side: Some markets are dominated by 3-5 big importers.

	Rice	Cassava	Sugar	Rubber	Palm Oil
Top-5 Importers	1. Philippines 2. Iran 3. Nigeria 4. Saudi Arabia 5. EU	1. EU 2. China	1. EU 2. Russia 3. US 4. Indonesia 5. India	1. China 2. EU 3. US 4. Japan 5. India	1. China 2. India 3. EU 4. Pakistan 5. Bangladesh
Market Share of Top-5 Importers	26.58%	80%	26.34%	70%	58.68 %

Source: FAO (Statistics of 2008)

(2) Characteristics of World Agricultural Markets

(2.3) Thin Market: The ratio of the traded volume/global production is very low in some agri commodities

	Rice	Cassava	Sugar	Rubber	Palm Oil
Traded Volume / Global Production	4.37%	2.78%	32.44%	31.51%	73.11 %

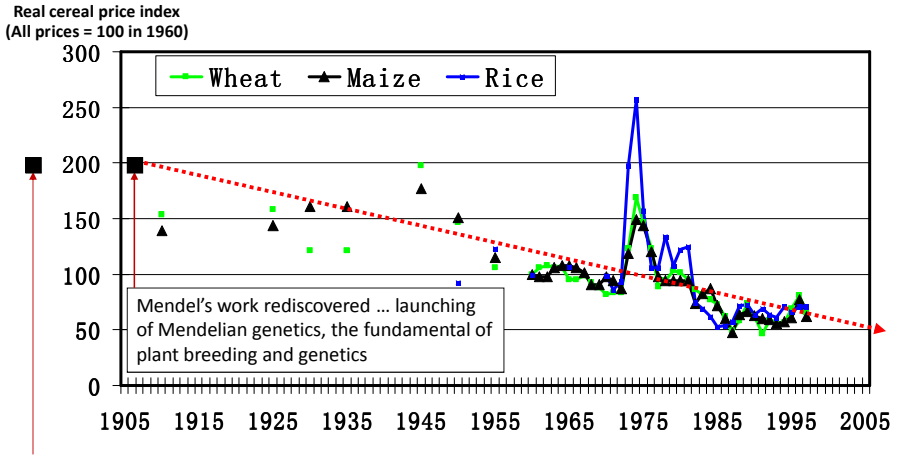
Source: FAO (Statistics of 2008)

(2) Characteristics of World Agricultural Markets

Summary: The world markets of agri products are mostly *oligopolistic* (mainly due to the geographical constraints). Hence, most exporting and importing countries had imposed tax, duty, subsidy and other trade barriers to correct this imperfect mechanism or to gain their benefits. But the establishment of GATT, WTO and Free Trade Agreement (FTA) has lessened these trade barriers in the past decade.

(3) Special Features of Recent Food-Fuel-Finance Linkage

The Genetic Revolution has lowered the real global cereal price index for a hundred years

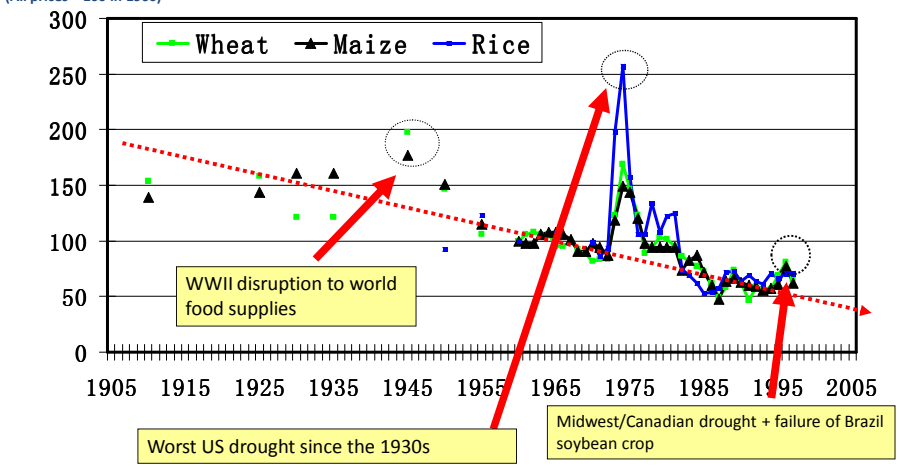


≈ Real price of food when Gregor Mendel published his paper: "Experiments in Plant Hybridization" [1866]

Source: IFPRI

Supply shortage caused "price spikes" in the past

All previous spikes preceded by major global supply shock (in a number of major exporting countries)



Source: IFPRI

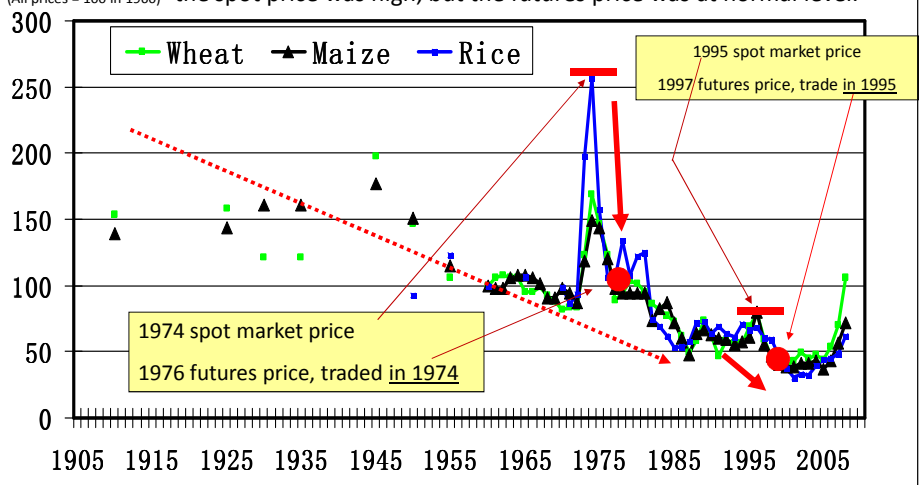
New evidence of global price relations

- Despite expected rises of grain and soybean productions in 2008, the prices in commodity future market for 2009-2010 are as high (or higher) as their current prices
- Markets are clearly expecting prices to stay high … clearly: this is not a supply shock-led rise

Source: IFPRI

Relationship between spot and futures prices during previous "world food crises"

All players knew that it was the year-specific supply shortage. Hence, the spot price was high, but the futures price was at normal level.



Source: IFPRI

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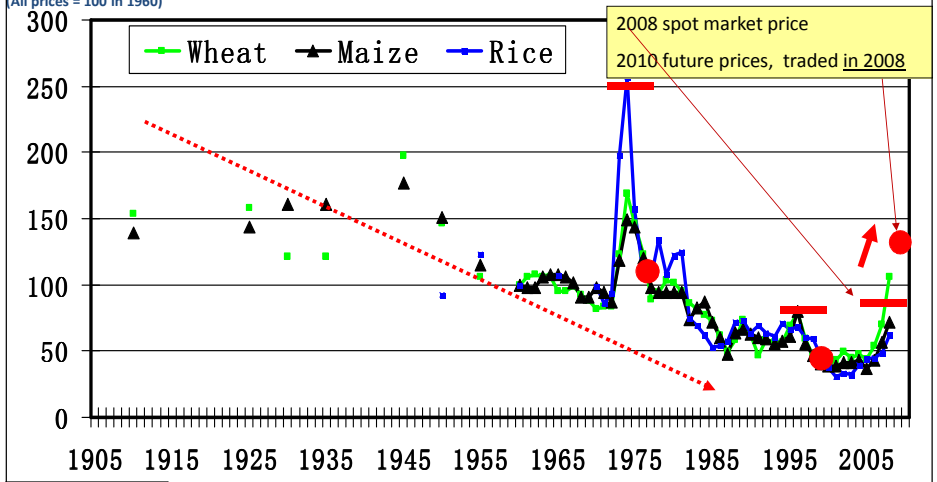
Relationship between spot and futures prices during CURRENT "world food crises"

This means markets do NOT expect prices to come back down to trend … obviously this time the price rise is not due (only) to a supply shock



Source: IFPRI

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Correlations among prices of *rice*, crude oil, gold and stock index

Range of samples: October 1995 – October 2009

	Crude Oil Price	Gold Price	Dow Jones Index
Rice price (CBOT)	0.152	0.134	0.191
Crude Oil Price		0.210	0.277
Gold Price			-0.073

Source: FPRI (Thailand)

Range of samples: January 2008 – October 2009

	Crude Oil Price	Gold Price	Dow Jones Index
Rice price (CBOT)	**0.519**	**0.265**	**0.426**
Crude Oil Price		0.195	**0.749**
Gold Price			0.079

Source: FPRI (Thailand)

Correlations among prices of rice, crude oil and the stock index have increased significantly since 2008.

Correlations among prices of *sugar*, crude oil, gold and stock index

Range of samples: October 1995 – October 2009

	Crude Oil Price	Gold Price	Dow Jones Index
Sugar price (NYME)	0.094	0.153	-0.062
Crude Oil Price		0.210	0.277
Gold Price			-0.073

Source: FPRI (Thailand)

Range of samples: January 2008 – October 2009

	Crude Oil Price	Gold Price	Dow Jones Index
Sugar price (NYME)	**0.398**	**0.481**	**0.529**
Crude Oil Price		0.195	**0.749**
Gold Price			0.079

Source: FPRI (Thailand)

Correlations among prices of *sugar*, crude oil and the stock index have increased significantly since 2008.

Econometric Test:

Influence of Speculative Volumes of Futures on Spot Price

Rice Price

Range of samples: October 1995 – October 2009

$$\Delta \text{Log}(\text{Spot}_t) = 0.001 + 0.265\ \Delta\text{Log}(\text{Future1Month}_{t-1}) + 0.184\ \Delta\text{Log}(\text{Future2Month}_{t-2})$$
$$(1.099) \quad (5.536)^{**} \quad (3.469)^{**}$$
$$+ 0.000\ \Delta\text{Log}(\text{Volume2Month}_t/\text{OpenInterest1Month}_t)$$
$$(0.083)$$
$$- 0.010\ \Delta\text{Log}(\text{Volume2Month}_t/\text{OpenInterest2Month}_t) + e_t$$
$$(-1.386)$$

Adjusted $R^2 = 0.281$

Range of samples: January 2007 – October 2009

$$\Delta \text{Log}(\text{Spot}_t) = 0.005 + 0.161\ \Delta\text{Log}(\text{Future1Month}_{t-1}) + 0.245\ \Delta\text{Log}(\text{Future2Month}_{t-2})$$
$$(1.857)^{+} \quad (1.821)^{+} \quad (2.613)^{*}$$
$$- 0.022\ \Delta\text{Log}(\text{Volume2Month}_t/\text{OpenInterest1Month}_t)$$
$$(-1.539)$$
$$- 0.041\ \Delta\text{Log}(\text{Volume2Month}_t/\text{OpenInterest2Month}_t) + e_t$$
$$(-2.046)^{**}$$

Adjusted $R^2 = 0.278$

Source: Computation by FPRI, Thailand's Ministry of Finance

Econometric Test:

Influence of Speculative Volumes of Futures on Spot Price

Sugar Price

Range of samples: January1989 – September 2009

$$\Delta\log(\text{Spot}_t) = 0.006 + 0.741\ \Delta\log(\text{Future}_{t-1}) + 0.008\ \text{Log}(\text{Volume}_t/\text{OpenInterest}_t) + e_t$$
$$(1.481) \quad (21.734)^{**} \quad (1.428)$$

Adjusted $R^2 = 0.658$

Range of samples: January 2006 – October 2009

$$\Delta\log(\text{Spot}_t) = 0.026 + 0.691\ \Delta\log(\text{Future}_{t-1}) + 0.03\ 4\ \text{Log}(\text{Volume}_t/\text{OpenInterest}_t) + e_t$$
$$(2.033)^{**} \quad (7.627)^{**} \quad (2.005)^{*}$$

Adjusted $R^2 = 0.575$

Source: Computation by FPRI, Thailand's Ministry of Finance

The speculative volume has had a statistically significant influence on the spot price since recent years.

Econometric Test:

Influence of Speculative Volumes of Futures on Spot Price

Palm Oil

Range of samples: January1997 – September 2009

$$\Delta\log(\text{Spot}_t) = 0.001 + 0.413\ \Delta\log(\text{Future}_{t-1}) + 0.077\ \Delta\text{Log}(\text{Volume}_t/\text{OpenInterest}_t) + e_t$$
$$(0.486) \quad (4.949)^{**} \quad (0.006)$$

Adjusted $R^2 = 0.191$

Range of samples: January 2006 –September 2009

$$\Delta\log(\text{Spot}_t) = 0.001 + 0.489\ \Delta\log(\text{Future}_{t-1}) + 0.138\ \Delta\text{Log}(\text{Volume}_t/\text{OpenInterest}_t) + e_t$$
$$(0.335) \quad (3.876)^{**} \quad (3.007)^{**}$$

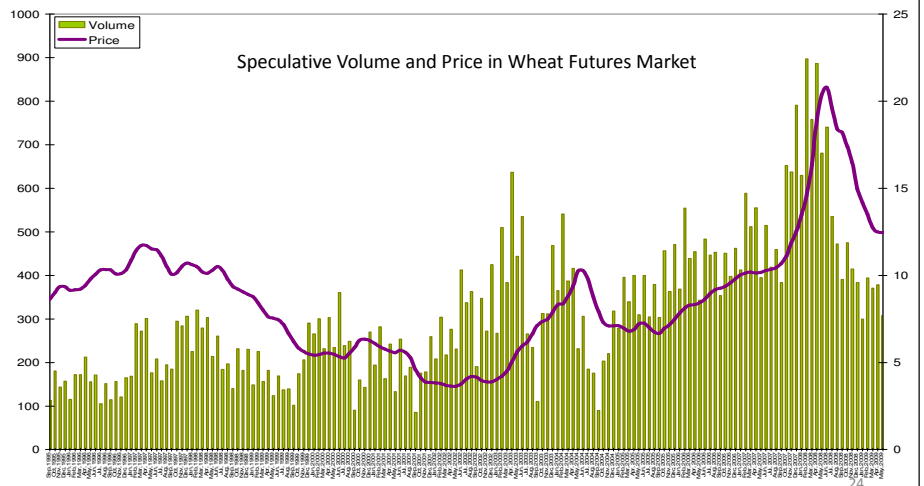
Adjusted $R^2 = 0.354$

Source: Computation by FPRI, Thailand's Ministry of Finance

Similar to the case of rice and sugar, the speculative volume of the palm-oil futures has had a statistically significant influence on the spot price since recent years.

Increasing transaction and price on futures market

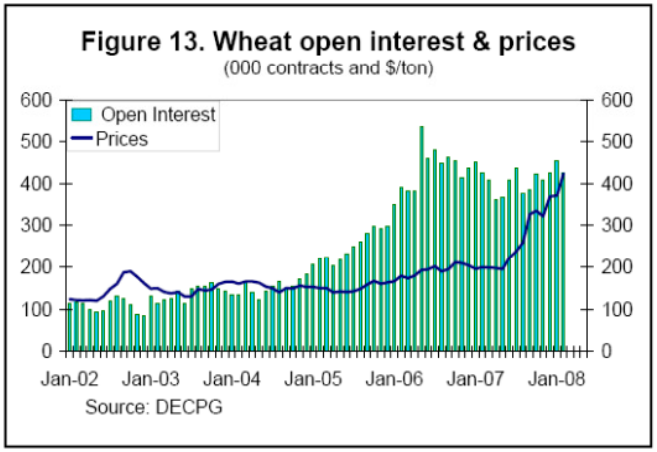
A study conducted by International Food Policy Research Institute (IFPRI) statistically indicates that the speculative activity in the futures market has been influential to the increasing agricultural commodity prices in 2007–08.



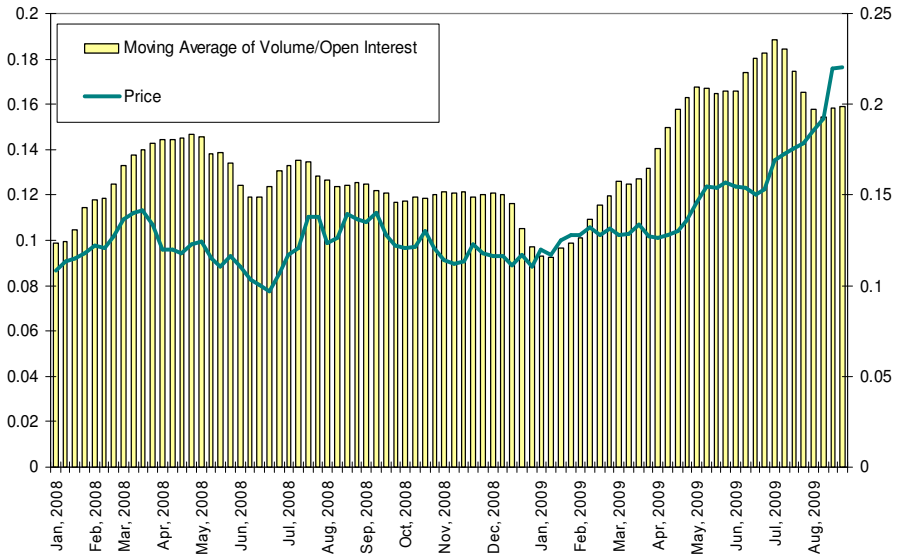
Source: When Speculation Matters by Miguel Robles, Maximo Torero, and Joachim von Braun (IFPRI, 2009)

Increasing transaction and price on futures market

- A reflection of this increased activity was the quadrupling of the number of wheat futures contacts traded on the Chicago Board of Trade from 2002 to 2006 as shown in the figure shown below.
- However, the impact on prices is hard to quantify and most studies do not find that such activity changes prices from the levels which would have prevailed without such activity (Gilbert 2007)



Source: A Note on Rising Food Prices, (Donald Mitchell, The World Bank 2008)

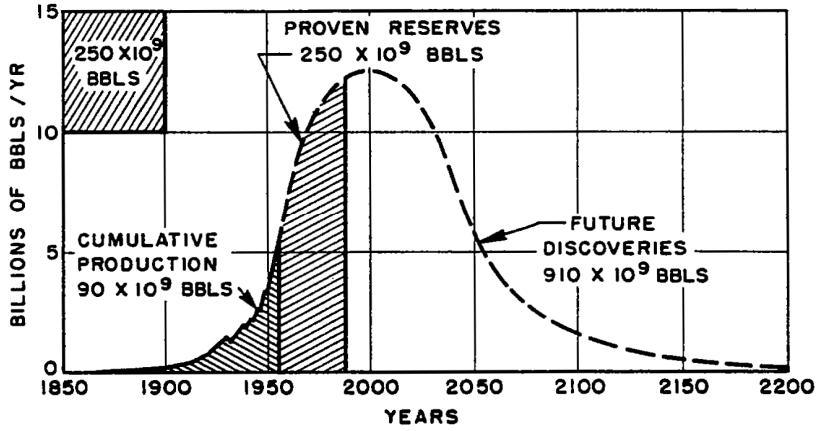


Source: Computation by FPRI, Thailand's Ministry of Finance

(4) Policy Formation toward Thailand's Food and Fuel Security

(4.1) Trends of Global Factors

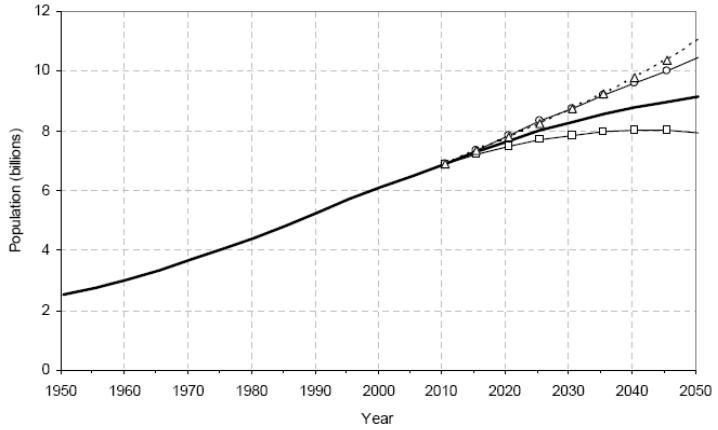
4.1.1 Declining Supply of Crude Oil



Source: http://www.hubbertpeak.com/hubbert/1956/1956.pdf

4.1.2 Increasing World Population

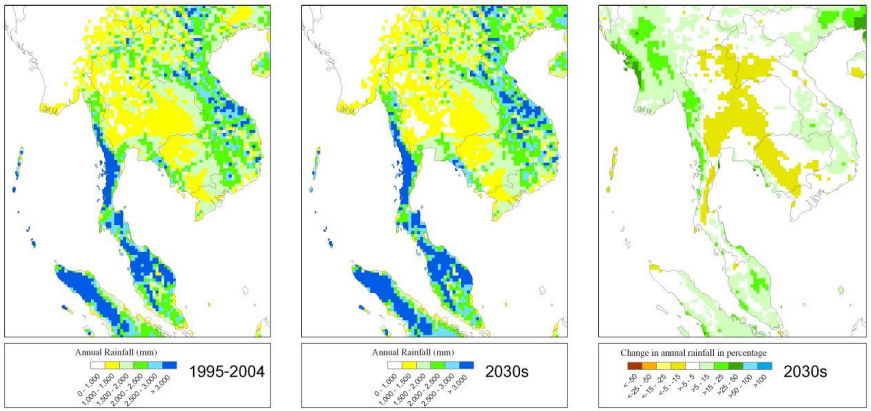
There will be 34.3% more population in 2050. At least 34.3% additional demand for food, water energy, clothes, medicine, etc.



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2009). World Population Prospects: *The 2008 Revision, Highlights*. New York, United Nations.

4.1.3 Effects of Climate Change

The climate change model, built by Chulalongkorn University, predicts that there will be a change in rainfall pattern in Thailand in the next 20 years. Some areas of major crops will be affected.



Source: START, Chulalongkorn University, Thailand

4.1.4 Food-Fuel-Finance Linkage

- High fluctuation and correlation among prices of food – fuel – financial instrument have been increasing since 2006 (the empirical evidences are exhibited in (3)).
- As the main agri exporter and the net energy importer, Thailand is on the verge of formulating a new development paradigm to cope with this change.

(4.2) Agricultural Production Modeling (including the impact of climate change)

Outline of Aggregate Modeling to Support the Formulation of Thailand's National Policy

Climate Change Model

Assumption: CO_2 emission

Output: Temperature, Rainfall, Sun light intensity, Moisture, etc.

Crop Yield Model

Assumption: Temperature, Rainfall, Sun light intensity, Moisture, etc.

Output: Crop yield in a specific area

National Agri Production Model

Assumption: (1) Crop yield (ton / Ha.)
(2) Change in land use
(2.1) Scenario 1: No change
(2.2) Scenario 2: Food maximization
(2.3) Scenario 3: Bio-fuel maximization

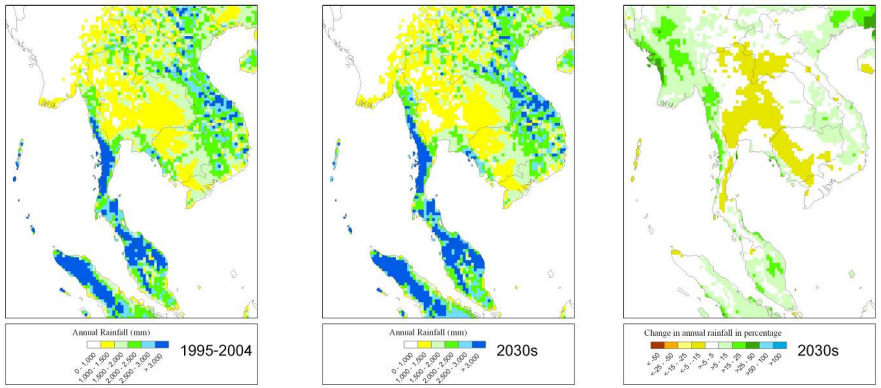
Output: National output

World Commodity Model

Assumption: Production of other exporters, World economic growth, etc.

Output: World Price of Agricultural Commodities

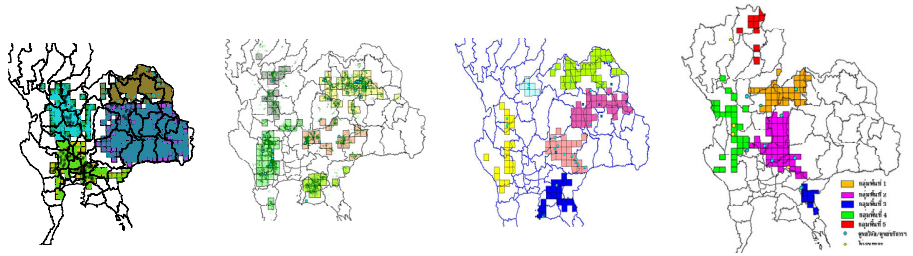
Predicted Changes in Rain Fall



Source: START, Chulalongkorn University

Land Allocation:

Scenario 1 – No change in land use

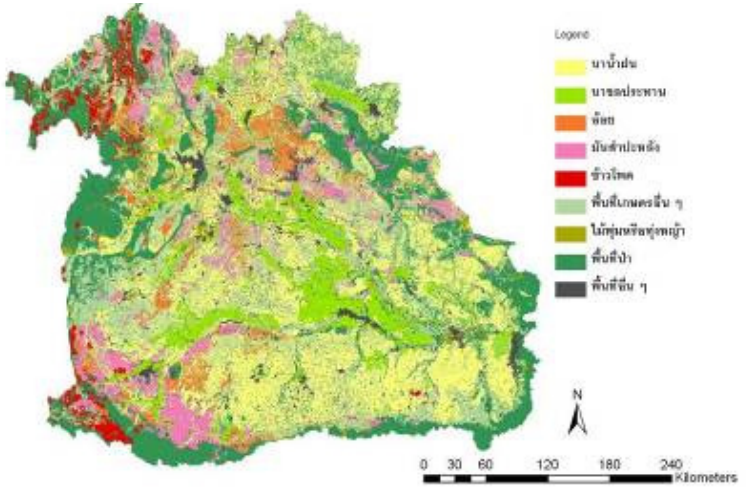


Rice Sugar cane Cassava Corn

Source: START, Chulalongkorn University

Land Allocation: Scenario 2 - Food Maximization

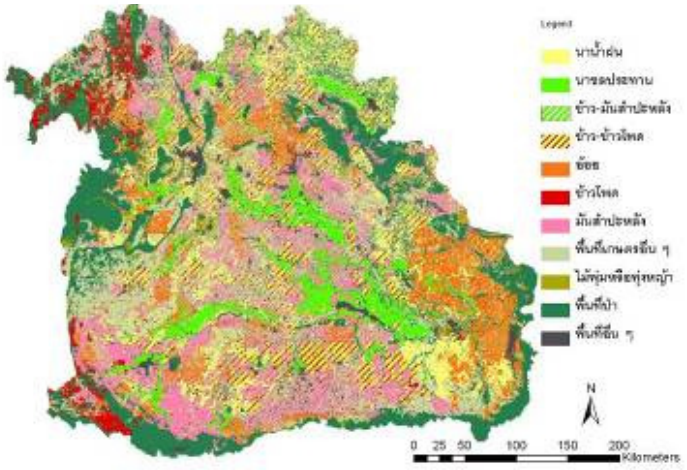
Northeastern Region of Thailand



Source: START, Chulalongkorn University

Land Allocation: Scenario 3 - BioFuel Maximization

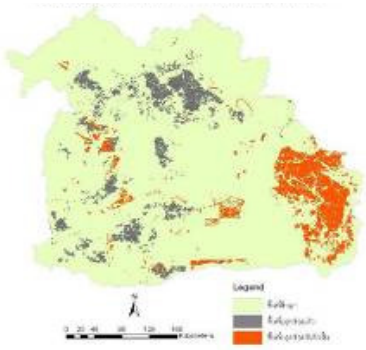
Northeastern Region of Thailand



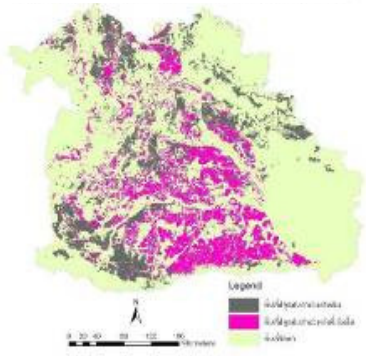
Source: START, Chulalongkorn University

Land Allocation: Scenario 3 - BioFuel Maximization

New areas for sugar cane



New areas for cassava



Source: START, Chulalongkorn University

Predicted Supply of Major Crops

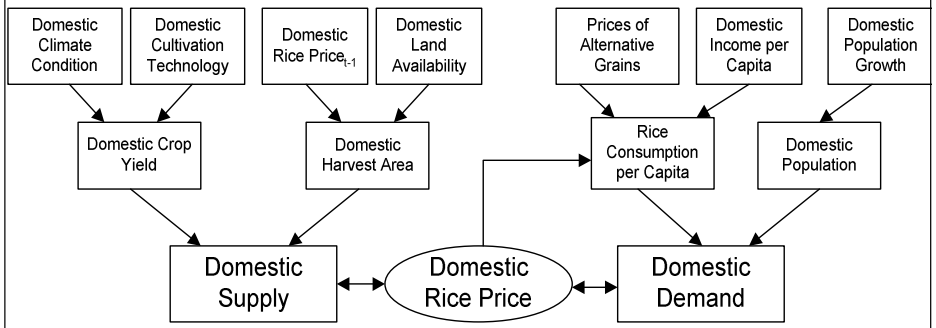
(with Effects from Climate Change and Land Use Changes)

(Unit: million tons)

	Average Annual Output (1995-2004)	Predicted Output in 2030 : Scenario I (No change)		Predicted Output in 2030 : Scenario II (Food Maximization)		Predicted Output in 2030 : Scenario III (BioFuel Maximization)	
Rice (Rain-Fed)	18.07	17.48	-3.36%	17.28	-4.33%	13.90	-23.07%
Rice (Irrigated)	8.23	8.31	0.92	9.18	11.46	8.23	-0.07%
Sugar cane	78.31	74.09	-5.7%	74.09	-5.4%	112.85	44.1%
Cassava	26.47	21.75	-17.8%	21.75	-17.8%	36.06	36.1%

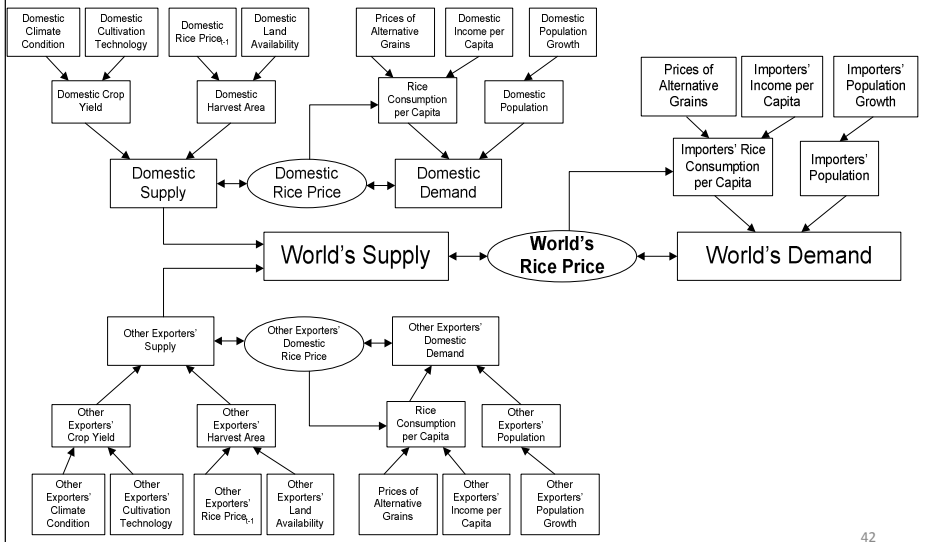
Source: START, Chulalongkorn University

Thailand's Rice Market Model



Source: FPRI

World's Rice Market Model

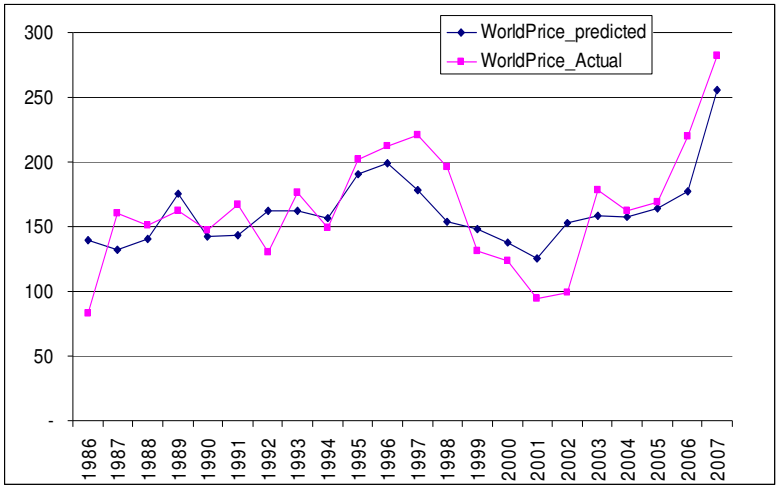


Source: FPRI

Model's Performance: World Rice Market

$$P\_USD = 31.40*P\_WHEAT\_USD_t + 7.75*e\text{-}007*D\_S\_GAP_t + 0.324*P\_USD(-2) + e_t$$
$$(6.97)^{**} \qquad (1.24) \qquad (3.15)$$

Adjusted $R^2 = 0.606$

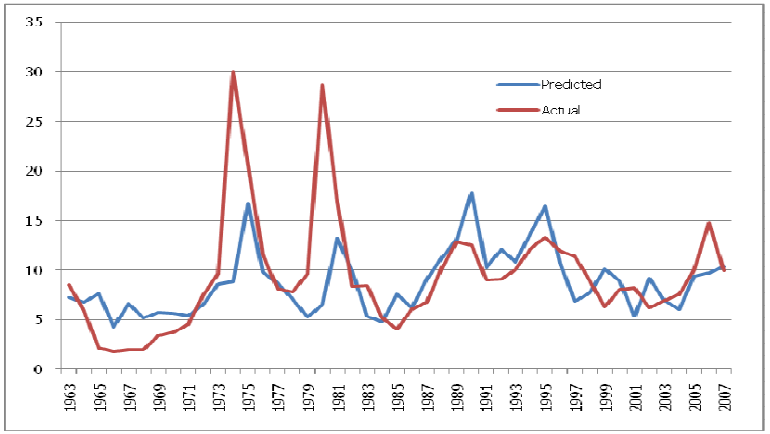


Source: FPRI

Model's Performance: World Sugar Market

$$\ln(Worldprice_t) = 0.141 - 1.44 \ln(Beginning\ Stock_t / Total\ Consumption_t) + e_t$$
$$(0.287) \quad (-3.962)^{**}$$

Adjusted $R^2 = 0.250$

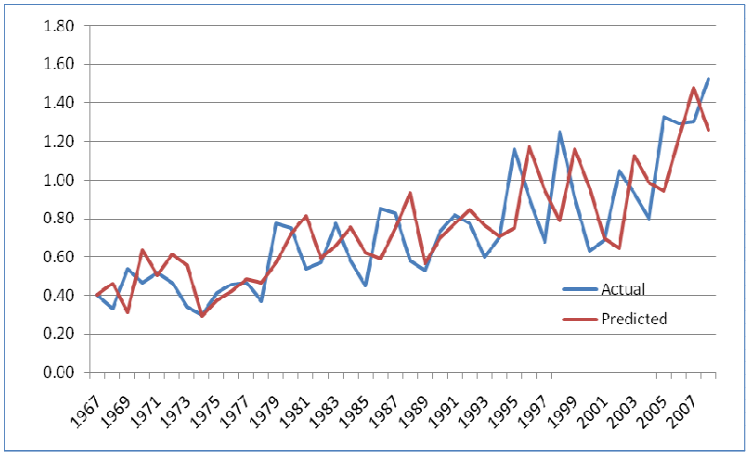


Source: FPRI

Model's Performance: World Cassava Market

$$\text{World Cassava Price}_t = 6.909 - 1.143\ D(\text{World Supply-Demand Gap}_t) + e_t$$
$$(0.066) \quad (-1.937)^{***}$$

Adjusted $R^2 = 0.605$

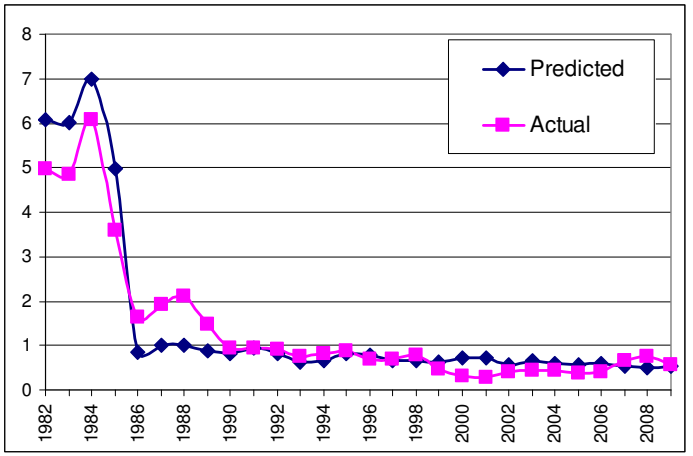


Source: FPRI

Model's Performance: World Palm-Oil Market

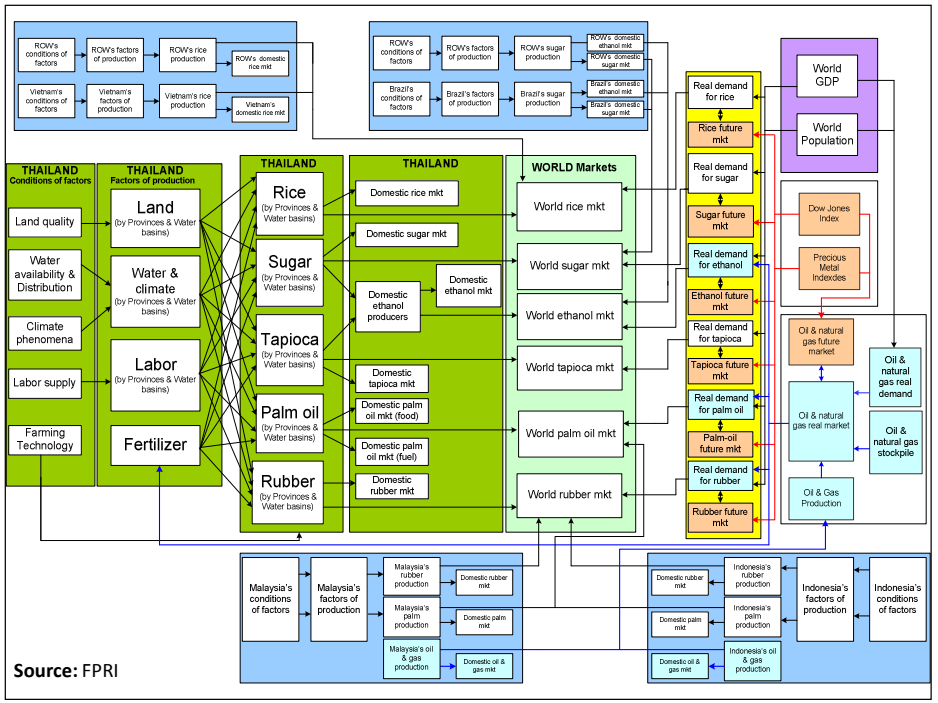
$$(\Delta\ \text{WorldPrice}_t) = 1.102 - 2.265\ (\Delta\text{Total Stock} / \Delta\text{Total Consumption}_{t-1}) + e_t$$
$$(7.853)^{***} \quad (-9.141)^{***}$$

Adjusted $R^2 = 0.782$



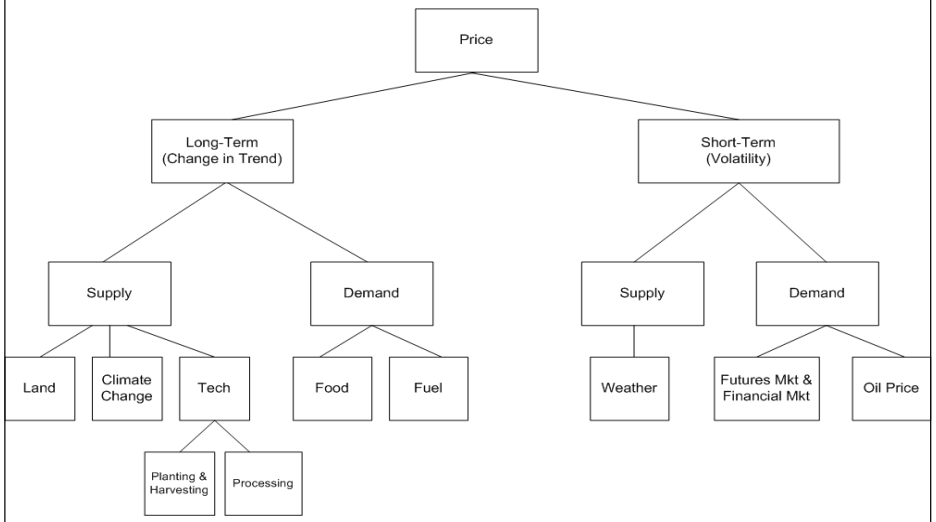
Source: FPRI

(4.3) Global Food -Fuel - Finance Linkage Model



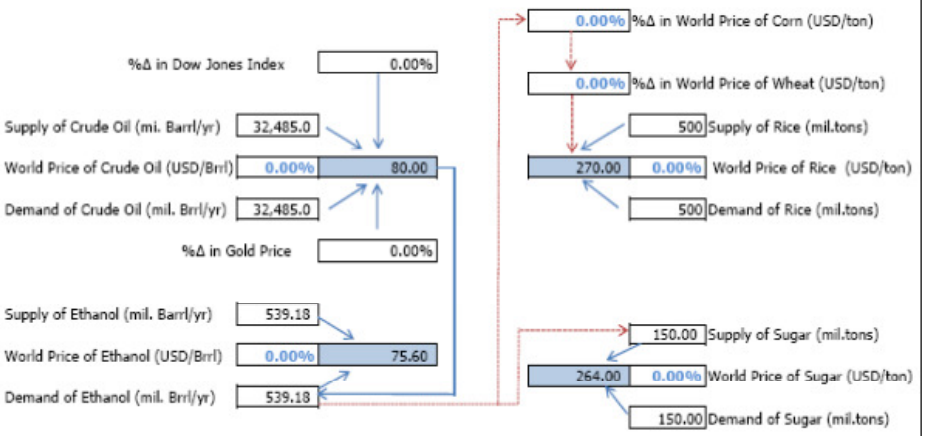
Source: FPRI

Key Factors Affecting Prices of Agri Commodities



Source: FPRI

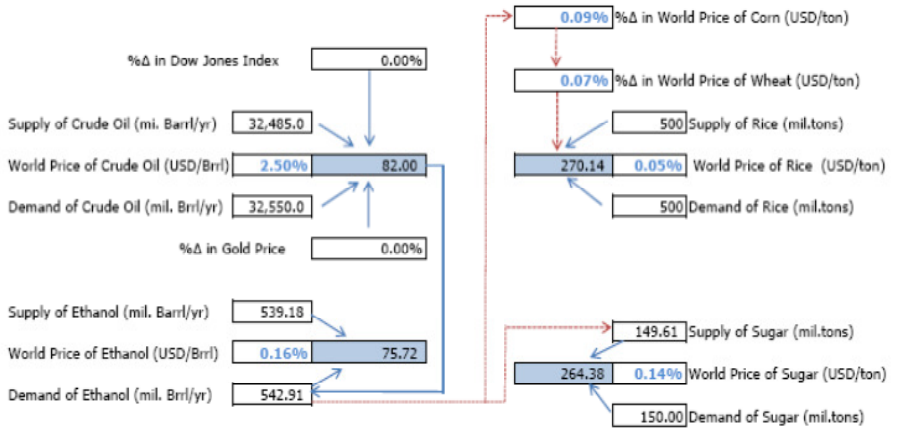
Summary of Food -Fuel - Finance Linkage Model



Source: FPRI

Summary of Food -Fuel - Finance Linkage Model

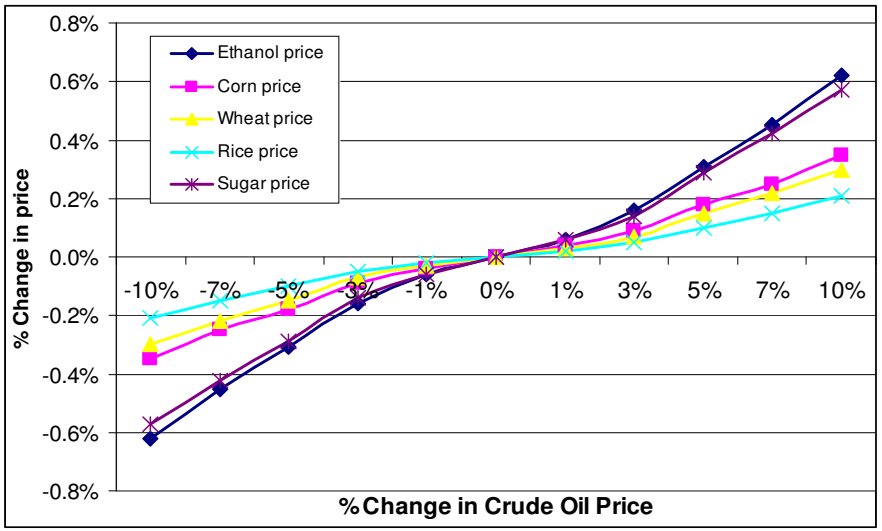
Simulation Result



Source: FPRI

Summary of Food -Fuel - Finance Linkage Model

Simulation Result



Source: FPRI

(4.4) Fuel Demand Model

Fuel Demand Model

Key factors determining total fuel demand

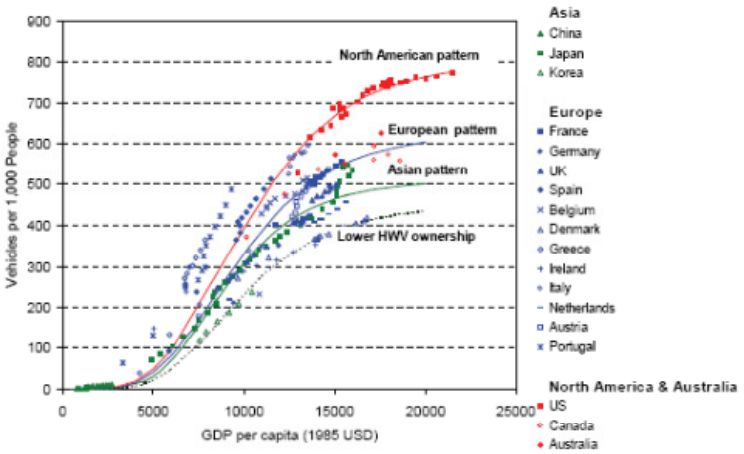
(1)Number of vehicles

(2)Fuel consumption per vehicle

(3)Percentage of biofuel blending

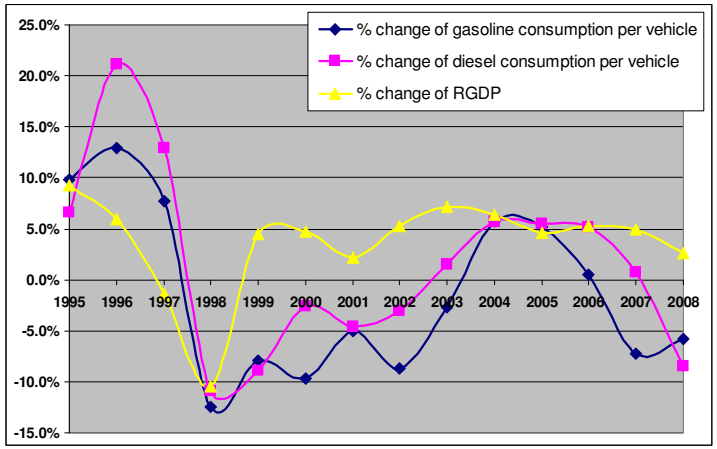
(1) Number of vehicles

S-Curve of Vehicle Ownership



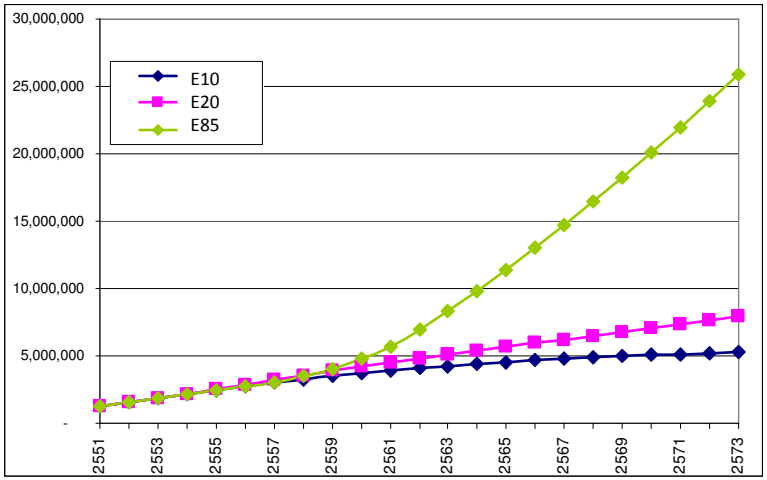
Source: Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO2 Emissions through 2050 Argonne National Laboratory, U.S. Department of Energy (2006)

(2) Fuel Consumption per Vehicle



In the case of Thailand, it is empirically found that the growth of fuel consumption is statistically correlated with the GDP growth.

Predicted Ethanol Demand (litres / day)



Source: FPRI

Thailand's Full Capability of Producing Ethanol

	Total Production (mil.tons/year)	Domestic Consumption (mil.tons/year)	Export (mil.tons/year)	Potential Volume of Ethanol Produced from Total Exported Sugar & Cassava
Sugar cane	71.8	21.54	50.26	11.02 mil.litres/day
Cassava	30.98	9.3	21.66	9.14 mil.litres/day
			Total	**20.16 mil.litres/day**

Source: Office of Agriculture Economics, Thailand (Statistics of 2009)

Thailand has a potential to be self-sufficient in bio gasoline (i.e. ethanol) production !!

Summary of Key Findings of This Study

- Thailand is globally one of the main exporters of rice, sugar, cassava and rubber
- Having a high level of food security (exporting more than 50% of total production)
- The current amount of exported sugar and cassava can alternatively be the feedstock for ethanol production that can serve E85 nationwide
- But 80% of crude oil is imported for domestic use

The Next Step of This Research

What is the optimal allocation of resources for food and fuel production?