The Global Food Price Crisis and China-World Rice Market Integration: 
A Spatial-Temporal Rational Expectations Equilibrium Model

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In a nutshell

The question

How would China affect the international rice market if it liberalized its trade in rice?

- China is the world’s largest producer and consumer;
- Only about 5% of rice is traded internationally.
In a nutshell

**The question**

How would China affect the international rice market if it liberalized its trade in rice?

- China is the world’s largest producer and consumer;
- Only about 5% of rice is traded internationally.

**The answer**

It will substantially reduce and stabilize the world rice price:

- reducing risk faced by major importers;
- particularly price spikes caused by export restrictions.

**The model**

Spatial-temporal rational expectations:

- four interdependent markets;
- storage by speculative storers and government.
Rice is one of the world’s main staples.

The poor spend around 40% of their income on staples.

The sudden price increase particularly hurt the poor in developing countries.

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Data source: FAO: Thailand, 100% B, 2nd grade, White rice broken, Bangkok, f.o.b.
Outline

1. Introduction
2. The Model
3. Results
4. Conclusions
The spatial dimension

**Exporters**
- Brazil
- Egypt
- India

**World Market**
- Bangladesh
- Indonesia
- Malaysia
- Philippines
- United States

**Importers**
- Cote d'Ivoire
- Iran
- Iraq
- Nigeria
- Saudi Arabia
- Senegal

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Romero-Aguilar, Liu, Chen, Miranda

The Global Food Price Crisis

2013 AAEA Meeting
The spatial dimension

The Model

Description

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The Global Food Price Crisis

2013 AAEA Meeting
The spatial dimension

China

World Market

Importers

Exporters
The spatial dimension
The spatial dimension

China

Exporters

World Market

Importers

$\text{Exporters \ ban exports}$

$\text{China gets integrated}$

$\text{Importers set buffer stock}$
The temporal dimensions
The temporal dimensions

Past

Present

Future

Yield

Acres
The temporal dimensions
The temporal dimensions

Past

Old Stock

New Harvest

Yield

Acres

Present

Future
The temporal dimensions

The Model

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<tr>
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The Model

The temporal dimensions

- Past
  - Acres
  - Yield

- Present
  - Old Stock
  - New Harvest
  - New Stock
  - Consumption
  - Export
  - Prices
  - Expectation

- Future
  - Prices
The temporal dimensions
Solving the model

- There are 31 variables in the model: 23 endogenous, 4 exogenous, and 4 predetermined.
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- Two main challenges:
  - Solving the mixed-complementarity conditions (Newton’s method applied to Fisher’s function, the *semismooth rootfinding formulation*)
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  - Approximating the expected prices as a function of availabilities (projection methods, using tensor product of quadratic Chebyshev polynomials).
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- Parameter calibration.
Putting the model to work

- Once solved, model is simulated to compare alternative scenarios
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- Comparison based on stationary distribution of variables
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- Once solved, model is simulated to compare alternative scenarios
- Comparison based on stationary distribution of variables
- Model allows to analyze the dynamic adjustment to new stationary equilibrium, following a regime change
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How much rice would be traded?

Over time, China would export on average 6.25% of its rice production.

Baseline: NO exporter ban, YES importer stock.
How much rice would be traded?

That would increase the world volume of rice trade, while reducing its variability.
The effect of China’s integration on world rice price

**Normal trade**

- **No stockpile in importers**
  - Distribution parameters:
    - Kernel density graph with values: $\mu = 1.01$, $\sigma = 0.09$

- **Importers have stockpile**
  - Distribution parameters:
    - Kernel density graph with values: $\mu = 0.99$, $\sigma = 0.05$

**Export bans**

- **No China**
  - Distribution parameters:
    - Kernel density graph with values: $\mu = 1.67$, $\sigma = 0.20$

- **No China**
  - Distribution parameters:
    - Kernel density graph with values: $\mu = 1.70$, $\sigma = 0.20$
The effect of China’s integration on world rice price

**Normal trade**

**No stockpile in importers**

- With China:
  - $\mu = 1.01$, $\sigma = 0.09$
  - $\mu = 0.92$, $\sigma = 0.02$

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Can importers stabilize domestic price?

Without a buffer stock, local prices in importing countries increase in response to a ban on exports.

Baseline: China not integrated
Can importers stabilize domestic price?

Having a stock provides minimal help during normal trade years...

Normal trade

Export bans

Baseline: China not integrated
Can importers stabilize domestic price?

...yet it is definitely ineffective in a trade disruption.
The dynamics of adjustment after China’s integration
The dynamics of adjustment after China’s integration

**Prices**

**Stockpiles**

- **new steady-state**
- **response to shock**
- **90% interval**
The dynamics of adjustment after China’s integration

**Prices**

- **World**
  - New steady-state
  - Response to shock
  - 90% interval

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Summary of results

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- Following China’s integration, price and acreage will increase in China. Opposite result in world market.
Conclusions

Summary of results

- Bans on exports increase the expected price of rice and its volatility.
- Storage by importer do not affect the world price nor their local price.
- In all scenarios, China’s integration to international rice market reduces both the mean and variance of the world price.
- Following China’s integration, price and acreage will increase in China. Opposite result in world market.
- Prices would adjust fast, while acreage and China’s stockpile would adjust slowly.
Additional material

Model equations:
- Consumption demand
- Prices: market clearing
- Storage conditions
- Production supply
- Trade: arbitrage
- Availabilities

High price volatility:
- Export restrictions and price
Consumption demand

0 \leq C_c \leq \infty \quad \& \quad C_c = \alpha_c P_c^{-\beta_c}
0 \leq C_x \leq \infty \quad \& \quad C_x = \alpha_x P_x^{-\beta_x}
0 \leq C_m \leq \infty \quad \& \quad C_m = \alpha_m P_m^{-\beta_m}
0 \leq C_w \leq \infty \quad \& \quad C_w = \alpha_w P_w^{-\beta_w}
Prices: Demand vs supply

\[
0 \leq P_c \leq \infty \quad \perp \quad C_c + Z_c - A_c + Y_c \\
0 \leq P_x \leq \infty \quad \perp \quad C_x + Z_x - A_x + Y_x \\
0 \leq P_m \leq \infty \quad \perp \quad C_m + Z_m - A_m \quad - Y_m \\
0 \leq P_w \leq \infty \quad \perp \quad C_w + Z_w - A_w - Y_c - Y_x + Y_m
\]
Storage

\[ 0 \leq Z_c \leq \bar{Z}_c \ \perp \ \bar{P}_c - P_c \]
\[ 0 \leq Z_x \leq \bar{Z}_x \ \perp \ \bar{P}_x - P_x \]
\[ 0 \leq Z_m \leq \bar{Z}_m \ \perp \ \bar{P}_m - P_m \]
\[ 0 \leq Z_w \leq \bar{Z}_w \ \perp \ \delta \ E P_w - P_w - K \]
Acreage and Production

Production

\[ Q_c = \bar{\epsilon}_c q_c, -1 \]
\[ Q_x = \bar{\epsilon}_x q_x, -1 \]
\[ Q_m = \bar{\epsilon}_m q_m, -1 \]
\[ Q_w = \bar{\epsilon}_w q_w, -1 \]

Acreage

\[ q_c \leq q_c \leq \bar{q}_c \quad \Downarrow \quad \phi_c(\mathbb{E} P_c)^{\theta_c} - q_c \]
\[ q_x \leq q_x \leq \bar{q}_x \quad \Downarrow \quad \phi_x(\mathbb{E} P_x)^{\theta_x} - q_x \]
\[ q_m \leq q_m \leq \bar{q}_m \quad \Downarrow \quad \phi_m(\mathbb{E} P_m)^{\theta_m} - q_m \]
\[ q_w \leq q_w \leq \bar{q}_w \quad \Downarrow \quad \phi_w(\mathbb{E} P_w)^{\theta_w} - q_w \]
Trade

\[ 0 \leq Y_c \leq \bar{Y}_c \perp P_w - P_c - \tau_c \]
\[ 0 \leq Y_x \leq \bar{Y}_x \perp P_w - P_x - \tau_x \]
\[ 0 \leq Y_m \leq \bar{Y}_m \perp P_m - P_w - \tau_m \]
Availability

\[ A_c = Q_c + Z_{c,-1} \]
\[ A_x = Q_x + Z_{x,-1} \]
\[ A_m = Q_m + Z_{m,-1} \]
\[ A_w = Q_w + Z_{w,-1} \]
The effects of export restrictions on rice prices

- Jan: Egypt restrict exports, and China adds 10% tax on exports & rescinds VAT rebate.
- Jan-Feb: Drought in Iran order 0.8 million mt of Thai rice.
- Jan-Apr: Philippines buys normal annual quota injust 4 months, including government-to-government deal with Vietnam.
- Mar: India, Vietnam, China & Cambodia impose tighter export restrictions & new Thai government discusses possibility of ban.
- Apr: Nigeria scraps 100% tariffs & imports 0.5 million mt Thai rice.
- Sep-Oct 2007, Vietnam and India place partial restrictions on exports.
- Sep: India lifts export ban on some higher quality varieties.
- Q1: Saudi Arabia subsidizes rice imports; Saudi imports from Thailand rise by nearly 90% after India’s ban.
- Jun: India lifts export ban on some higher quality varieties.
- Jun: Record harvests, Japan allowed to re-export rice stocks, dollar strengthens, oil & other crop prices fall.
- Jun: Cambodia removes ban.
- Jun: Egypt announces re-export of rice from Sep.
- Sep: India lifts export ban on some higher quality varieties.
- Strong demand from energy exporters keeps rice prices 25-30% above 2007 levels.

Source: Headey 2011 *Rethinking the global food crisis: The role of trade shocks*