The U.S. Biofuel Mandate and World Food Prices: An Econometric Analysis of the Demand and Supply of Calories

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Columbia - February 15, 2010
Outline

1. Motivation
2. Agriculture and Ethanol
3. Methodology
4. Data
5. Empirical Results
6. Conclusions
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1 Motivation
2 Agriculture and Ethanol
3 Methodology
4 Data
5 Empirical Results
6 Conclusions
Recent threefold increase in price of maize
- Between Summer 2006 and Summer 2008
- Prices for wheat, soybeans, and rice increased as well

Food is basic commodity
- Rising hunger and malnutrition
- Potential for increased conflict
Setting the Stage

Background - World Food Prices

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    - New York Times: consumers in developing countries, not U.S. cut back on food consumption
  - Potential for increased conflict
    - Miguel et al. (2004): weather induced income shocks lead to civil conflict in Africa
    - Most African countries are net food importers
    - Increase in price implies reduction in real income
Background - World Food Prices

Across Globe, Empty Bellies Bring Rising Anger

In a garbage dump in Port-au-Prince, people recently scavenged for food. More Photos >

By MARC LACEY
Published: April 18, 2008
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Possible explanations for threefold price increase

- Detrimental weather
  - Prolonged drought in Australia
- Rising oil price
- Increased demand for meat (China and India)
  - China: 33fold increase in per-capita meat consumption (1961-2006)
  - Meat requires 5-10 times the area per calorie
  - 20% reduction in U.S. meat consumption equivalent to switching from Camry to Prius
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- Environmental Protection Agency
  - Recent Report (February 4th)
    - Net CO$_2$ reduction
    - Advocates increased use of biofuels
  - Driving forces behind analysis
    - Increased yield per acre
    - Little area expansion required

- Searchinger et al.
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  - Land expansion results in big CO$_2$ increase
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Goal of this Paper

- Estimate supply / demand for calories
  - Calories: aggregate maize, wheat, rice, and soybeans

- Instrument: Yield Shock (deviations from trend)

- Identification of Demand
  - Current yield shock shifts supply curve
  - Used since P.G. Wright introduced IV (1928)

- Identification of Supply
  - Past yield shocks shift expected price
  - Instrument futures price in supply equation
  - New extension: Previous estimates find inelastic supply, yet simulations use positive elasticity

- Assess U.S. ethanol mandate
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![Graph showing the intersection of demand and supply curves at a price point (p₀) and a quantity level (q₀).]
Goal of this Paper
Setting the Stage

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[Graph showing demand and supply curves with equilibrium point at $p_0$ and $q_0$.]
Goal of this Paper

Setting the Stage

Graph: Demand and Supply curves with intersection at $p_0$ and $q_0$. Arrow $v$ indicates change in demand, and arrow $u$ indicates change in supply.
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<th>Conclusions</th>
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In the graph, the demand and supply curves intersect at point $q_0$, indicating the equilibrium quantity. The change in price from $p_0$ to $p_1$ results in a change in quantity demanded from $q_0$ to $q_1$. The arrow $V$ represents a change in quantity due to a change in price.
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2. Agriculture and Ethanol
3. Methodology
4. Data
5. Empirical Results
6. Conclusions
## World Caloric Production and Prices

- Commodity crops form basis of food chain
  - Cassman (1999) attributes two thirds of caloric production to maize, wheat, and rice
  - Adding in soybeans brings ratio to 75%

- Conversion of production quantities into calories
  - Williamson and Williamson (1942)

- Green revolution
  - Growth on intensive margin (output per area)
  - Limited expansion in area
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- Limited expansion in area
  - Increase by 40%
Background: Agricultural Production

World Caloric Production and Prices
Background: Agricultural Production

World Caloric Production and Prices

![Graph showing world caloric production and prices over time for maize, wheat, rice, and soybeans.](chart.jpg)
## Background: Agricultural Production

### U.S. Share of Caloric Production

<table>
<thead>
<tr>
<th>Country</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maize</strong></td>
<td></td>
</tr>
<tr>
<td>United States of America</td>
<td>42.00</td>
</tr>
<tr>
<td>China</td>
<td>15.66</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.21</td>
</tr>
<tr>
<td>USSR</td>
<td>3.52</td>
</tr>
<tr>
<td>Mexico</td>
<td>3.01</td>
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<tr>
<td><strong>Wheat</strong></td>
<td></td>
</tr>
<tr>
<td>USSR</td>
<td>21.23</td>
</tr>
<tr>
<td>China</td>
<td>14.05</td>
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<tr>
<td>United States of America</td>
<td>12.07</td>
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<tr>
<td>India</td>
<td>8.53</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>6.86</td>
</tr>
<tr>
<td><strong>Soybeans</strong></td>
<td></td>
</tr>
<tr>
<td>United States of America</td>
<td>56.73</td>
</tr>
<tr>
<td>Brazil</td>
<td>14.43</td>
</tr>
<tr>
<td>China</td>
<td>13.05</td>
</tr>
<tr>
<td>Argentina</td>
<td>6.62</td>
</tr>
<tr>
<td>India</td>
<td>1.63</td>
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Background: Agricultural Production

U.S. Share of Caloric Production

![Graph showing the U.S. share of caloric production from 1965 to 2005. The graph indicates fluctuations in the percentage of world production that the U.S. contributed, with a peak around 1980 and a decline thereafter.](image-url)
Background: Agricultural Production

U.S. Effect on World Markets

- U.S. market share
  - calories from maize, wheat, rice, soybeans
  - roughly 23 percent

- Any policy that changes U.S. production has potential to influence world prices

- What is the influence of ethanol mandates?
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History of Biofuels

- Long history of ethanol as fuel
  - Ford’s Model-T designed to run on ethanol
  - Slow phase-out of ethanol as petroleum became cheaper

- Renewed interest in ethanol to combat CO₂ emissions
  - 2007 U.S. Energy Bill: 36 billion gallons by 2022
  - 2009 Renewable Fuels Standard: 11 billion gallons in 2009

- Gasoline use: 0.39 billion gallons per day
  - 11 billion gallons: 28 days (8% of yearly demand)
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History of Biofuels

US Production Capacity (1980-2007)
History of Biofuels

Share of Global Capacity in 2006

- U.S.: 35.99%
- Brazil: 33.29%
- Rest of World: 19.45%
- China: 7.539%
- India: 3.722%
History of Biofuels

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Implications for Commodity Markets

- U.S.: Ethanol predominantly produced from maize
  - 11 billion gallons
  - Require 4.23 billion bushels of corn
    - Using 2.6 gallons per bushel average conversion

- Total U.S. maize production
  - 13 billion bushels

- Ethanol Mandate
  - One third of U.S. corn production
  - 13 percent of world maize production
  - 5 percent of world caloric production
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- Competitive agricultural producers make two decisions
  - Food availability is $z_t$
  - How much to store $x_t$
    - Cost of storage $\phi(x)$ convex
  - How much effort to put into new production $\lambda_t$
    - Cost of effort $g(\lambda)$ convex

- Production subject to random weather shock
  - $s_{t+1} = \lambda_t \omega_{t+1}$

- Equation of motion
  - $z_{t+1} = x_t + \lambda_t \omega_{t+1}$
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Bellman equation

\[ v(z_t) = \max_{x_t, \lambda_t} \{ u(z_t - x_t) - \phi(x_t) - g(\lambda_t) + \delta \mathbb{E} [v(z_{t+1})] \} \]

subject to

\[ z_{t+1} = x_t + \lambda_t \omega_{t+1} \]
\[ x_t \geq 0, \quad z_t - x_t \geq 0, \quad \lambda_t \geq 0 \]

Solved by Scheinkman and Schechtman (1983) and Bobenrieth et al. (2002)

(i) consumption \( c_t = z_t - x_t \) is strictly increasing in \( z_t \)

(ii) storage \( x_t \) is weakly increasing in \( z_t \)

(iii) effort \( \lambda_t \) is weakly decreasing in \( z_t \)
Implications of Storage Literature

- Negative weather shock in current period
  - Reduces consumption $c_t$
  - Increases price $p_t$
  - Increases price $p_{t+1}$ (prices linked through storage)
  - Increased effort in $t + 1$ (supply response)

- Past yield shocks can be used to identify supply
  - Storage links periods
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Empirical Implementation

Model

Estimated equations

\[ \log(s_t) = \alpha_s + \beta_s \log(\mathbb{E}[p_t|_{t-1}]) + \gamma_s \omega_t + f(t) + u_t \]
\[ \log(z_t - x_t) = \alpha_d + \beta_d \log(p_t) + g(t) + v_t \]

- \( s_t \): production of calories at time \( t \)
- \( z_t - x_t \): demand for calories at time \( t \)
- \( p_t \): price of calories at time \( t \)
- \( \log(\mathbb{E}(p_t|_{t-1})) \): futures price (delivery in \( t \), traded in \( t - 1 \))
- \( \omega_t \): Yield shocks (weather induced) at time \( t \)
- \( f(t), g(t) \): time trend (technological change, population growth)
- \( u, v \): error terms
Identifying Demand

- Yield shock $\omega_t$ (rel. deviation from quadratic time trend)
  - Interacted with inverse stock levels (percent of production)

- Likely due to weather shocks
  - No autocorrelation in time series
  - No correlation across space

- Ideal instrument
  - Exogenous supply shifter
  - No direct effect on demand (trade mitigates direct impact)
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Identifying Supply

- Futures price $\log(\mathbb{E}[p_t|_{t-1}])$ impacted through yield shocks $\omega_{t-k}, k > 0$

- Storage smooths production shocks over time
  - Speculative storage
  - Deaton & Laroque (1992,1996), Williams & Wright (1991)

- Bad weather shocks in past
  - Reduces inventory
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Identifying Supply

![Graph showing billion people's data over years]

- **X** Production
- **●** Consumption

Year:
- 1965
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005

Billion People (2000 calories/day):
- 2
- 3
- 4
- 5
- 6
- 7

The graph illustrates the trend in billion people's production and consumption of 2000 calories over the years from 1965 to 2005.
**Identifying Supply**

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Difference to Earlier Research

- Aggregation of crops by caloric content
  - Don’t confound own-price elasticity with cross-price elasticity

- Traditional Supply Estimation
  - Nerlove (1958): Regress supply on expected price
    - Function of lagged price and quantities
  - Our concern: expected price is endogenous
  - Instrumenting futures prices with yield shock
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Supply / Demand System

First-stage regressions:

\[
\log(p_t) = \pi_{d0} + \sum_{k=0}^{K} \mu_{dk} \omega_{t-k} + \sum_{i=1}^{I} \rho_{di} t^i + \epsilon_{dt}
\]

\[
\log(\mathbb{E}[p_t|_{t-1}]) = \pi_{s0} + \sum_{k=0}^{K+1} \mu_{sk} \omega_{t-k} + \sum_{i=1}^{I} \rho_{si} t^i + \epsilon_{st}
\]
Empirical Implementation

Supply / Demand System

Second-stage supply:

$$\log(s_t) = \alpha_s + \beta_s \log(\mathbb{E}[p_{t-1}]) + \lambda_s \omega_t + \sum_{i=1}^{l} \tau_{si} t^i + u_t$$

Stage-one variable excluded from the stage-two: $$\omega_{t-k}, k=1...K+1$$
Empirical Implementation

Supply / Demand System

Second-stage demand:

\[ \log(s_t - \Delta x_t) = \alpha_d + \beta_d \log(P_t) + \sum_{i=1}^{l} \tau_{di} t^i + v_t \]

Stage-one variable excluded from the stage-two: \( \omega_{t-k}, k=0...K \)
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  - Crops used: maize, wheat, rice, and soybeans
    - Production, area, and yield (1961-2007)
    - Change in inventories (1961-2003)

- Common unit: calories
  - Conversion using calories per unit of production

- USDA
  - Inventory levels (1961): corn, wheat, and rice
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**Data Sources - Caloric Yield Shocks**

- **Yield shocks**
  - Baseline model: country-specific deviations from quadratic yield trends for each crop

- **Countries used**
  - Countries with more than 1% of world production of crop
  - Remaining countries lumped together as "Rest of World"

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  - Sum of country and crop-specific shocks
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Data Sources - Caloric Yield Shocks

- **Yield shocks**
  - Baseline model: country-specific deviations from quadratic yield trends for each crop

- **Countries used**
  - Countries with more than 1% of world production of crop
  - Remaining countries lumped together as "Rest of World"

- **Caloric Shock**
  - Sum of country and crop-specific shocks
  - Normalized by quadratic production trend
Yield Shocks

Jackknifed Residuals

Maize

- Argentina
- Brazil
- Canada
- China
- France
- Hungary
- India
- Indonesia
- Italy
- Mexico
- Rest of World
- Romania
- South Africa
- USSR
- United States of America
- Yugoslav SFR

Year
Jackknifed Residuals

Yield Shocks

Maize

Argentina
Brazil
Canada
China

France
Hungary
India
Indonesia

Italy
Mexico
Rest of World
Romania

South Africa
USSR
United States of America
Yugoslav SFR

Year

Jackknifed Yield Residual (percent)

-50 0 50
Potential concern

- Are yields endogenous to price?
  - Higher price could lead to higher sowing density
  - Higher price could imply shift to marginal land
- Lack of autocorrelation in yields suggests no
- Lack of correlation between years suggests no

Sensitivity check
- Country-and-crop specific yield regressions
- US data (Schlenker and Roberts, 2009)
- World data: NCC (6-hour time step of 1 degree grid)

Caloric Shock
- Attributable to deviations from average weather
Data Sources - Weather Data

- **Maize**
- **Wheat**
- **Rice**
- **Soybeans**
Potential concern
- Are yields endogenous to price?
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Sensitivity check
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  - Average over agricultural area

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Caloric Shock
- Attributable to deviations from average weather
Growing Areas

NCC grid system
Maize: Growing Area (Fraction of Grid)
Weather Data

Growing Areas

Wheat: Growing Area (Fraction of Grid)
Growing Areas

Rice: Growing Area (Fraction of Grid)
Soybeans: Growing Area (Fraction of Grid)
Price Data

Data Sources - Prices

- **Long time series**
  - Crop prices in US in December of each year
    - 1915-2008

- **Futures prices**
  - Chicago Board of trade: September delivery
  - $p_t$: average price in September of delivery
  - $\log (E[p_{t-1}])$: average price in October of previous year
  - Only available for maize, soybeans, and wheat

- **Price per calory**
  - Converted using calory per unit of production
  - Deflated using CPI
Price Data

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### Descriptive Statistics

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<th>Variable</th>
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Outline

1. Motivation
2. Agriculture and Ethanol
3. Methodology
4. Data
5. Empirical Results
6. Conclusions
## Regression Results - Demand

<table>
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<tr>
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# Regression Results - Demand

## Supply - Demand Model

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<td>Price ( p_t )</td>
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Demand

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<td>(1.65e-02)</td>
<td>(2.17e-02)</td>
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Time Trend

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<tr>
<td>2SLS</td>
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<td>(9.02e-04)</td>
<td>(2.97e-03)</td>
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<td>3SLS</td>
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<tr>
<td>(9.39e-04)</td>
<td>(3.35e-03)</td>
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Time Trend^2

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<td>2SLS</td>
<td>-4.17e-04***</td>
<td>-6.51e-04***</td>
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<td>(2.40e-05)</td>
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Time Trend^3

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Observations

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Time Trend I

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Shock Lags K

|                | 1 | 1 | 1 | 1 |
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| Shock Lags K  | 1  | 1  | 1  | 1  | 2  | 2  |
## Regression Results - Supply

### Supply - Demand Model

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### Supply

- $\mathbb{E}[p_t | t-1]$: 1.16e-01***
  - (2.20e-02)
- Shock $\omega_t$: 2.59e-01***
  - (2.95e-02)
- Time Trend: 4.34e-02***
  - (8.87e-04)
- Time Trend$^2$: -3.31e-04***
  - (2.53e-05)
- Time Trend$^3$

<table>
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## Supply - Demand Model

### Regression Results - Supply

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### Supply

|                          |                | 1.16e-01***   |               |               |               |               |               |
|                          |                | (2.20e-02)    |               |               |               |               |               |
| Shock $\omega_t$         |                | 2.59e-01***   |               |               |               |               |               |
|                          |                | (2.95e-02)    |               |               |               |               |               |
| Time Trend               |                | 4.34e-02***   |               |               |               |               |               |
|                          |                | (8.87e-04)    |               |               |               |               |               |
| Time Trend$^2$           |                | -3.31e-04***  |               |               |               |               |               |
|                          |                | (2.53e-05)    |               |               |               |               |               |
| Time Trend$^3$           |                |               |               |               |               |               |               |

|                          |                |               |               |               |               |               |               |
| Observations             |                | 41            |               |               |               |               |               |
| Time Trend I             |                | 2             |               |               |               |               |               |
| Shock Lags K             |                | 1             |               |               |               |               |               |
Motivation
Background
Methodology
Data
Results
Conclusions

Supply - Demand Model

Regression Results - Supply

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Supply

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### Supply - Demand Model

#### Regression Results - Supply

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- **Observations**: 41
- **Time Trend I**: 2
- **Shock Lags K**: 1
## Supply - Demand Model

### Regression Results - Supply

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### Model

| **E[p_t | t-1]** | 1.16e-01*** | 1.16e-01*** | 8.64e-02*** | 8.81e-02*** | 8.71e-02*** | 8.64e-02*** |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
|               | (2.20e-02)  | (2.00e-02)  | (1.83e-02)  | (1.67e-02)  | (1.85e-02)  | (1.71e-02)  |
| Shock $\omega_t$ | 2.59e-01*** | 2.58e-01*** | 2.67e-01*** | 2.67e-01*** | 2.68e-01*** | 2.68e-01*** |
|               | (2.95e-02)  | (2.69e-02)  | (2.41e-02)  | (2.22e-02)  | (2.41e-02)  | (2.22e-02)  |
| Time Trend    | 4.34e-02*** | 4.34e-02*** | 5.27e-02*** | 5.27e-02*** | 5.32e-02*** | 5.33e-02*** |
|               | (8.87e-04)  | (8.31e-04)  | (2.23e-03)  | (2.06e-03)  | (2.70e-03)  | (2.49e-03)  |
|               | (2.53e-05)  | (2.34e-05)  | (1.20e-04)  | (1.11e-04)  | (1.41e-04)  | (1.30e-04)  |
| Time Trend$^3$ | 7.64e-06*** | 7.59e-06*** | 7.95e-06*** | 7.95e-06*** | 7.95e-06*** | 7.96e-06*** |
|               | (1.74e-06)  | (1.61e-06)  | (1.99e-06)  | (1.84e-06)  | (1.84e-06)  | (1.84e-06)  |

| Observations  | 41            | 41            | 41            | 41            | 40            | 40            |
| Time Trend I  | 2             | 2             | 3             | 3             | 3             | 3             |
| Shock Lags K  | 1             | 1             | 1             | 1             | 2             | 2             |
## Regression Results - First Stage

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- **Observations:** 41
- **Time Trend:** 2, 2, 3
- **Shock Lags K:** 1, 1, 2
Sensitivity Checks

Sensitivity Check - Yield Deviations

- Jackknifed Yield Residuals
  - Check: Linear instead of quadratic trend

- Production trend
  - Check: Linear instead of quadratic trend
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<td>0.0881***</td>
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<td>34.82</td>
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**Panel B: Caloric Shock Derived using Linear Time Trend**

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- **Observations**: 41, 41, 41, 41, 40, 40
- **Time Trend I**: 2, 2, 3, 3, 3, 3
- **Shock Lags K**: 1, 1, 1, 1, 2, 2
Sensitivity Check - Yield Deviations

Caloric shock is product of
- Jackknifed yield residuals
- Area harvested
- Caloric conversion (calories per unit of output)

Check:
- Predicted area (quadratic trend) instead of actual
### Motivation

Background

Methodology

Data

Results

Conclusions

---

### Sensitivity Checks

#### Sensitivity Check - Yield Deviations

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<tr>
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| Observations | 41 | 41 | 41 | 41 | 40 | 40 |
| Time Trend I | 2  | 2  | 3  | 3  | 3  | 3  |
| Shock Lags K | 1  | 1  | 1  | 1  | 2  | 2  |
Sensitivity Checks

Sensitivity Check - Yield Deviations

- Caloric conversion factors
  - Given in Williamson and Williamson (1942)

- Check:
  - Ratio of caloric conversion factors equals ratio of averages prices
Sensitivity Check - Yield Deviations
Sensitivity Check - Yield Deviations
### Sensitivity Check - Yield Deviations

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<tr>
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Sensitivity Checks

Sensitivity Check - Yield Deviations

- **Shock** $\omega_t$
  - Ratio of relative caloric shock to relative inventory level

- **Check:**
  - Do not normalize by inventory level
## Sensitivity Checks

### Sensitivity Check - Yield Deviations

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### Panel E: Caloric Shock not Divided by Inventory

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</table>
Sensitivity Check - Weather Shocks

- Caloric shocks
  - Deviations from yield trend

- Check
  - Yield shocks that are attributable to weather shocks
### Sensitivity Check - Weather Shocks

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<td>1</td>
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<td>2</td>
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</table>
Sensitivity Check - Weather Shocks

- Weak instruments and decrease significance levels
  - Likely due to data problems

- Correlation between two yield shocks
  - Deviations from trend
  - Attributable to weather

- US (good daily data): 0.71
- Rest of world not as good
Sensitivity Check - Weather Shocks

The graph shows the relationship between Caloric Shock (Jackknifed Residual) in Percent and Caloric Shock (Weather Instrument) in Percent for the United States of America. The data points are color-coded based on the value of the Environmental Event Data Index of Climate (2017-2021), with colors ranging from light green to dark red.
Sensitivity Check - Weather Shocks

The diagram shows a scatter plot with the x-axis representing Caloric Shock (Jackknifed Residual) in Percent and the y-axis representing Caloric Shock (Weather Instrument) in Percent. The data points are color-coded with a gradient scale indicating the magnitude of the shocks. The title, "Brazil," is located at the center of the plot.
Sensitivity Checks

Sensitivity Check - Weather Shocks
## Contrast to Other Approaches

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<th>Demand Instrumented / Supply Not Instrumented</th>
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### Contrast to Other Approaches

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### Contrast to Other Approaches

#### SUR - Price Not Instrumented Demand Instrumented / Supply Not Instrumented

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* (s.e.) = Standard Error

- **Demand Elas.**
  - **Price Not Instrumented:** -0.0166 (0.0091)
  - **Demand Instrumented / Supply Not Instrumented:** -0.0177 (0.0095)

- **Supply Elas.**
  - **Price Not Instrumented:** 0.0155 (0.0172)
  - **Demand Instrumented / Supply Not Instrumented:** 0.0140 (0.0152)

- **Price Inc.**
  - **Price Not Instrumented:** 168.77
  - **Demand Instrumented / Supply Not Instrumented:** 82.84

- **95% Int.**
  - **Price Not Instrumented:** (-654,1151)
  - **Demand Instrumented / Supply Not Instrumented:** (-531,1109)

- **Time Trend**
  - (1) 2
  - (2) 3
  - (3) 2
  - (4) 2
  - (5) 2
  - (6) 3

- **Shocks K**
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  - (2) n.A.
  - (3) 1
  - (4) 1
  - (5) 1
  - (6) 2

- **Supply Lags**
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  - (2) n.A.
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## Explaining World Production Area

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## Area Responses

### Explaining World Production Area

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## Area Responses

### Explaining World Production Area

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## Explaining World Production Area

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<td>0.3694(***)</td>
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### Explaining World Production Area

#### China

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Ethanol mandate: 5% of world caloric production

- Food prices increase 33 percent

Loss in consumer surplus: 170 billion annually

- But: offsetting increase in producer surplus
- Potential consumer surplus from lower fuel prices

Elastic supply
Implications
## Area Responses

### Implications

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  - Food prices increase 33 percent

- **Loss in consumer surplus**: 170 billion annually
  - But: offsetting increase in producer surplus
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  **Rajagopal (2007)**
  - Need demand / supply elasticity of fuels

- **Elastic supply**
  - Lower price increase
  - Larger expansion in area / yield
  - 2 percent increase or 30 million acres
  - Land use constitutes 20% of CO₂ emissions
Implications

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Outline

1 Motivation
2 Agriculture and Ethanol
3 Methodology
4 Data
5 Empirical Results
6 Conclusions
Conclusions

- Demand and supply model of commodity calories

- What’s new?
  - Aggregation of crops by caloric content
  - New supply instrument (instrumented lagged price)

- Major results
  - Significant supply and demand elasticities
  - Previous literature found insignificant supply elasticities

- Implications for U.S. ethanol mandate
  - Predicted to raise world prices by 33 percent
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  Previous literature found insignificant supply elasticities

Implications for U.S. ethanol mandate
  Predicted to raise world prices by 33 percent
  Loss of consumer surplus 170 billion annually
  Expansion in area by 2 percent (30 million acres)
Outline

7 Data
Major Agricultural Producers

Maize: Production Share greater than 1 Percent
Major Agricultural Producers

Wheat: Production Share greater than 1 Percent
Rice: Production Share greater than 1 Percent
Soybeans: Production Share greater than 1 Percent
## Production Shares

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<th>Country</th>
<th>Maize</th>
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## Production Shares

<table>
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<td><strong>Soybeans</strong></td>
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<td>Argentina</td>
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<td>Japan</td>
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Yield Shocks

Jackknifed Residuals

Maize

- Argentina
- Brazil
- Canada
- China
- France
- Hungary
- India
- Indonesia
- Italy
- Mexico
- Rest of World
- Romania
- South Africa
- USSR
- United States of America
- Yugoslav SFR

Year

1960 1980 2000

Yield (ton/ha)

0 5 10
Yield Shocks

Jackknifed Residuals

Maize

- Argentina
- Brazil
- Canada
- China
- France
- Hungary
- India
- Indonesia
- Italy
- Mexico
- Rest of World
- Romania
- South Africa
- USSR
- United States of America
- Yugoslav SFR

Year

Data Yield Shocks
Yield Shocks

Jackknifed Residuals

Wheat

- Argentina
- Australia
- Canada
- China
- Czechoslovakia
- France
- Germany
- India
- Iran
- Italy
- Kazakhstan
- Pakistan
- Poland
- Rest of World
- Romania
- Russian Federation
- Spain
- Turkey
- USSR
- Ukraine
- United Kingdom
- United States of America
- Yugoslav SFR

Year

Yield (ton/ha)
### Jackknifed Residuals

#### Wheat

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<thead>
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<th>Country</th>
<th>Argentina</th>
<th>Australia</th>
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<table>
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<th>Pakistan</th>
<th>Poland</th>
<th>Rest of World</th>
<th>Romania</th>
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<table>
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<th>Turkey</th>
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<th>Ukraine</th>
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<table>
<thead>
<tr>
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<th>United States of America</th>
<th>Yugoslav SFR</th>
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Yield Shocks

Jackknifed Residuals

Rice

- Bangladesh
- Brazil
- China
- India
- Indonesia
- Japan
- Korea
- Myanmar
- Pakistan
- Philippines
- Rest of World
- Thailand
- United States of America
- Viet Nam

Year
Yield Shocks

Jackknifed Residuals

Rice

- Bangladesh
- Brazil
- China
- India
- Indonesia
- Japan
- Korea
- Myanmar
- Pakistan
- Philippines
- Rest of World
- Thailand
- United States of America
- Viet Nam

Year
Data Yield Shocks

Jackknifed Residuals

Yield (ton/ha)

Year

1960 1980 2000

Argentina
Brazil
Canada
China
India
Rest of World

United States of America

Soybeans
Jackknifed Residuals