Tools to measure price transmission from international to local markets

Presented by:
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Tools to measure price transmission from international to local markets

Nicholas Minot
International Food Policy Research Institute

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Outline

• What is price transmission?
• Why does price transmission occur (nor not)?
• Review measures of price transmission
  – Simple percentage changes
  – Correlation analysis
  – Regression analysis
  – Co-integration analysis
• Results of study of impact of world markets on African food prices
• Conclusions
What is price transmission?

• Price transmission is when a change in one price causes another price to change

• Three types of price transmission:
  – Spatial: Between two markets for same commodity
    • Price of maize in South Africa $\rightarrow$ price of maize in Mozambique
  – Vertical: Between two points in supply chain
    • Price of wheat $\rightarrow$ price of flour
  – Cross-commodity: Between two commodities
    • Price of maize $\rightarrow$ price of rice
Why is it useful to study price transmission?

- Study of price transmission helps to understand causes of changes in prices, necessary to address root causes
  - Example: If little price transmission from world markets, then trade policy will not be effective in reducing volatility
- Study of price transmission may help forecast prices based on trends in related prices
  - Example: If changes in soybean prices transmitted to sunflower markets, then soybean futures markets may predict sunflower prices
- Study of price transmission helps diagnose poorly functioning markets
  - Example: If two markets are close together, but show little price transmission, this may indicate problems with transportation network or monopolistic practices
Why does spatial price transmission occur?

- **Spatial price transmission** occurs because of flows of goods between markets & spatial arbitrage
  - If price gap > marketing costs, trade flows will narrow gap
  - If price gap < marketing cost, no flows
  - Therefore, price gap <= marketing cost
Why does vertical price transmission occur?

- Vertical price transmission occurs because of ability to convert raw product into processed product at certain cost; “processing arbitrage”
Why does **cross-commodity** price transmission occur?

- **Cross-commodity price transmission** occurs because of substitution in consumption and/or production.
Why might price transmission *not* occur?

- High transportation cost makes trade unprofitable
  - Or high processing costs makes processing unprofitable
- Trade barriers make trade unprofitable
- Lack of information about prices in other markets
- Long time to transport from one market to another (lagged transmission)
- In case of inter-commodity transmission, two commodities are not close substitutes for each other
What is an elasticity of price transmission?

• Price transmission elasticity: % change in one price for each 1% increase in the other price

• Example: if a 10% increase in the world price of maize causes a 3% increase in the local price of maize, then price transmission elasticity is:

\[
0.03 / 0.10 = 0.3
\]
What is an elasticity of price transmission?

- Elasticity of 1.0 is not always “perfect transmission”

Example:
- World price = $200/ton
- Local price = $400/ton
- Perfect transmission would be if a $50 increase in world price → $50 increase in local price (assuming fixed margin)
- But transmission elasticity in this case would be 
  \[
  \frac{50/400}{50/200} = \frac{.125}{.250} = 0.50
  \]

- For imports, perfect transmission elasticity are < 1.0
- For exports, perfect transmission elasticity are > 1.0
How is price transmission measured?

- There are several methods – four are discussed here
  - Ratio of percentage changes between two time periods
  - Correlation coefficient
  - Regression analysis
  - Co-integration analysis
1. Ratio of percentage changes

Ratio of percentage changes between two time periods

<table>
<thead>
<tr>
<th></th>
<th>Price of maize in Dar es Salaam</th>
<th>Price of US #2 Yellow Maize</th>
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<tbody>
<tr>
<td></td>
<td>US$ / ton</td>
<td>US$ / ton</td>
</tr>
<tr>
<td>June 2007</td>
<td>120</td>
<td>165</td>
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<tr>
<td>June 2008</td>
<td>239</td>
<td>287</td>
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<tr>
<td>% Change</td>
<td>99%</td>
<td>74%</td>
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</table>

Elasticity of transmission is 1.34 (= .99 / .74)

Note that both prices increased by about $120/ton
1. Ratio of percentage changes - example

- Disadvantage: Crude method, only uses two points in time and does not take trends into account
2. Correlation coefficient

- Indicates the degree of relatedness of two variables
- Two related measures
  - Pearson correlation coefficient = $r$
  - Coefficient of determination = $R^2 = r \times r$
  - Both range from 0 (no relation) to 1 (perfect relation)
2. Correlation coefficient

- Advantage
  - Easy to calculate (can use Excel)
  - Easy to understand (R2 as pct explained)

- Disadvantages
  - Only takes into account two prices, excludes effect of other prices and variables
  - Only considers relationship between prices at same time, does not take into account lags in effect
  - Cannot identify causality
  - Misleading results if prices are non-stationary
3. Regression analysis

- Multiple regression analysis:
  \[ Y = a + bX_1 + cX_2 + \ldots + \epsilon = a + \sum b_iX_i + \epsilon \]

- Advantages
  - Gives information to calculate transmission elasticity
  - Can test relationships statistically
  - Can take into account lagged effects, inflation, and seasonality
  - Can analyze relationship of > 2 prices

- Disadvantages
  - Difficult to identify causality
  - Misleading results if data are non-stationary
Non-stationarity - Definition

- What is a non-stationary variable?

<table>
<thead>
<tr>
<th>Stationary variable $Y$</th>
<th>Non-stationary variable $Y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t = a + \rho Y_{t-1} + bX_t + \varepsilon_t$ where $</td>
<td>\rho</td>
</tr>
<tr>
<td>Tends to go back toward mean</td>
<td>Does not tend to go back to mean, “random walk”</td>
</tr>
<tr>
<td>Finite variance</td>
<td>Infinite variance as $N \to \infty$</td>
</tr>
</tbody>
</table>

![Graphs showing time series data](image-url)
Non-stationarity - Problem

• Why are non-stationary variables a problem?
  – One of the assumptions of OLS regression analysis is that the error term has a constant variance
  – When a variable is non-stationary, the \( \text{var}(\varepsilon) \) changes over time. As \( N \to \infty \), \( \text{var}(\varepsilon) \to \infty \)
  – Since assumptions are violated, regression analysis will give misleading results
  – With non-stationary variables, regression analysis will often indicate that there is a statistically significant relationship even when there is NO relationship
  – Excel demonstration
  – Unfortunately, many time-series variables are non-stationary
Non-stationarity – Testing

- Augmented Dickey-Fuller test

\[ \Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \]

- Testing \( \gamma = 0 \) tests the null hypothesis of non-stationarity
- Intuition:
  - If data are stationary, a high value of \( y_{t-1} \) implies that \( \Delta y_t \) will be negative as it returns toward the mean, implying negative coefficient
  - If data are non-stationary (random walk), the value of \( y \) has no effect on \( \Delta y_t \), so coefficient will be zero
- In Stata, use “dfuller [variable name]”
Non-stationarity – Testing

- **Phillips-Perron test**
  - Also based on Dickey-Fuller but uses Newey-West standard errors to take into account higher-order auto-correlation
  - Advantage over ADF
    - Does not require information about order of autocorrelation
    - Does not assume conditional homoskedasticity
    - Will be more powerful than ADF based on wrong order
  - Disadvantage compared to ADF
    - Less powerful than ADF if ADF is based on correct order
- In Stata, use “pperron [variable name]”
Non-stationarity – Solution

• Many time-series variables are non-stationary, but the first difference is stationary:
  – Example: $Y_t = Y_{t-1} + \varepsilon_t$ so $\Delta Y_t = \varepsilon_t$ where $\varepsilon_t \sim N(0, \sigma^2)$
  – $Y$ is integrated to degree one or $I(1)$

• Even if variables are non-stationary, a linear combination of them may be stationary
  • Example: $Y_t$ and $X_t$ are $I(1)$ but $\Delta Y_t - b \Delta X_t = \varepsilon_t$
  • $Y$ and $X$ are said to be co-integrated
  • Cointegration can be tested with Johansen procedure

• Cointegrated variables can be expressed as a error-correction model (described later)
Non-stationarity – Solution

Are variables stationary (ADF or PP unit root test)

- No
  - Are variables cointegrated? (EG or Johansen test)
    - Yes
      - Vector error correction model
    - No
      - No relationship
- Yes
  - VAR model in levels
Applying methods to price transmission

• How to interpret co-movement of prices
  – Frequently, co-movement of prices is taken as a sign of efficient markets
  – However, Harriss (1975) and Barrett and Li (2002) note that:
    • Co-movement possible with high transport cost and/or collusion among traders
    • Lack of co-movement may reflect no trade or trade reversal even if markets are efficient
Applying methods to price transmission

• Mundlak and Larson (1992)
  – International-local price transmission for 58 countries
  – Static regression model
  – Very high transmission, median elasticity 0.95

• Quiroz and Soto (1996)
  – Similar data but 78 countries
  – Error correction model
  – No long-run relationship (LRR) for 30 of 78 countries
  – No LRR for 7 of 16 African countries

• Conforti (2004)
  – ARDL and Error Correction Model for 16 countries
  – Ethiopia: LRR for 4 of 7 commodities
  – Ghana: no LRR for maize and sorghum
  – Senegal: LRR for rice but not maize
Data and methods

• Data on international commodity prices
  – Maize: US No 2 yellow maize FOB Gulf of Mexico
  – Rice: Super A1 Thai rice FOB Bangkok
  – Wheat: US No 1 hard red winter wheat FOB Gulf of Mexico

• Data on domestic commodity prices
  – Source: FEWS-NET and others
  – Monthly price data for nine sub-Saharan African countries
  – 62 price series (commodity-market combinations)
  – Average of 7 price series per country
  – 5-10 years of monthly data, usually including 2008

• Data on exchange rates from IMF
Data and methods

• Methods
  – Convert domestic prices to constant US$/ton
  – Test for integration (unit root) with ADL and Phillips-Perron
  – Test for co-integration with Johansen rank test
  – Error correction model

\[ \Delta p_t^d = \alpha + \rho (p_{t-1}^d - \beta p_{t-1}^w) + \delta \Delta p_{t-1}^w + \theta \Delta p_{t-1}^d + \varepsilon_t \]
## Results: East Africa

### Transmission of world food prices to domestic markets in East Africa

<table>
<thead>
<tr>
<th>Country</th>
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<th>Commodity</th>
<th>ADF test</th>
<th>Perron-Phillips test</th>
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## Results: Tanzania

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## Results: Malawi

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*Denotes significant at the 5% level.
### Transmission of world food prices to domestic markets in Zambia

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<td>Maize</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Zambia</td>
<td>Lusaka</td>
<td>Maize</td>
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<td>Yes</td>
<td>No</td>
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<tr>
<td>Zambia</td>
<td>Mansa</td>
<td>Maize</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Mongu</td>
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<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Zambia</td>
<td>Solwezi</td>
<td>Maize</td>
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<td>No</td>
<td>No</td>
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</table>
### Results: Ghana

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
<th>Commodity</th>
<th>Unit root in domestic price?</th>
<th>Long-run relationship?</th>
<th>Error correction model (if long-run relationship confirmed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td>Accra</td>
<td>Imported rice</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ghana</td>
<td>Kumasi</td>
<td>Imported rice</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ghana</td>
<td>Tamale</td>
<td>Imported rice</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ghana</td>
<td>Techiman</td>
<td>Imported rice</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ghana</td>
<td>Kumasi</td>
<td>Local rice</td>
<td>No</td>
<td>No</td>
<td>Yes 0.20 *</td>
</tr>
<tr>
<td>Ghana</td>
<td>Tarnale</td>
<td>Local rice</td>
<td>No</td>
<td>No</td>
<td>-0.13</td>
</tr>
<tr>
<td>Ghana</td>
<td>Techiman</td>
<td>Local rice</td>
<td>Yes</td>
<td>Yes</td>
<td>0.47</td>
</tr>
</tbody>
</table>
Results: Summary

<table>
<thead>
<tr>
<th>Result of test of long-run relationship</th>
<th>Johansen test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13</td>
</tr>
<tr>
<td>No</td>
<td>41</td>
</tr>
<tr>
<td>Stationary</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results of test of long-run relationship by country</th>
<th>Prices with relationship</th>
<th>Total nbr. of prices</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>1</td>
<td>3</td>
<td>33%</td>
</tr>
<tr>
<td>Ghana</td>
<td>1</td>
<td>7</td>
<td>14%</td>
</tr>
<tr>
<td>Kenya</td>
<td>0</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Malawi</td>
<td>3</td>
<td>8</td>
<td>38%</td>
</tr>
<tr>
<td>Mozambique</td>
<td>4</td>
<td>11</td>
<td>36%</td>
</tr>
<tr>
<td>South Africa</td>
<td>0</td>
<td>4</td>
<td>0%</td>
</tr>
<tr>
<td>Tanzania</td>
<td>4</td>
<td>16</td>
<td>25%</td>
</tr>
<tr>
<td>Uganda</td>
<td>0</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Zambia</td>
<td>0</td>
<td>9</td>
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</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>62</td>
<td>21%</td>
</tr>
</tbody>
</table>
### Results: Summary

<table>
<thead>
<tr>
<th>Crop</th>
<th>Prices with relationship</th>
<th>Total nbr. of prices</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>4</td>
<td>40</td>
<td>10%</td>
</tr>
<tr>
<td>Rice</td>
<td>8</td>
<td>17</td>
<td>47%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1</td>
<td>4</td>
<td>25%</td>
</tr>
<tr>
<td>Wheat</td>
<td>0</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>62</td>
<td>21%</td>
</tr>
</tbody>
</table>
Summary of results

• Reasons for lack of price transmission
  Maize
  – Most African countries are self-sufficient in maize
  – Domestic price falls between export parity and import parity
  – Even efficient markets will not show price transmission in this situation
  – Intervention in maize markets also reduces transmission
    • Kenya supports price, Tanzania bans exports, Malawi and Zambia have large state trading enterprises that intervene in maize markets

Rice
  – Almost all African countries rely on rice imports
  – Degree of price transmission is higher for rice
Summary of price transmission methods

• Price transmission occurs between markets, between stages of a market channel, and between commodities... but not always

• Correlation coefficient
  – Easy to calculate and interpret
  – But only captures contemporaneous effects between two prices

• Regression analysis
  – Gives estimate of price transmission
  – Can take into account lagged effects
  – But is misleading if prices are non-stationary (and they often are)
Summary of price transmission methods

• Non-stationarity
  – Means prices follow a “random walk”
  – Regression results will be misleading
  – Can be tested using ADF and Phillips-Perron

• If prices are non-stationary, need to test for cointegration with Johansen test

• If prices are non-stationary and cointegrated, can use error correction model to study short and long-run price transmission elasticities
References (1)

  http://www.fao.org/docrep/007/j2730e/j2730e00.htm#Contents


References (2)

