Tools to measure price transmission from international to local markets

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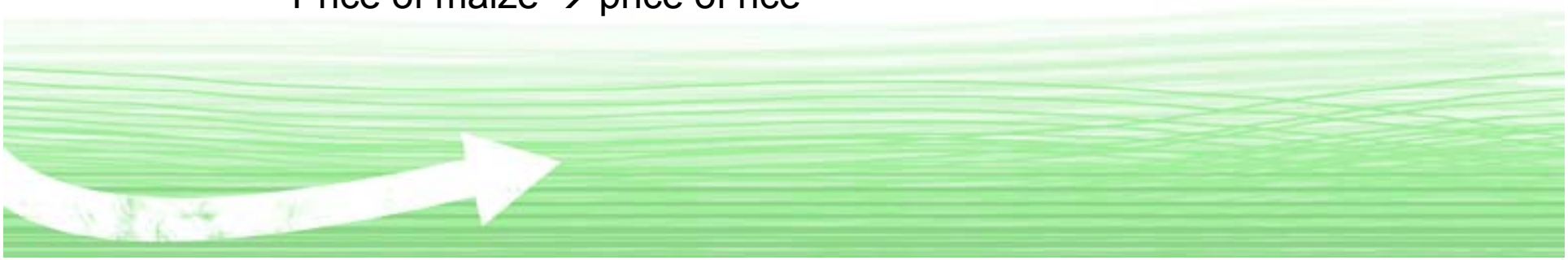
Outline

- 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 → price of maize in Mozambique
  - Vertical: Between two points in supply chain
    - Price of wheat → price of flour
  - Cross-commodity: Between two commodities
    - Price of maize → price of rice

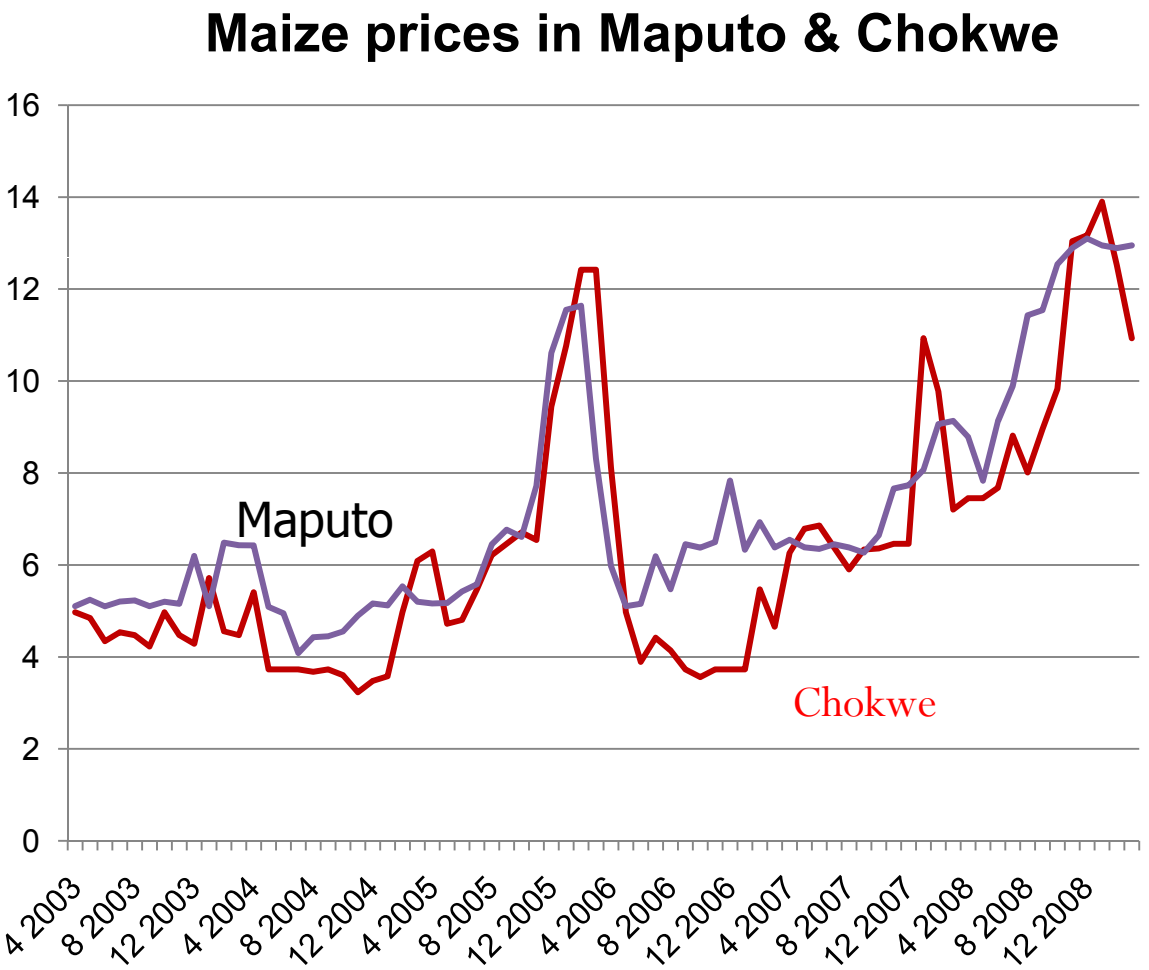


Why is it useful to study price transmission?

- 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

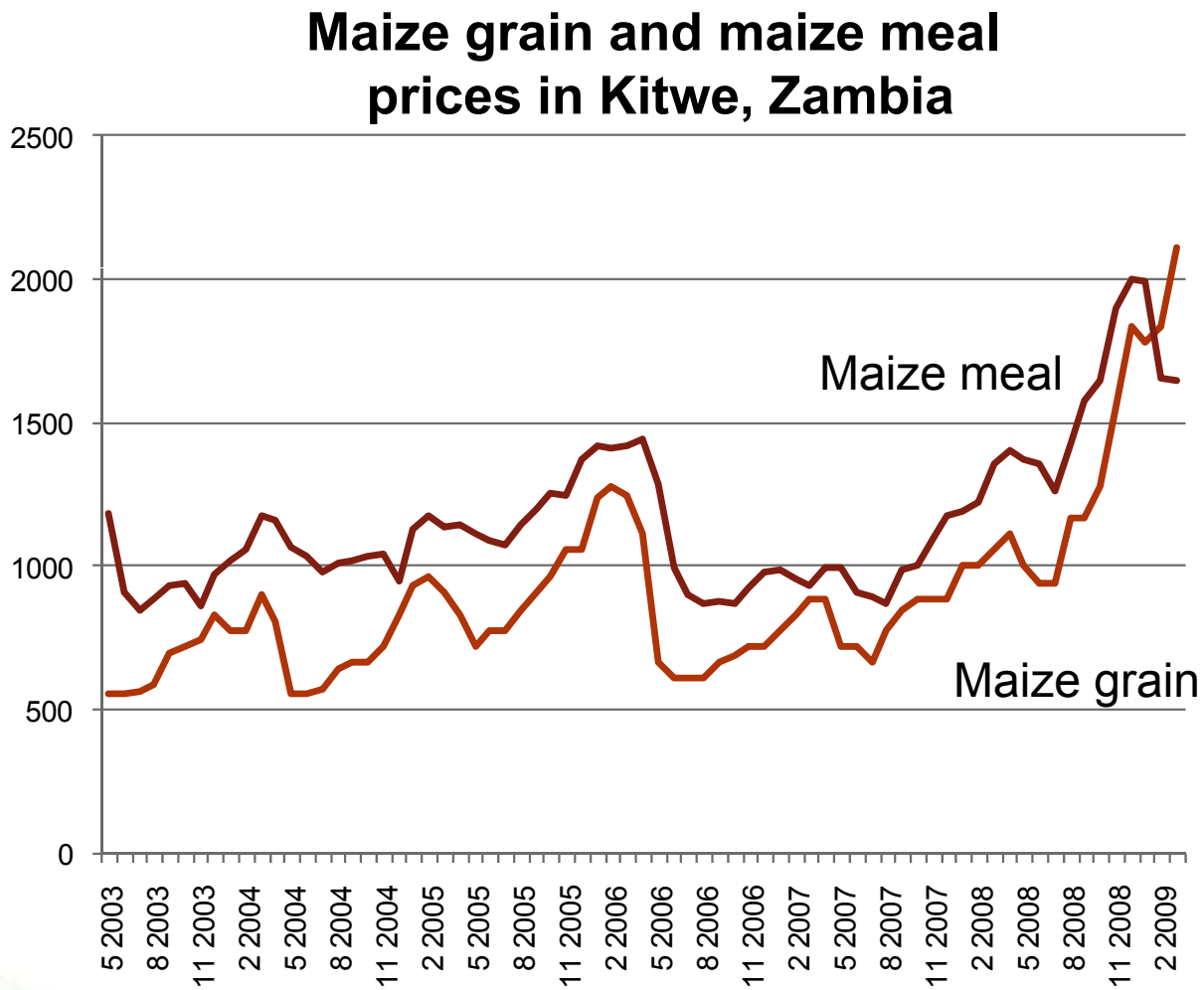
Why does spatial price transmission occur?

- **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



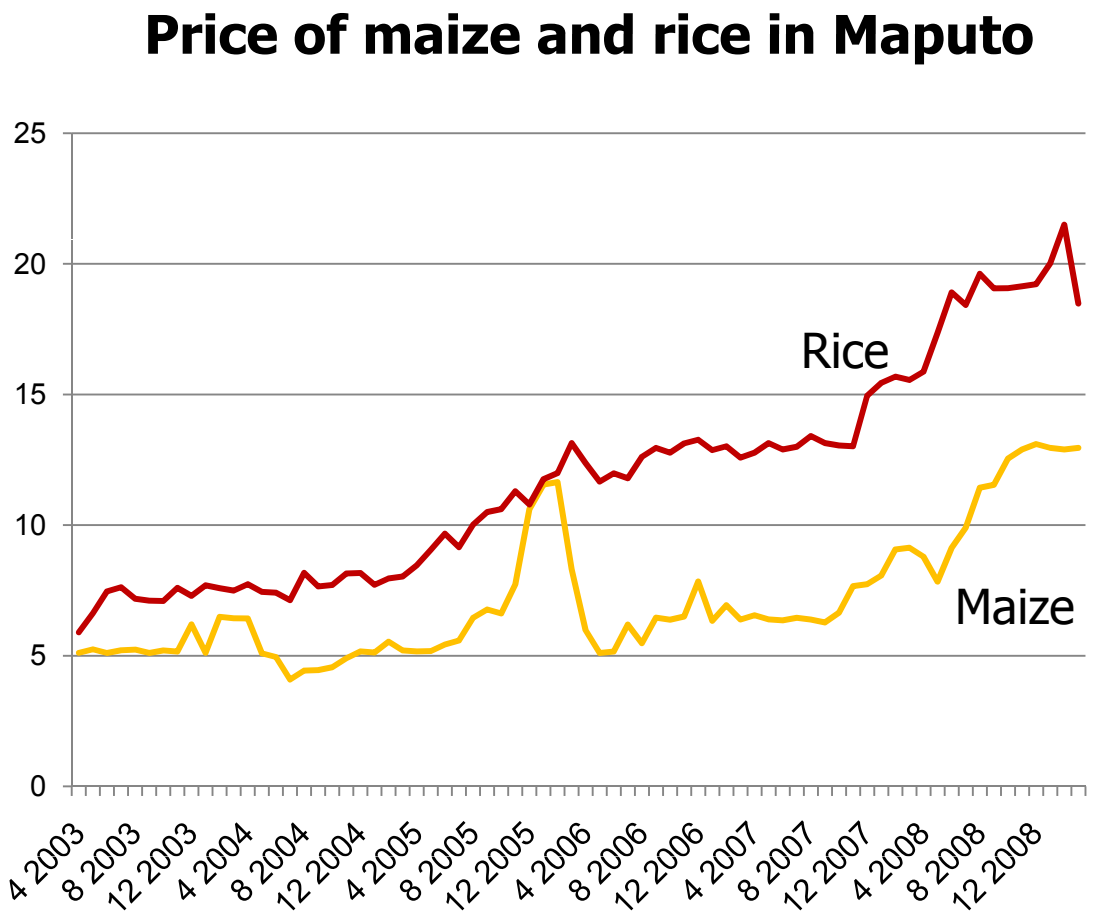
Why does vertical price transmission occur?

- **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 (50/400)/(50/200)= .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

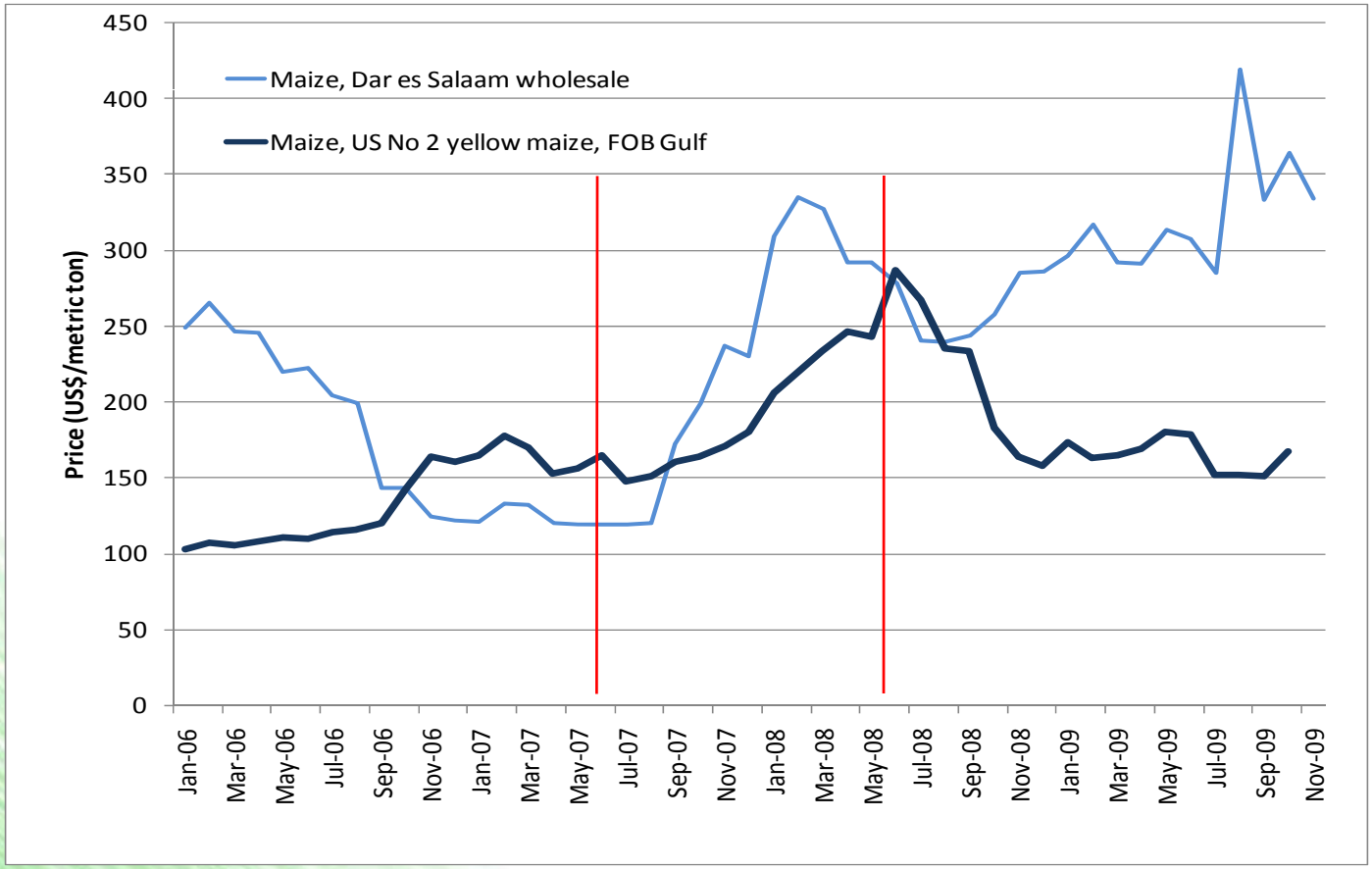
	Price of maize in Dar es Salaam	Price of US #2 Yellow Maize
	US$ / ton	US$ / ton
June 2007	120	165
June 2008	239	287
% Change	99%	74%

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

Note that both prices increased by about $120/ton

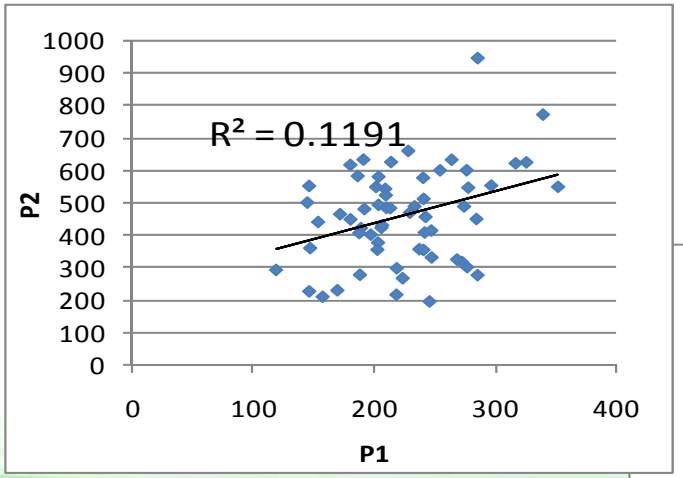
1. Ratio of percentage changes - example

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



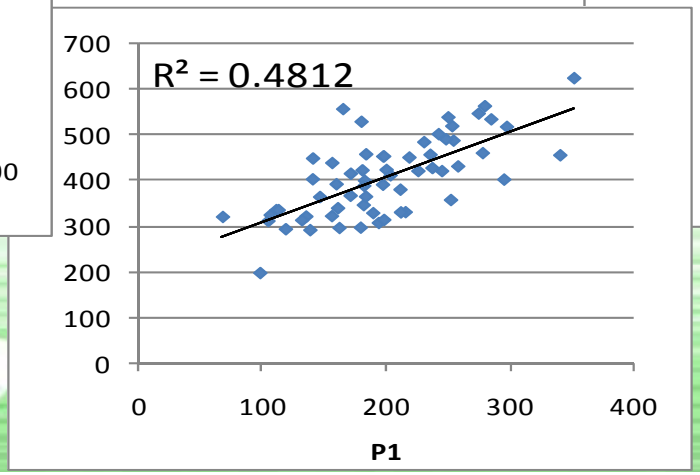
2. Correlation coefficient

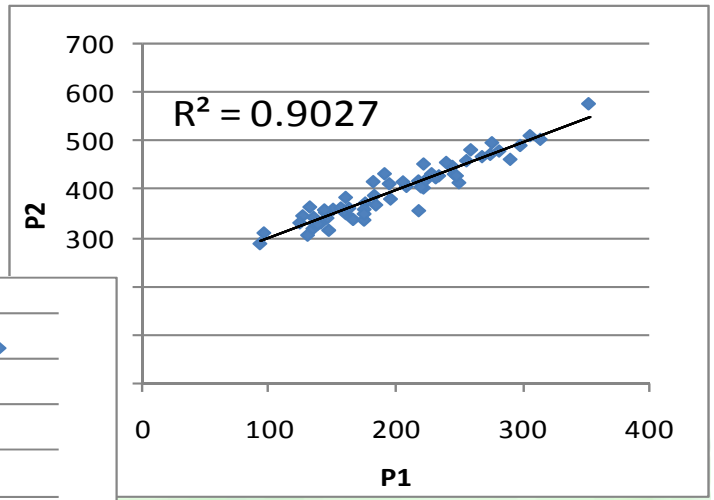
- Indicates the degree of relatedness of two variables
- Two related measures
  - Pearson correlation coefficient = r
  - Coefficient of determination = R^2 = r * r
  - Both range from 0 (no relation) to 1 (perfect relation)



Weak correlation

Medium correlation





Strong correlation

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

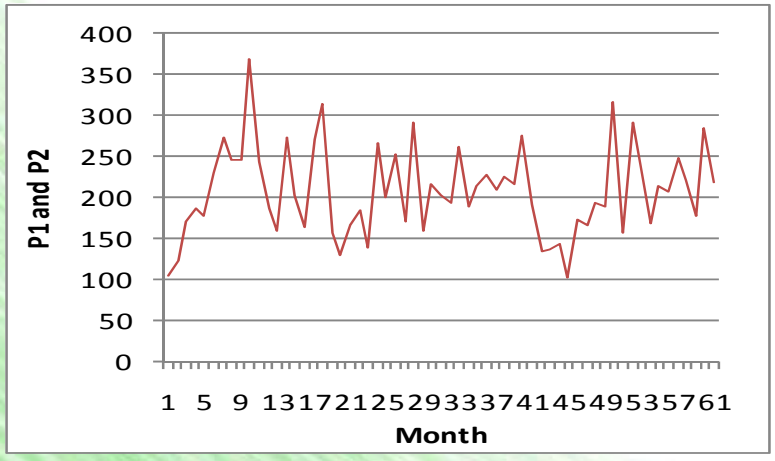
- Multiple regression analysis:
- $Y = a + b*X_1 + c*X_2 \ldots + \varepsilon = a + \Sigma b_i X_i + \varepsilon$

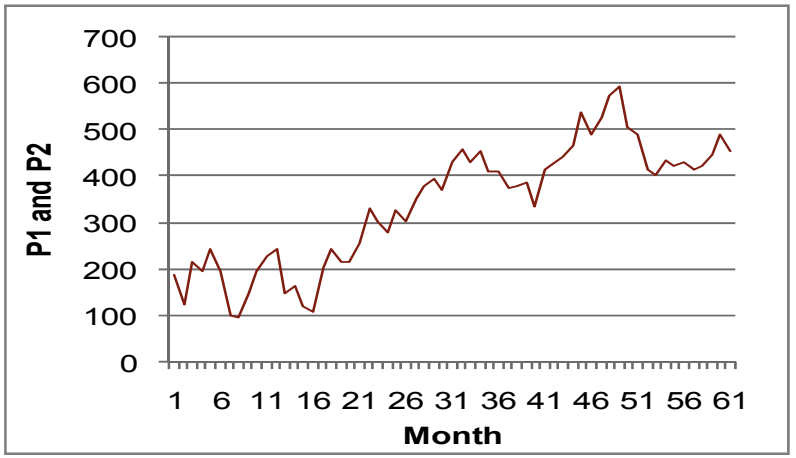
- Advantages
  - Gives information to calculate transmission elasticity
  - Can test relationships statistically
  - Can take into account lagged effects, inflation, and seasonality
  - can analyze relationship of > 2 prices
- Disadvantages
  - Difficult to identify causality
  - Misleading results if data are **non-stationary**

Non-stationarity - Definition

- What is a non-stationary variable?

Stationary variable Y	**Non-stationary variable Y**
$Y_t = a + \rho Y_{t-1} + bX_t + \varepsilon_t$ where $\lvert\rho\rvert<1$	$Y_t = a + Y_{t-1} + bX_t + \varepsilon_t$
Tends to go back toward mean	Does not tend to go back to mean, "random walk"
Finite variance	Infinite variance as $N \to \infty$





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 var(ε) changes over time. As $N \rightarrow \infty$, $var(\varepsilon) \rightarrow \infty$
  - 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 Δy_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 Δy_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]”

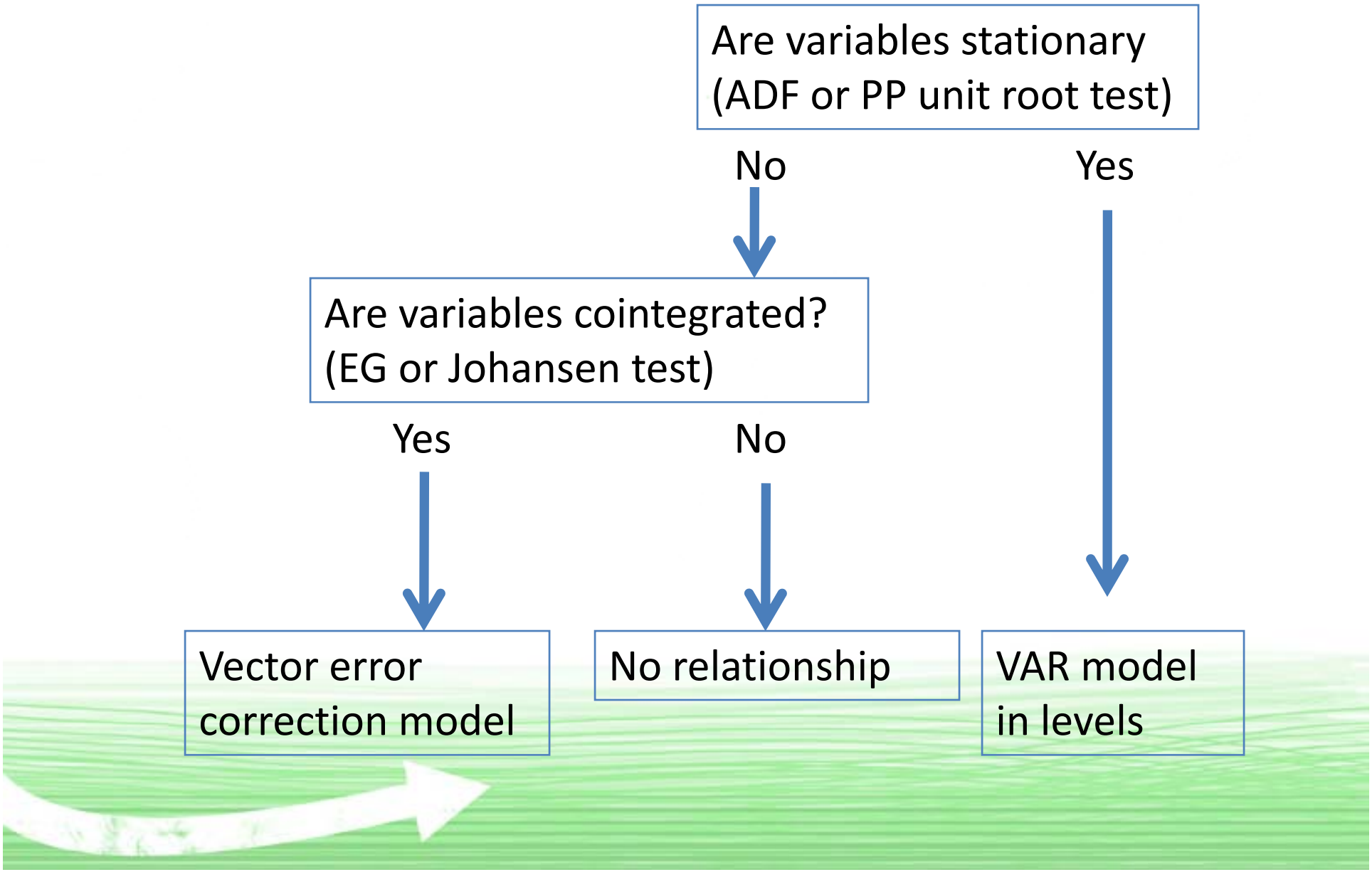
Non-stationarity – Solution

- 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

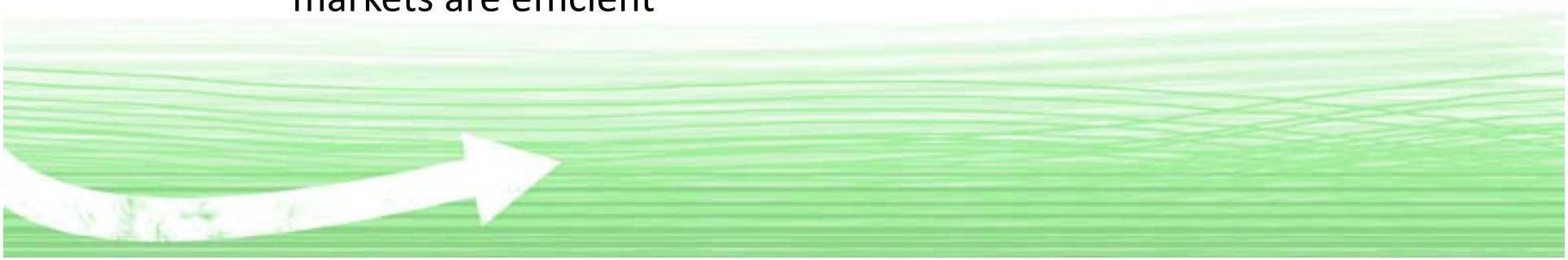
- Cointegrated variables can be expressed as a **error-correction model** (described later)

Non-stationarity – Solution



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
  - Ethiopa: 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
  - Source: FAO (http://www.fao.org/es/esc/prices/PricesServlet.jsp?lang=en)
  - 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

$$\Delta p_t^d = \alpha + \rho\left(p_{t-1}^d - \beta p_{t-1}^w\right) + \delta \Delta p_{t-1}^w + \theta \Delta p_{t-1}^d + \varepsilon_t$$

Change in domestic price

Error correction term (speed of adjustment)

Long-run relationship

Long-run elasticity of transmission

Short-run elasticity of transmission

Lagged change in world price

Lagged change in domestic price

Results: East Africa

Transmission of world food prices to domestic markets in East Africa

			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)		
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment	Short-run Adjust-ment	Long-run Adjust-ment
Ethiopia	Addis Ababa	Maize	Yes	Yes	No			
Ethiopia	Addis Ababa	Sorghum	No	Yes	No			
Ethiopia	Addis Ababa	Wheat	No	No	Stationary			
Kenya	Mombasa	Maize	Yes	Yes	Stationary			
Kenya	Nairobi	Maize	Yes	Yes	Stationary			
Uganda	Kampala	Maize	Yes	Yes	No			
Uganda	Mbale	Maize	Yes	Yes	Stationary			

Results: Tanzania

Transmission of world food prices to domestic markets in Tanzania

			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)		
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment	Short-run Adjust-ment	Long-run Adjust-ment
Tanzania	Arusha	Maize	No	No	Yes	0.54 *	-0.23	0.54
Tanzania	Dar es Salaam	Maize	Yes	Yes	No			
Tanzania	Mbeya	Maize	No	No	No	-	-	-
Tanzania	Arusha	Maize	Yes	Yes	No	-	-	-
Tanzania	Dar es Salaam	Maize	Yes	Yes	No	-	-	-
Tanzania	Mtwara	Maize	No	No	No	-	-	-
Tanzania	Singida	Maize	Yes	Yes	No	-	-	-
Tanzania	Songea	Maize	No	Yes	No	-	-	-
Tanzania	Arusha	Rice	No	No	No	-	-	-
Tanzania	Dar es Salaam	Rice	No	No	Yes	0.58 *	1.12 *	0.54 *
Tanzania	Mtwara	Rice	No	No	Yes	0.50 *	0.77	0.28
Tanzania	Singida	Rice	No	No	No	-	-	-
Tanzania	Songea	Rice	No	No	Yes	0.65 *	0.86	0.24
Tanzania	Dar es Salaam	Sorghum	No	No	No	-	-	-
Tanzania	Mtwara	Sorghum	Yes	Yes	Yes	0.30 *	0.84	0.54 *
Tanzania	Singida	Sorghum	Yes	Yes	No	-	-	-

Results: Malawi

Transmission of world food prices to domestic markets in Malawi										
			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)				
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment		Short-run Adjust-ment		Long-run Adjust-ment
Malawi	Chitipa	Maize	Yes	No	Yes	0.14	*	0.09		0.70
Malawi	Karonga	Maize	No	No	No					
Malawi	Lilongwe	Maize	No	No	Yes					
Malawi	Lunzu	Maize	No	No	No					
Malawi	Mitundu	Maize	No	No	No					
Malawi	Mzuzu	Maize	No	No	No					
Malawi	Nkhata Bay	Maize	No	No	Yes	0.20	*	0.44		0.07
Malawi	Rumphi	Maize	Yes	Yes	No	-		-		-

Results: Mozambique

Transmission of world food prices to domestic markets in Mozambique												
			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)						
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment		Short-run Adjust-ment		Long-run Adjust-ment		
Mozambique	Beira	Maize	Yes	Yes	No	-		-		-		
Mozambique	Chokwe	Maize	Yes	Yes	No	-		-		-		
Mozambique	Gorongosa	Maize	Yes	Yes	No	-		-		-		
Mozambique	Maputo	Maize	Yes	Yes	No	-		-		-		
Mozambique	Nampula	Maize	Yes	Yes	No							
Mozambique	Tete	Maize	Yes	Yes	No	-		-		-		
Mozambique	Chokwe	Rice	No	No	Yes	0.37	*	-0.24		0.39	*	
Mozambique	Gorongosa	Rice	Yes	Yes	Yes	0.31	*	-0.23		0.16	*	
Mozambique	Maputo	Rice	Yes	Yes	No							
Mozambique	Nampula	Rice	Yes	Yes	Yes	0.31	*	-0.24		0.97	*	
Mozambique	Tete	Rice	Yes	Yes	Yes	0.30	*	-0.40	*	0.70	*	

Results: Zambia

Transmission of world food prices to domestic markets in Zambia								
			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)		
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment	Short-run Adjust-ment	Long-run Adjust-ment
Zambia	Chipata	Maize	Yes	Yes	No			
Zambia	Choma	Maize	Yes	Yes	No			
Zambia	Kabwe urban	Maize	Yes	Yes	No			
Zambia	Kasama	Maize	Yes	No	No			
Zambia	Kitwe	Maize	Yes	Yes	No			
Zambia	Lusaka	Maize	Yes	Yes	No			
Zambia	Mansa	Maize	Yes	Yes	No			
Zambia	Mongu	Maize	No	No	No			
Zambia	Solwezi	Maize	No	No	No			

Results: Ghana

Transmission of world food prices to domestic markets in Ghana

			Unit root in domestic price?		Long-run relationship?	Error correction model (if long-run relationship confirmed)		
Country	Location	Commodity	ADF test	Phillips-Perron test	Johansen test	Speed of Adjust-ment	Short-run Adjust-ment	Long-run Adjust-ment
Ghana	Accra	Imported ric	No	No	No			
Ghana	Kumasi	Imported ric	Yes	Yes	No			
Ghana	Tamale	Imported ric	No	No	No			
Ghana	Techiman	Imported ric	Yes	Yes	No			
Ghana	Kumasi	Local rice	No	No	Yes	0.20 *	-0.13	0.47
Ghana	Tamale	Local rice	No	No	No			
Ghana	Techiman	Local rice	Yes	Yes	No			

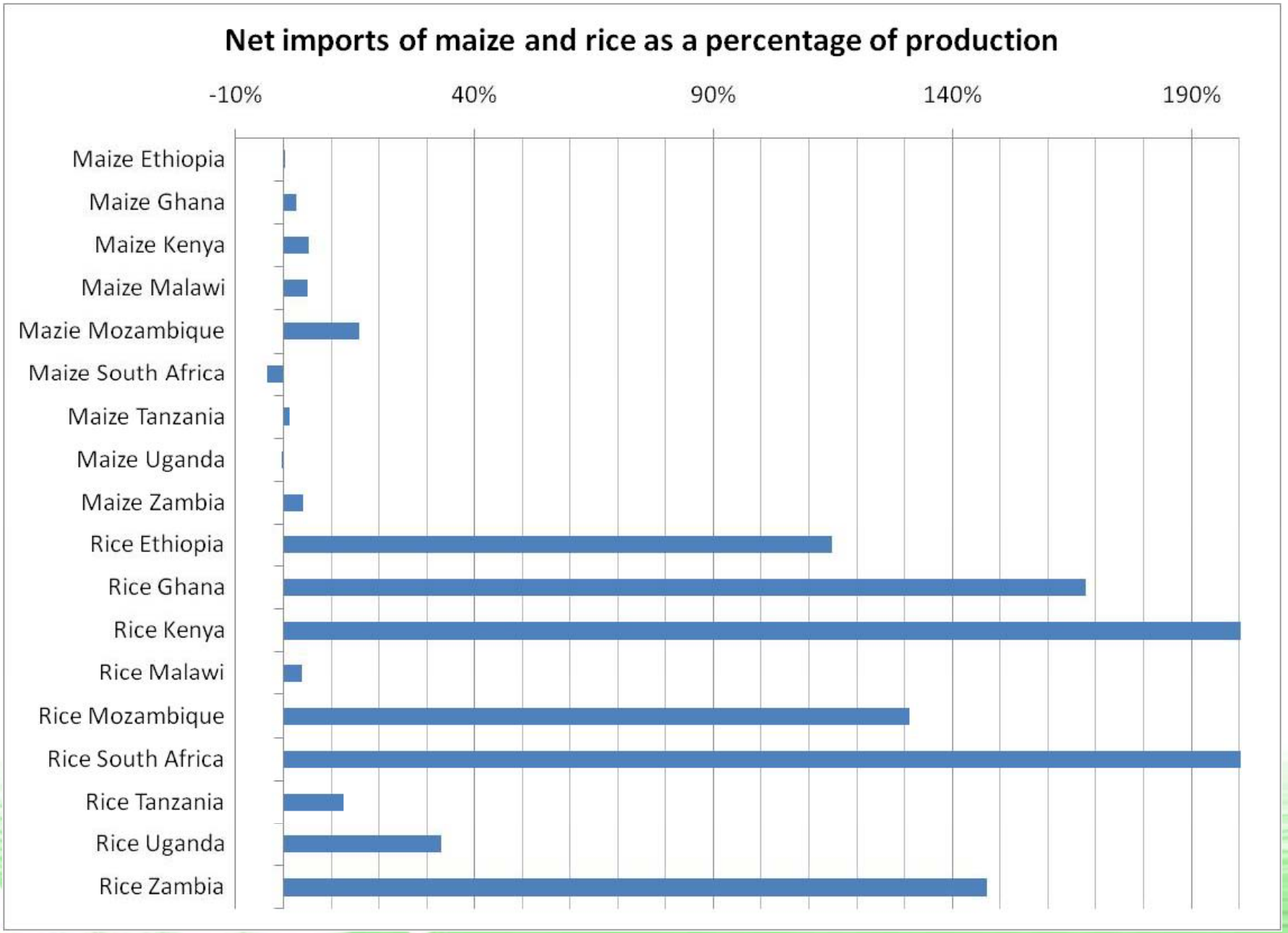
Results: Summary

Result of test of long-run relationship		Johansen test
Yes		13
No		41
Stationary		8
Total		62

Results of test of long-run relationship by country				
		Prices with relationship	Total nbr. of prices	Percen-tage
Ethiopia		1	3	33%
Ghana		1	7	14%
Kenya		0	2	0%
Malawi		3	8	38%
Mozambique		4	11	36%
South Africa		0	4	0%
Tanzania		4	16	25%
Uganda		0	2	0%
Zambia		0	9	0%
Total		13	62	21%

Results: Summary

Results of test of long-run relationship by crop				
		Prices with relationship	Total nbr. of prices	Percen-tage
Maize		4	40	10%
Rice		8	17	47%
Sorghum		1	4	25%
Wheat		0	1	0%
Total		13	62	21%


Net imports of maize and rice as a percentage of production
-10%
40%
90%
140%
190%
Maize Ethiopia
Maize Ghana
Maize Kenya
Maize Malawi
Mazie Mozambique
Maize South Africa
Maize Tanzania
Maize Uganda
Maize Zambia
Rice Ethiopia
Rice Ghana
Rice Kenya
Rice Malawi
Rice Mozambique
Rice South Africa
Rice Tanzania
Rice Uganda
Rice Zambia

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

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