INDIRECT ESTIMATION OF STOCKS FROM PRICE DATA

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Post- "*Inside Job*" I perceive a need for disclosure:

Recent or current grant support:

- NIH
- NSF
- USPTO
- Giannini Foundation

- No recent positions in commodity markets
- No investments in agricultural input or service providers, or significant commodity market or energy market participants.

Focus of this presentation:

- ✓ ***Producers and users of stocks data***
- ✓ ***3 major grains:*** *wheat, rice and maize*
- ✓ ***Global, or global excluding China***
- ✓ ***Annual data***
- ✓ ***(Mostly) Pre-biofuels market behavior****

*Wright, Brian D. 2014. "Global Biofuels: Key to the Puzzle of Grain Market Behavior." *Journal of Economic Perspectives* Vol. 28 no. 1, Winter.

Bobenrieth, Eugenio, Brian D. Wright and Di Zeng. 2013. "Stocks-To-Use Ratios and Prices As Indicators Of Vulnerability To Spikes In Global Cereal Markets." *Agricultural Economics* 44 1–10.

Questions:

① *Why study stocks? Does current production variation on its own explain periods of market volatility?*

② *For wheat, rice and maize, (the "major grains") does current production variation explain current price?*

③ *Can we find a meaningful global aggregate of stocks, and of prices?*

④ *Does an aggregate grain calorie price index usefully forecast next-year price?*

⑤ *Does aggregate grain production variation "drive" current price of each major grain, or of aggregate calories from the three "major grains?"*

⑥ *Is the current stocks/use ratio ("use") related to current grain price for each crop, or to aggregate calorie price?*

Questions:

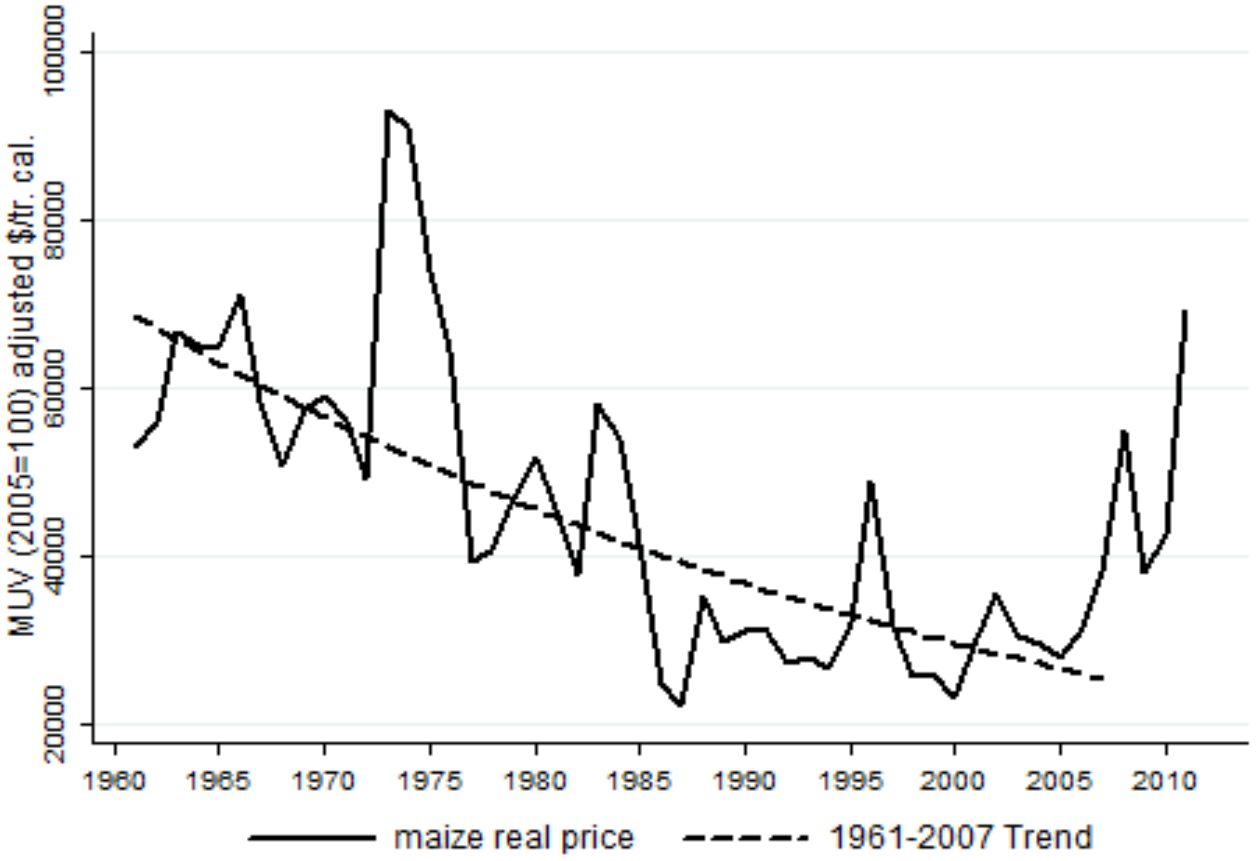
⑦ ***Does the current stocks/use ratio ("use") forecast next-year grain price for each crop, or for aggregate?***

⑧ ***A test: How well can we reconstruct the ratio of current current stocks/use ratio from a model estimated on grain prices, only, adjusted for constant or slowly moving essential stocks?***

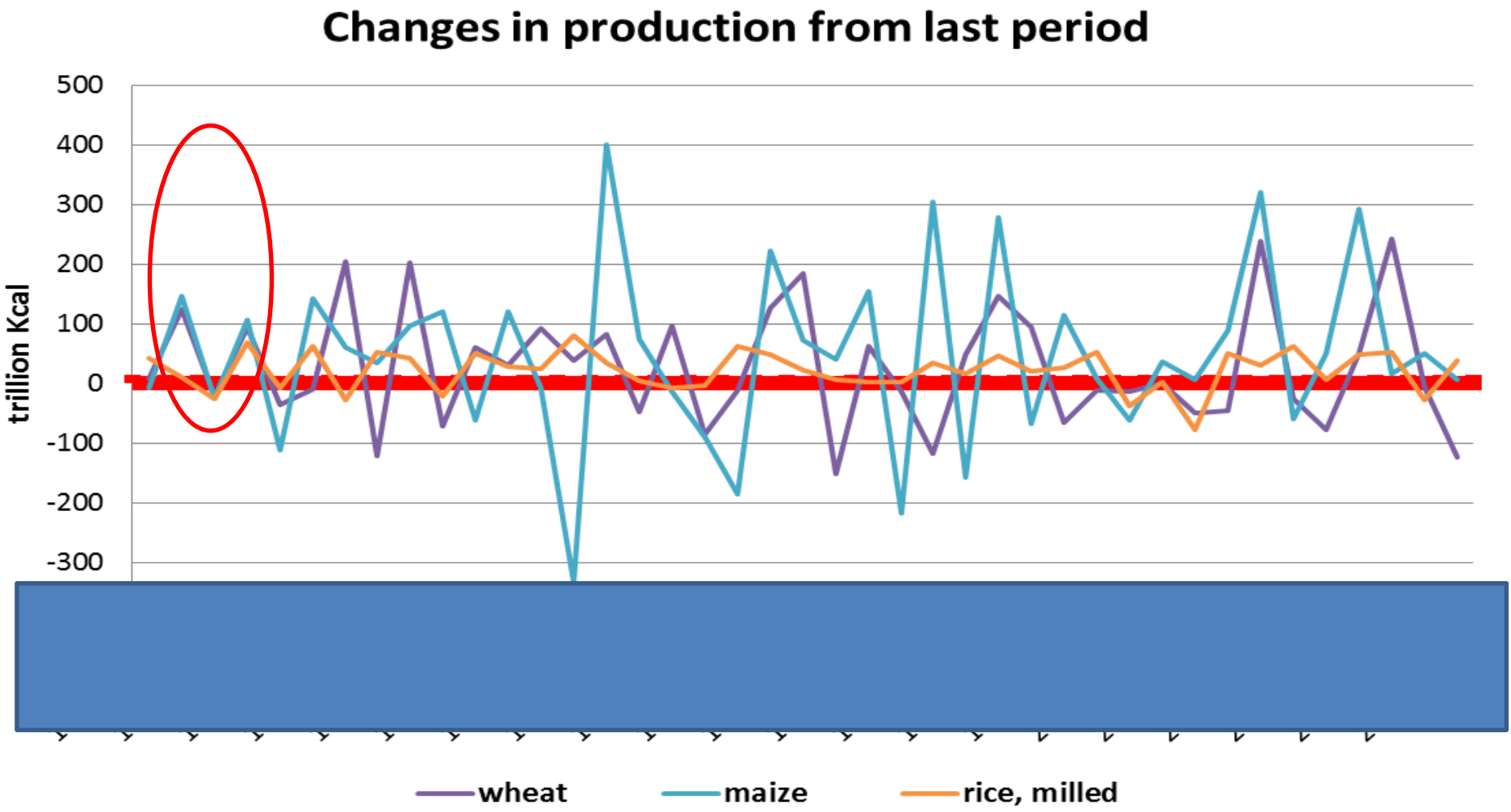
⑨ ***Can observed stocks/use ratio supplement current price in helping explain future grain prices?***

Typical Grain Price Behavior: Maize Real Price and Trend

Deflator: Manufactures Unit Value (MUV)

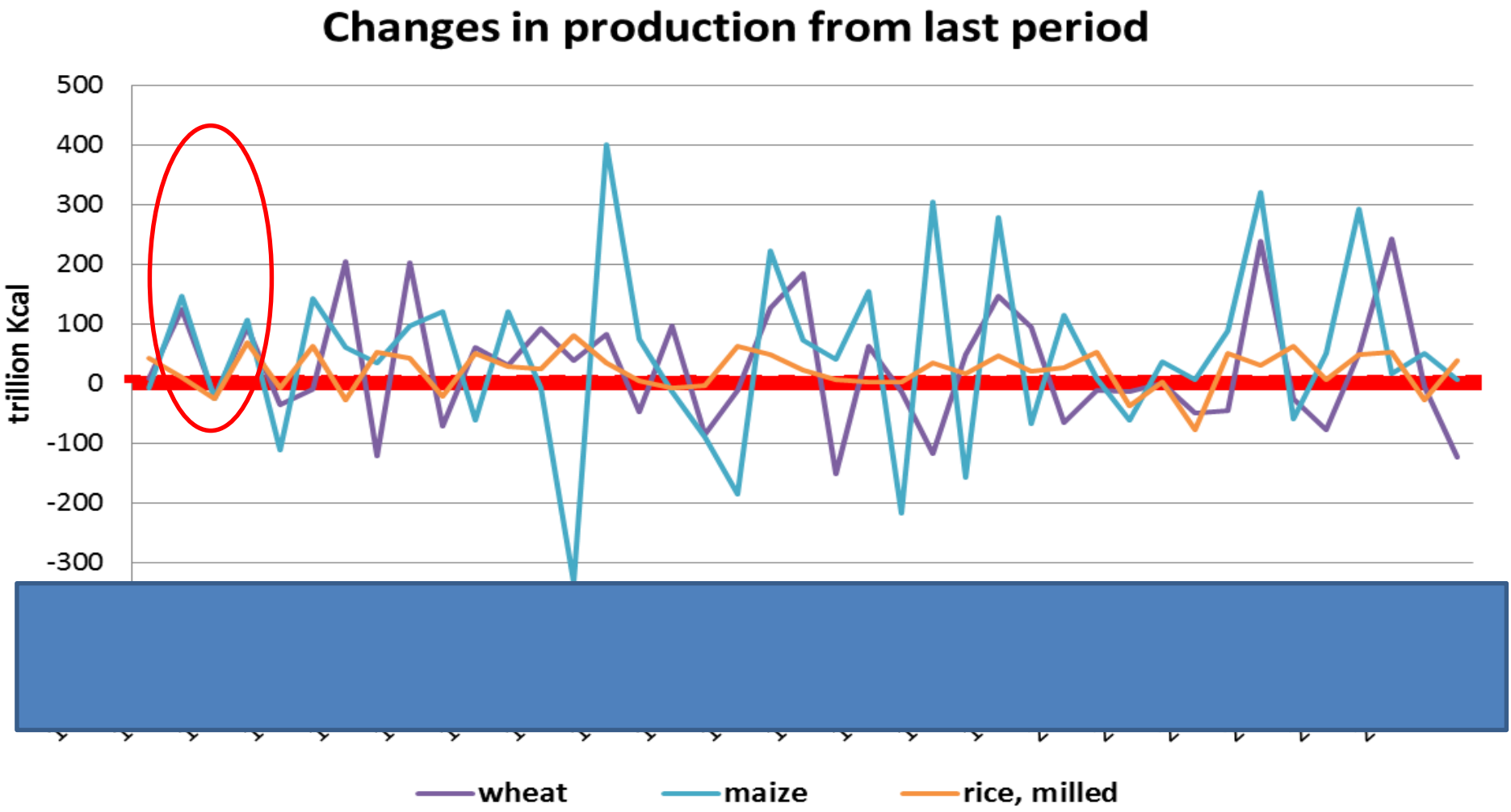


Does Production Volatility "drive" Price Spikes?



Source: Calculated using Data from PSD Online, USDA.

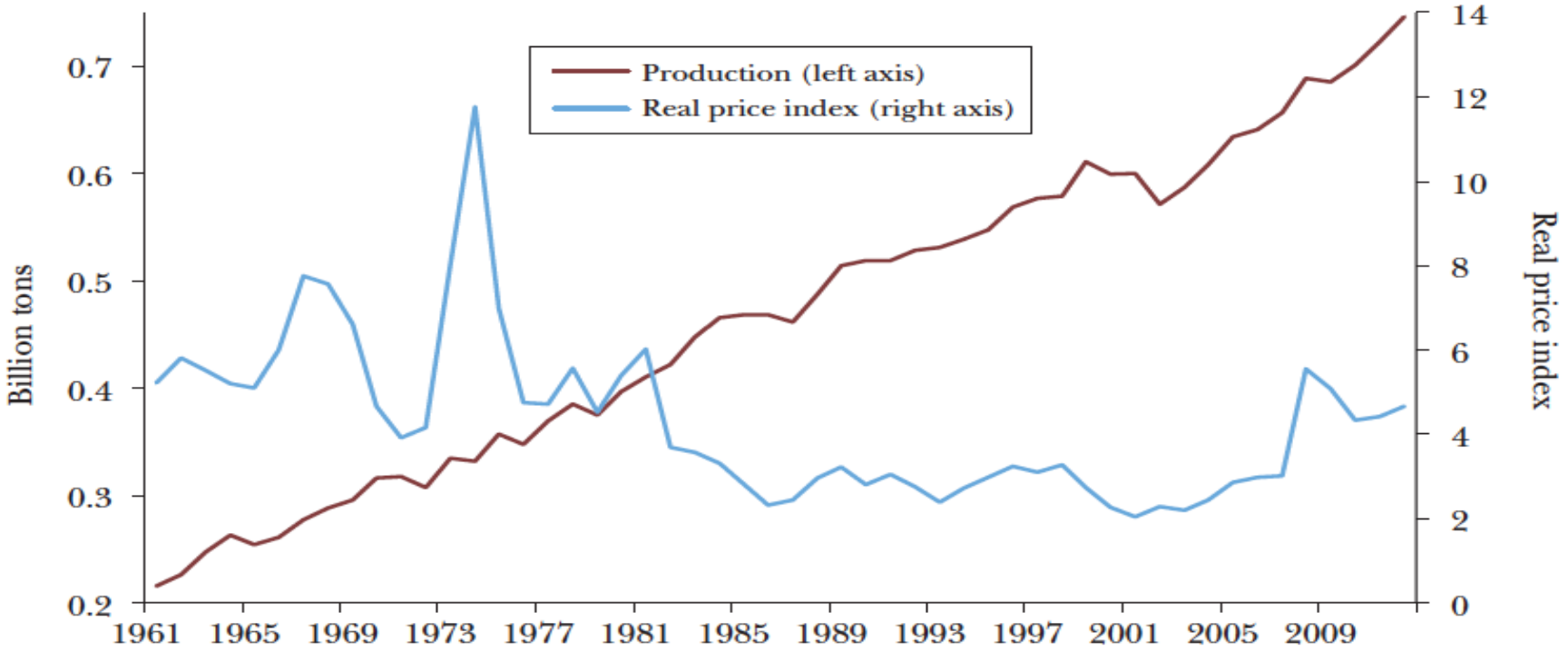
Does Production Volatility "drive" Price Spikes?



Source: Calculated using Data from PSD Online, USDA.

Rice: Does current production variation explain current rice prices?

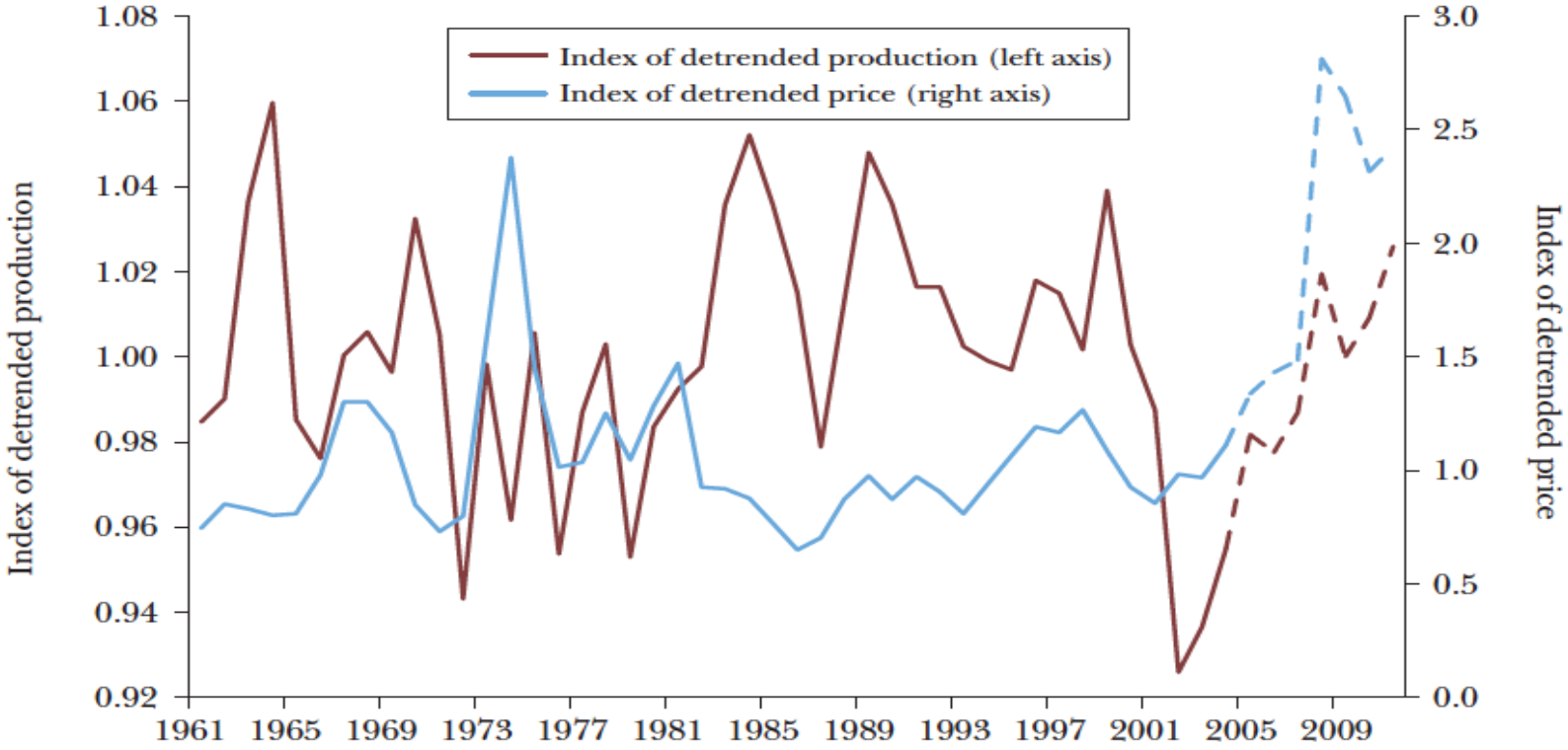
Rice: Real Price Index and Production, 1961–2012



Notes: The nominal rice price from 1961 to 2012 is the calendar year annual average price for rice (Thailand 5% broken) from the commodity price dataset of the World Bank (the pink sheet). The real price index for rice is obtained by deflating the nominal price using Manufactures Unit Value (MUV) from the same dataset. The world rice production from 1961 to 2011 is the calendar year production data for rice paddy from the FAOSTAT of the UN Food and Agriculture Organization. For 2012, we use the US Department of Agriculture (USDA) production data for rice (milled) for the marketing year 2011/2012 adjusted by a ratio between the FAOSTAT 2011 data and USDA 2010/2011 data to roughly account for the difference between paddy and milled rice.

Rice Prices and Production: A closer look, detrended

Rice: World Detrended Price versus Index of Detrended Production, 1961–2012



Notes: The real price index is assumed to be trend stationary. The index of detrended price is obtained by taking the exponential of the residuals from regressing log real price against a constant and time. The world production is assumed to be the product of a linear function of time and a stationary shock. We regressed the log production against the log of the linear function time. We take the exponential of the resulting residuals and use the series as the index of detrended production. The correlation coefficient between the resulting two detrended series through the year of 2004 is –0.2. The dashed lines indicate a new market regime in effect after 2005.

So:

For individual grain crops, production variation is not enough to explain price volatility

- Try aggregation of grains?

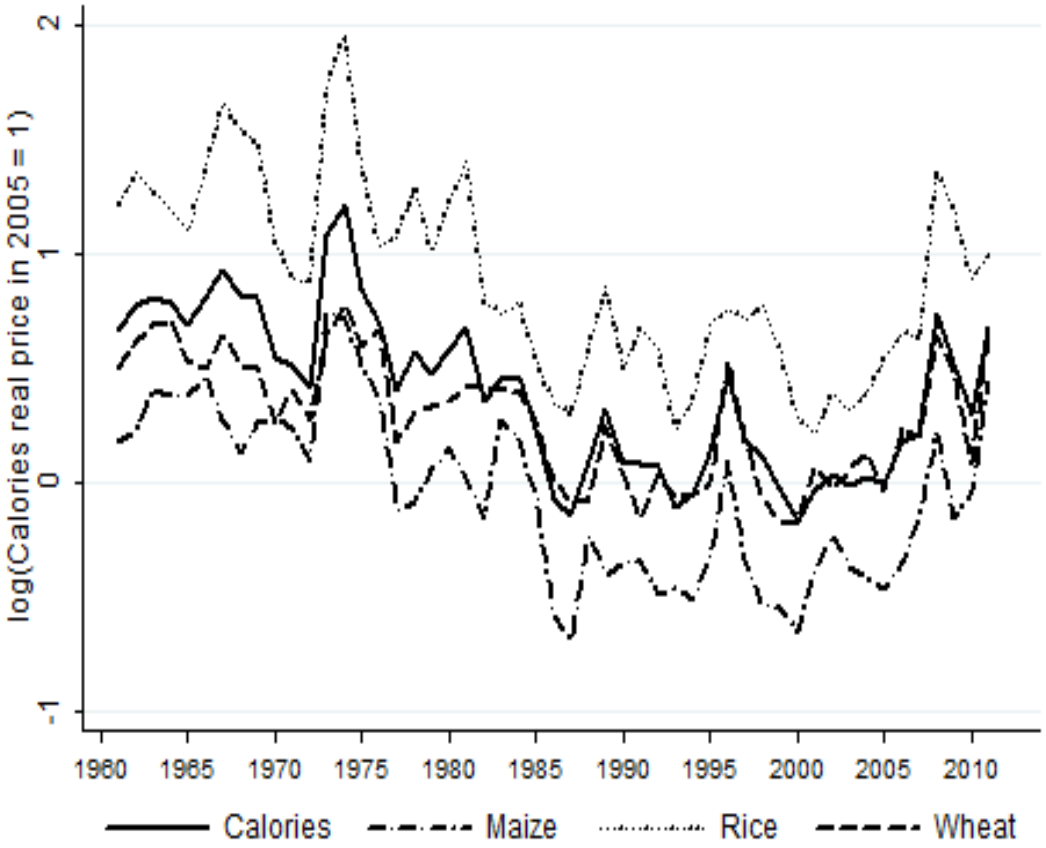
Calorie-weighted Price Index: Correlations with Real Detrended Major Grain Prices

Price of	Wheat	Maize	Rice	Calories
Wheat	1.0000			
Maize	0.7875	1.0000		
Rice	0.5803	0.6280	1.0000	
Calories	**0.8318**	**0.8598**	**0.9133**	1.0000

Co-movement:

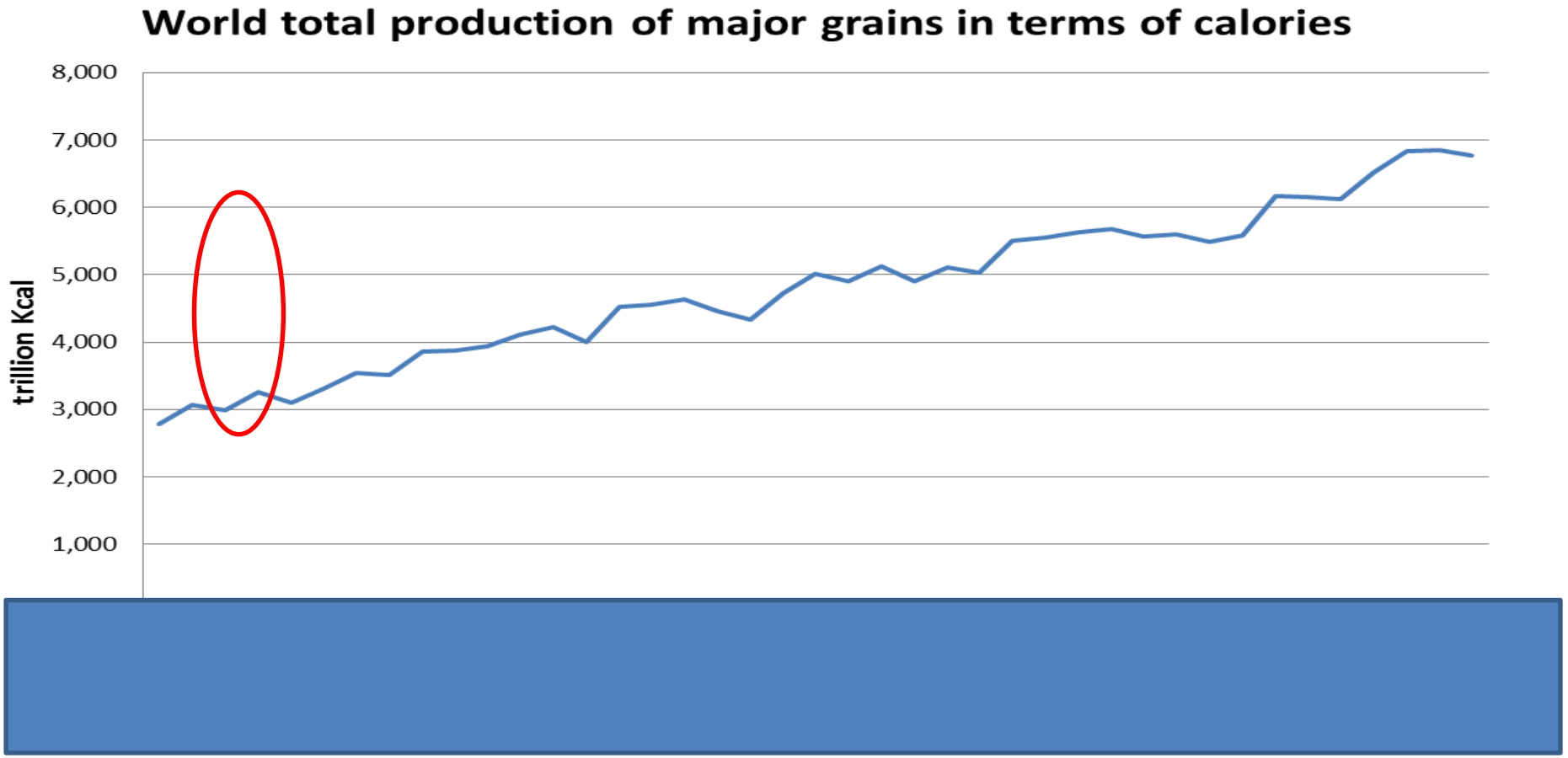
Real prices of wheat, rice, maize **and calories**

(natural logarithm scale)



Grain Calories: Do realized prices reflect current production?

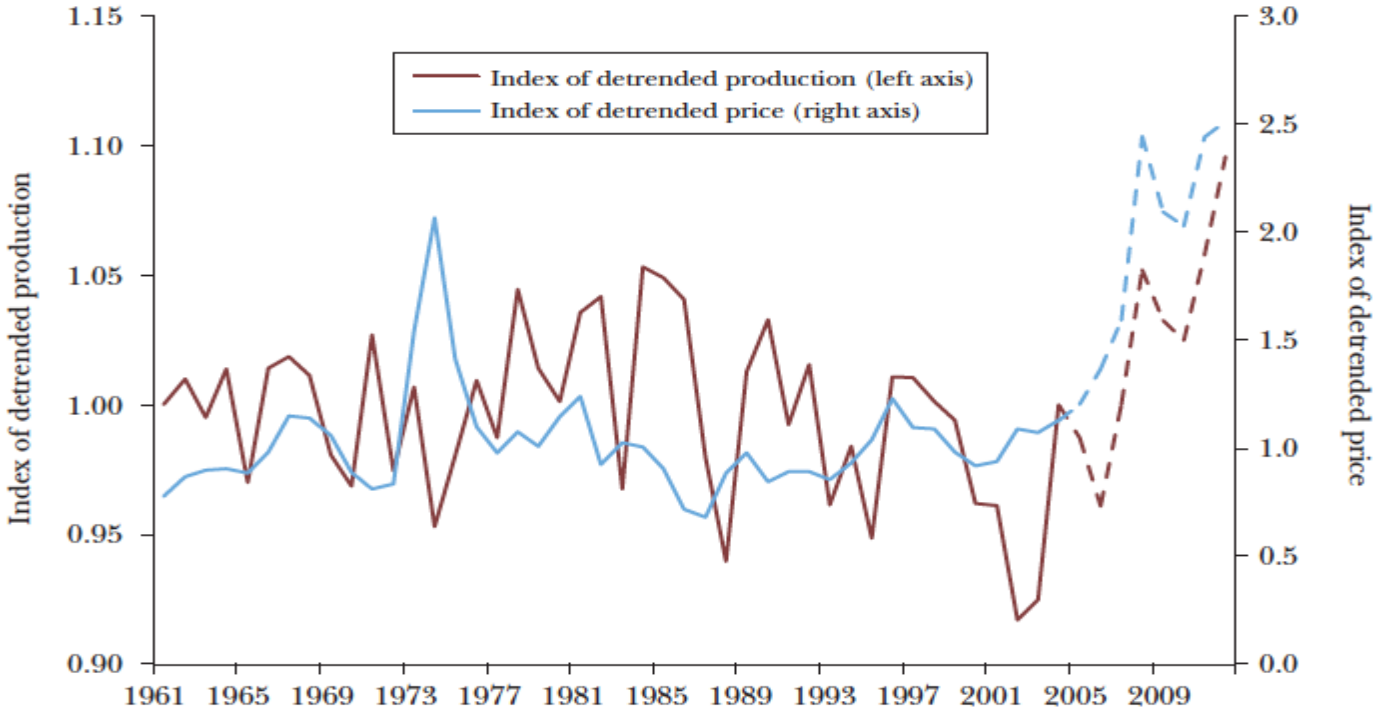
Was largest aggregate grain production shortfall during 1970s spikes?



Source: Calculated using Data from PSD Online, USDA.
Note. World grains = wheat + maize + milled rice. All quantities converted into Calories assuming, for wheat 3338Kcal per Kg, for maize 3650 Kcal per Kg, and for milled rice 3656 Kcal per Kg).
2010/2011 is projection.

Calorie Price does not necessarily reflect production

Calories: Index of World Detrended Price versus Index of World Detrended Production



Notes: We convert the production quantities for corn, rice, and wheat to calorie units using the calorie content data from the US Department of Agriculture (USDA) National Nutrient Database. The world grains calorie production is obtained by aggregating calorie contents in the production of these three grains. The nominal price for calories is obtained by dividing the total nominal value of grain calorie production by total grain calorie production. After deflation, we obtain the detrended real price, which is detrended using the same technique as outlined in Figure 2. The world production of the three grains from 1961 to 2011 is the calendar year production data from the FAOSTAT of the UN Food and Agriculture Organization. For 2012, we use the USDA production data for corn, rice (milled), and wheat for the marketing year 2011/2012 using the technique described in the note to Figure 1 to generate the rice production data in 2012. The dashed lines indicate a new market regime in effect after 2005.

So:

Aggregate grain production does not “drive” prices

So Aggregation does not make grain production "drive" prices

- **So let's consider stocks ….**

$$Stocks(t-1)+Production(t)-Consumption(t)=Stocks(t)$$

At year *t*:

- **Carry-in stocks are given**
- **Current production is given**, with exogenous yield variation

Production and policy "drive" price, consumption, and stocks

At year *t*:

- Consumption is endogenous
- Carry-out stocks are endogenous
- Consumption is related to price by consumption demand function:

  Consumption (t) =F(Price, Policy)

- ***So Consumption and Price are both endogenous:***

  - Consumption does not "drive" price

  - Price does not "drive" consumption

To understand relation of stocks to price spikes better, we need a little storage theory:

- Storers smooth out troughs in price and low-value consumption after high harvests by "***buying low to sell high***"
- Storers smooth **expected** shortages ***if cash is available:***
  - ***invest in stocks, raise current price, reduce expected shortage***

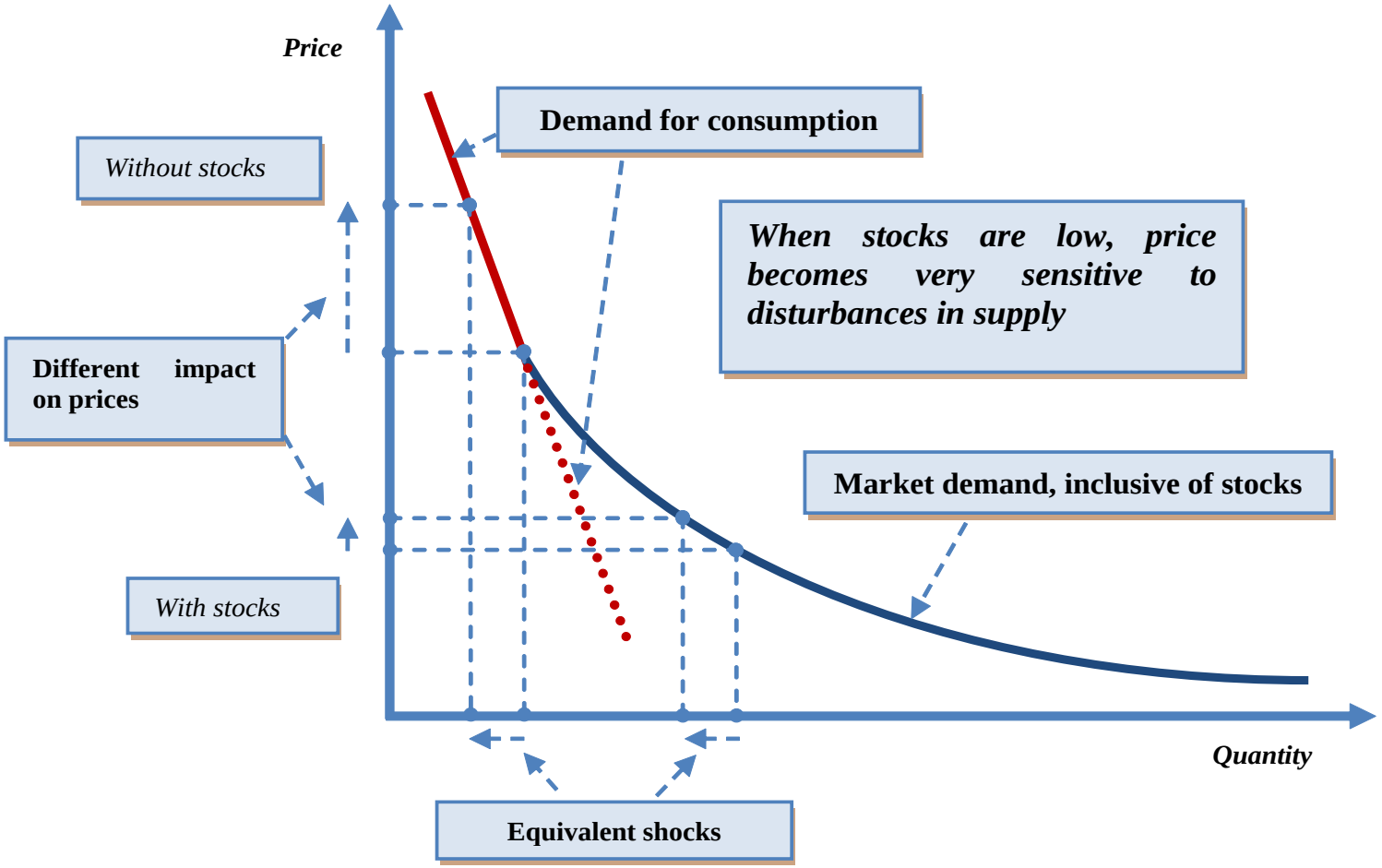
Role of storage arbitrage

Key relations: *Buy when P low, sell when P high*

$$P(t) + \text{cost of storage} = \frac{E[P(t+1)]}{1+r} \; if \;\; stocks > 0$$

$$P(t) + \text{cost of storage} \geq \frac{E[P(t+1)]}{1+r} \; if \;\; stocks = 0$$

Why is price much more sensitive to annual shocks when stocks are minimal?

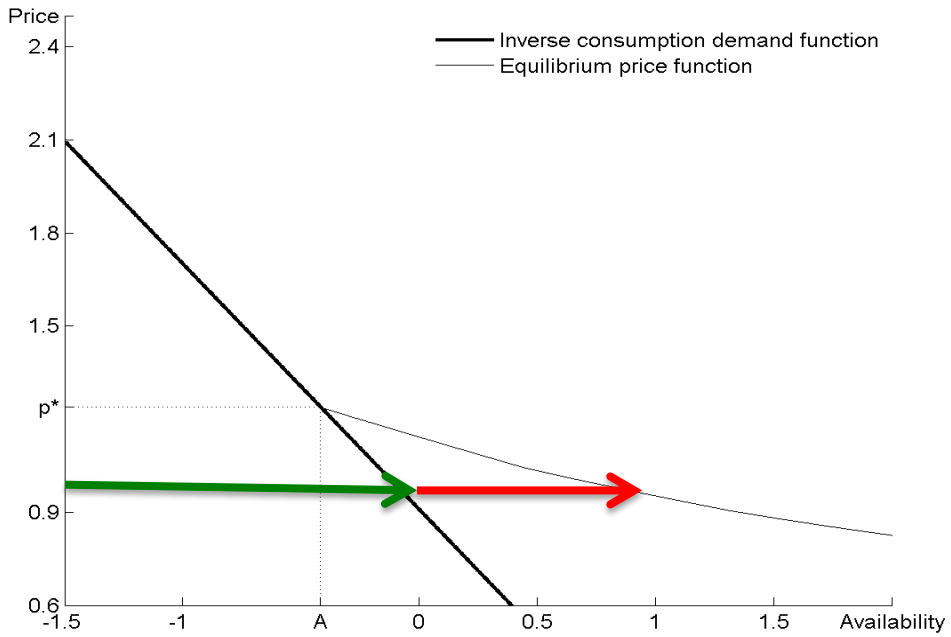


Theory: Effects of storage.

- Storers smooth out peaks after ***unexpected*** production shocks, but ***only until their stocks run out***
- ***When stocks run out, price spikes are required, to force consumers to respond one-for-one to shocks***

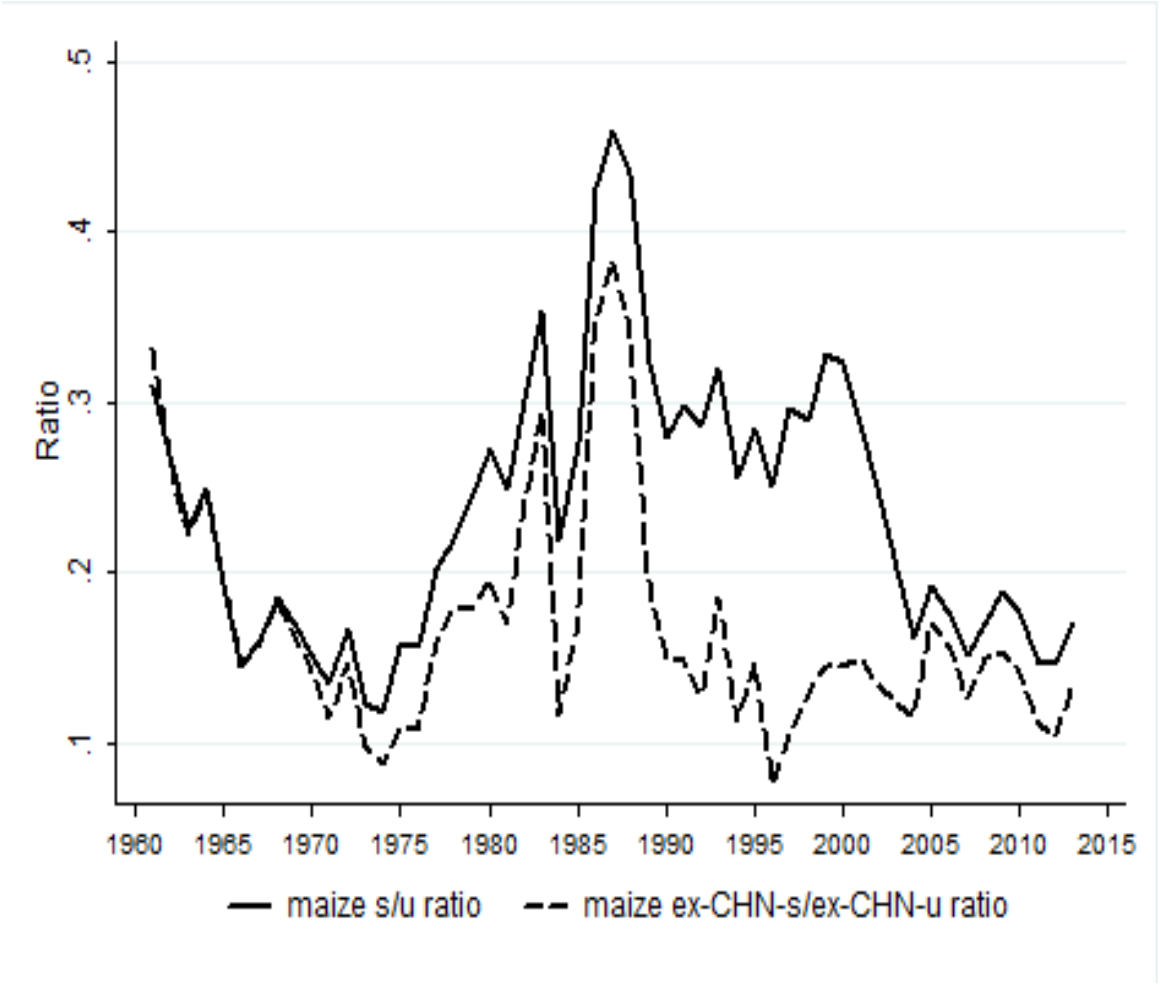
SPIKES OCCUR after short-run production shocks ONLY IF STOCKS ARE LOW

Let's measure stocks by the ratio of stocks of grain

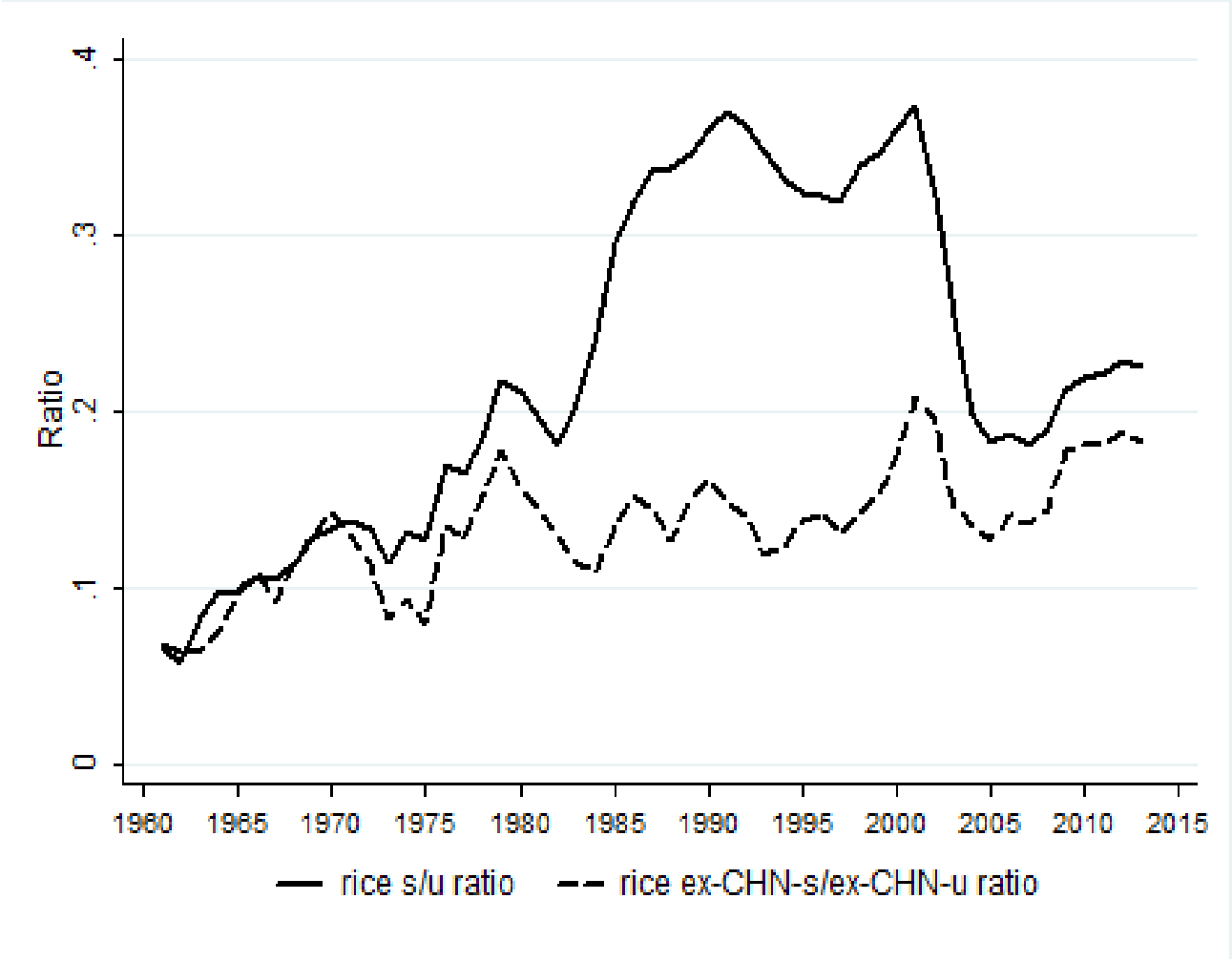


e.g. RED/GREEN = Stocks/Use at Price=0.9

Maize Stocks/Use Ratios
- with and without China

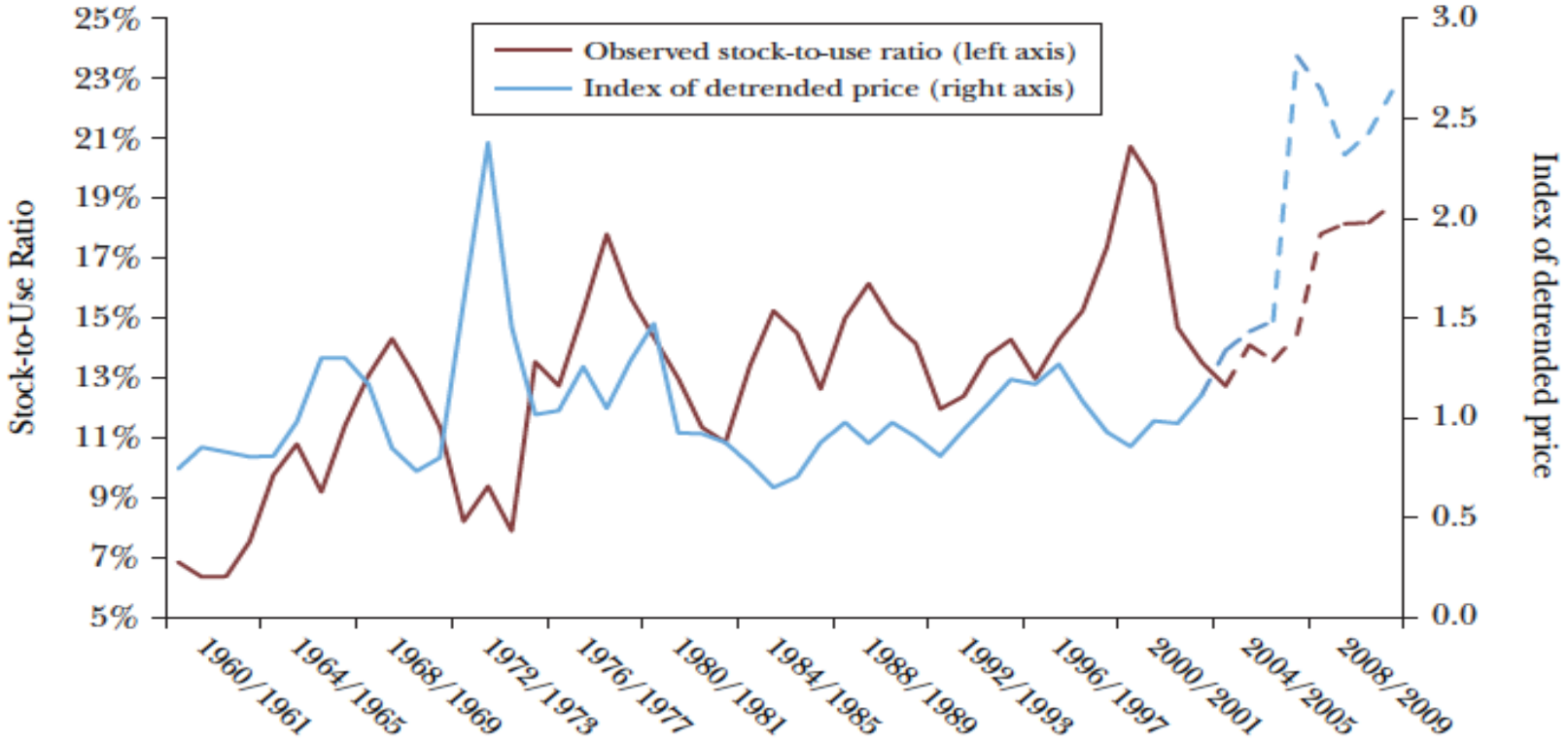


Rice: Stocks/Use Ratios
- with and without China



Does stocks-to-use ratio explain world rice price?

Rice: Detrended Price versus Observed Stock-to-Use Ratio

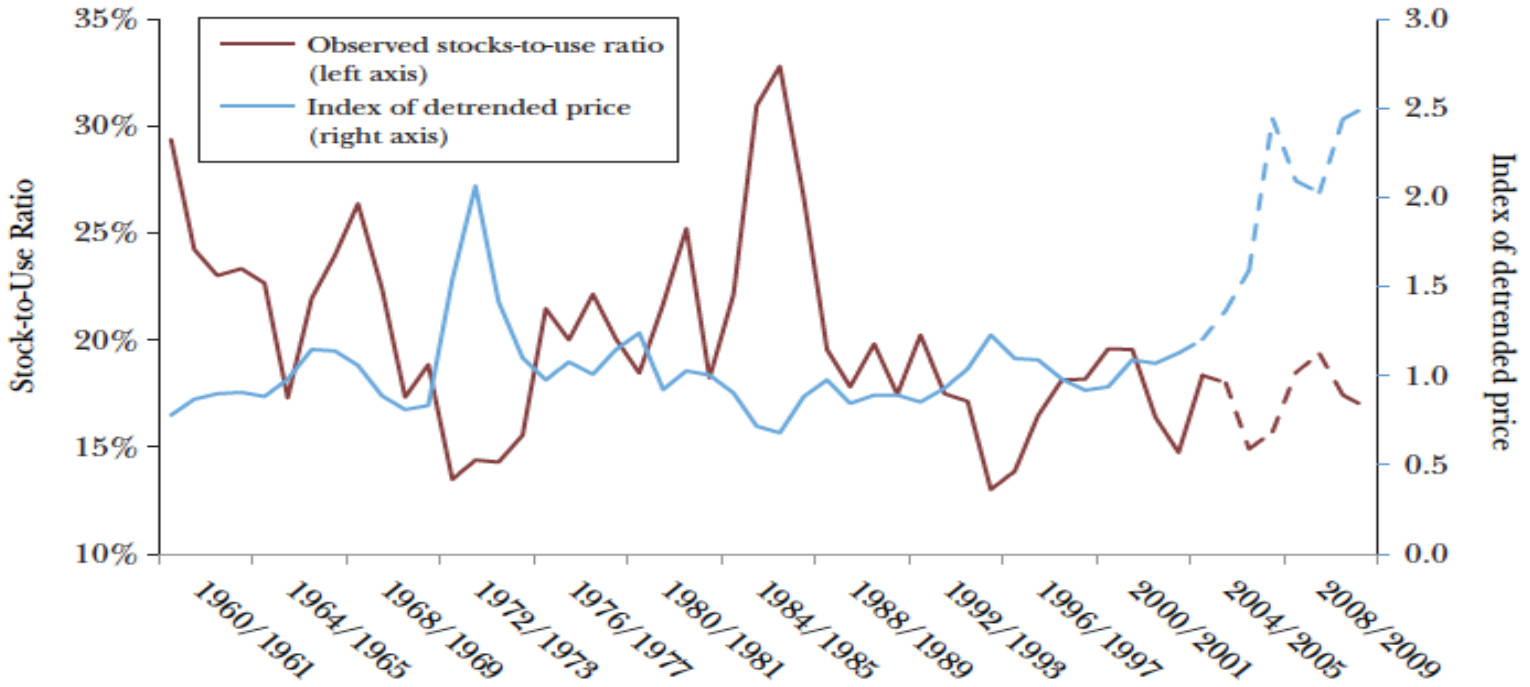


Source: The stocks and consumption (use) data are from the Production, Supply, and Distribution (PSD) Online of the US Department of Agriculture.

Notes: In the stocks-to-use ratio, the numerator is observed stocks, including slow-changing essential "pipeline stocks" as well as the discretionary stocks discussed, while the denominator approximates consumption as "use," typically calculated as production less changes in stocks. The stocks-to-use ratio excludes Chinese stocks and use. The index of detrended price for rice is the same as in Figure 2. The trend is estimated through 2004, to avoid the influence of a possible change in market regime after that year. The correlation coefficient between the two series till 2004 is –0.1355.

Does stocks/use relate to aggregate grain calorie price index?

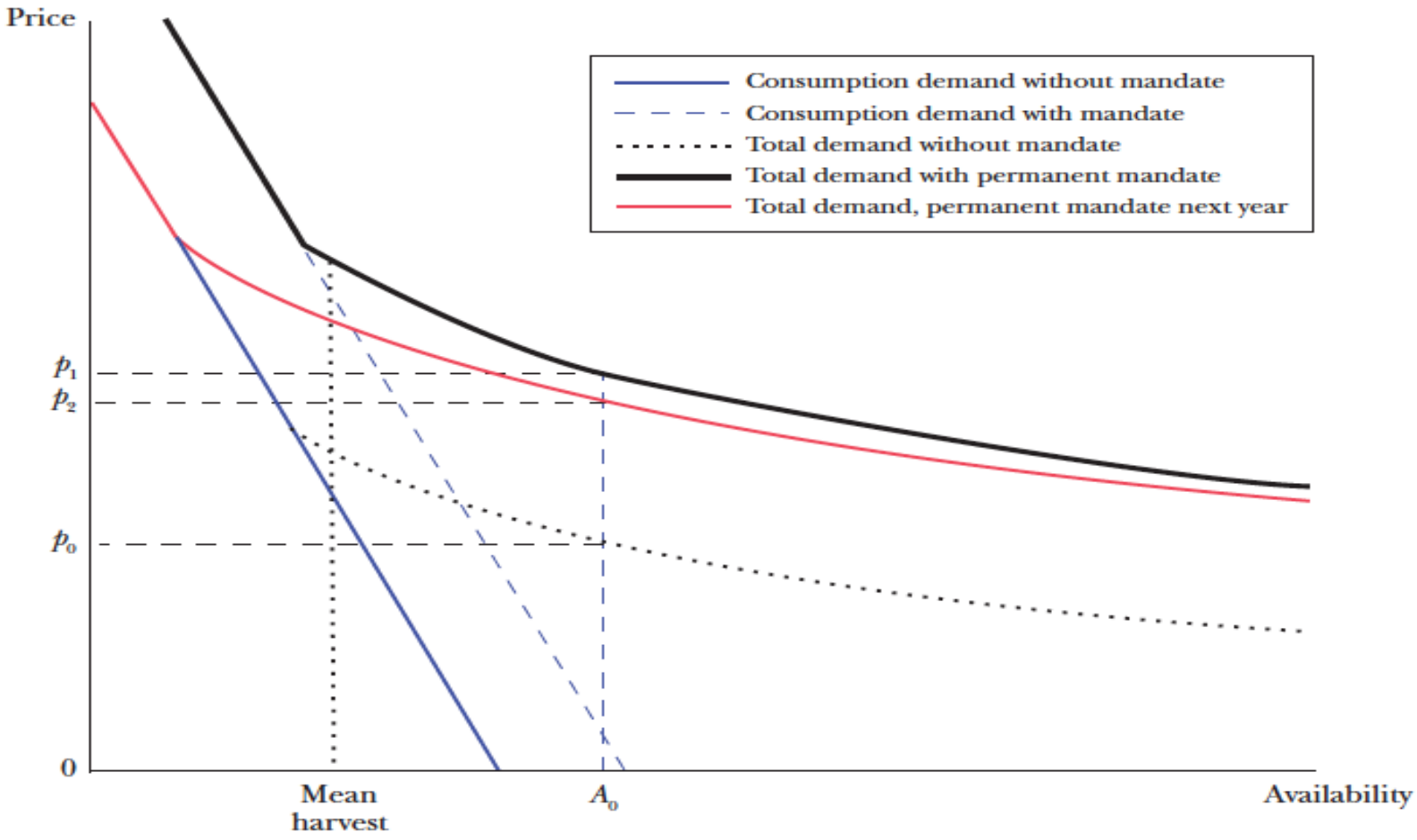
Calories: Index of Detrended Price versus Observed Stock-to-Use Ratio



Notes: In the stocks-to-use ratio, the numerator is observed stocks, including slow-changing essential "pipeline stocks" as well as the discretionary stocks discussed, while the denominator approximates consumption as "use," typically calculated as production less changes in stocks. The stocks-to-use ratio excludes Chinese stocks and use. The stocks and consumption (use) data for corn, rice, and wheat are from the Production, Supply, and Distribution (PSD) Online of the US Department of Agriculture. Grain calorie consumption and stocks are constructed as for the grains calorie production in Figure 5. The index of detrended price for calories is the same as in Figure 5. The correlation coefficient between the two series through 2004 is –0.5645. The dotted lines indicate a new market regime in effect after 2005.

Why is price rising with stock-to-use ratio around 2006-08? Biofuels mandates in US, EU.

Demand Shifts and Price Jumps upon Announcement of a Permanent Mandate



Notes: $p_2 - p_0$ represents the price rise due to anticipation of a permanent mandate next year.

Calorie stocks/use ratio has highest correlation with detrended real price of each major grain

	Wheat detrended real price	**Maize** detrended real price	**Rice** detrended real price	**Calories** detrended real price
Wheat stock/use ratio	-0.4018	-0.4413	-0.3438	-0.4344
Maize stock/use ratio	-0.3971	-0.5034	-0.4356	-0.5156
Rice stock/use ratio	-0.2286	-0.2048	**-0.1731**	-0.2136
Calories stock/use ratio	**-0.4996**	**-0.5723**	**-0.4729**	**-0.5792**

Years: 1961-2007
Stocks/use ex-China

Does price summarize all market information?

- Is price a sufficient statistic of market conditions and outlook?

- If markets are “perfect,” yes

The challenge for predicting spikes: *Global data are problematic*

- Price is at best an average of diverse prices consumers actually pay for grain consumed
- Production data vary in accuracy
- Stocks data are estimates, guesses and worse…

Can realized stocks add anything realized production data cannot tell us?

- First: What ratio is most informative:

- Assumption:

Price Spikes coincide with real shortages

Can carryover stocks-use ratio help predict quantity shortages?

Transition matrix for calorie SUR.

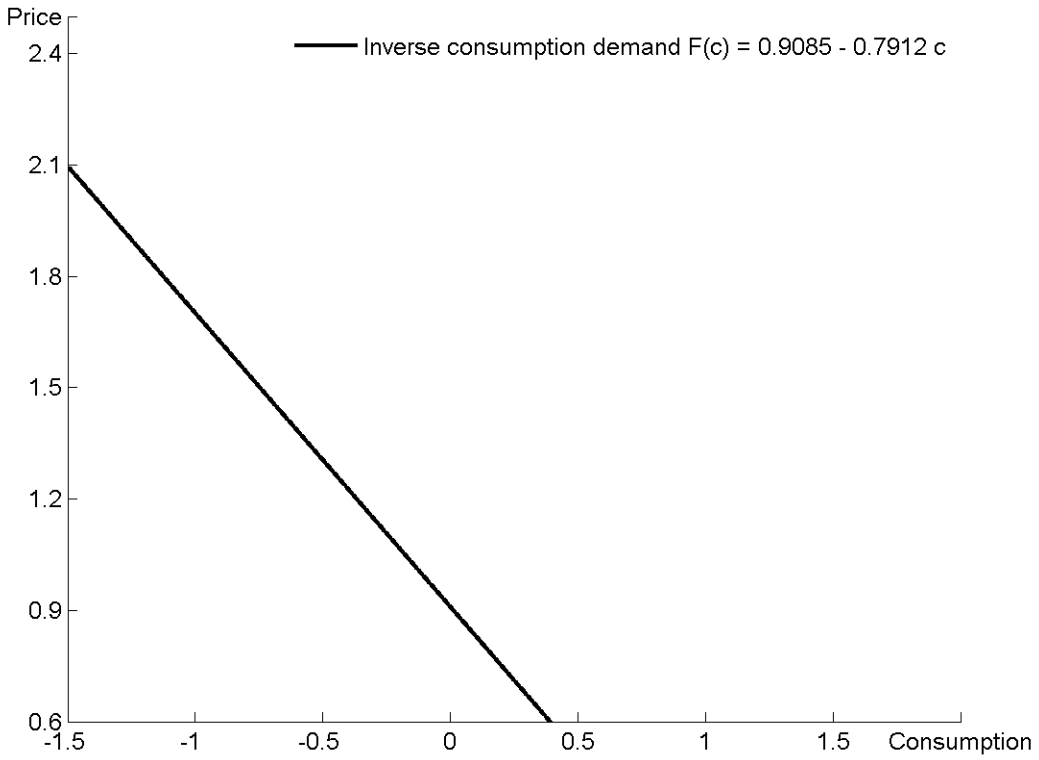
		To (percentiles)				
		0-20	20-40	40-60	60-80	80-100
From (percentiles)	0-20	0.625	0.125	0.125	0.125	**0.000**
	20-40	0.200	0.300	0.300	0.200	**0.000**
	40-60	0.222	0.333	0.111	0.333	**0.000**
	60-80	**0.000**	0.300	0.200	0.100	**0.400**
	80-100	**0.000**	0.000	0.222	0.333	**0.444**

We estimated a model of each grain market, estimating demand for stocks and for consumption, *using only price data*

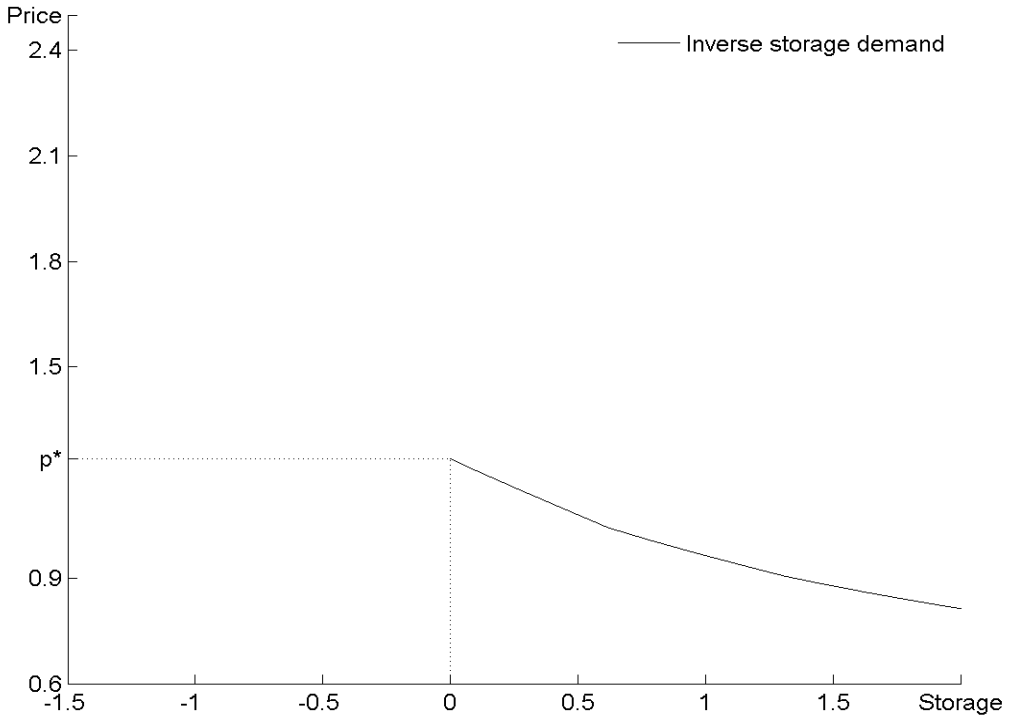
- Avoids using "bad" stocks data
- Follows estimation tradition in this area
  - but used Max Likelihood approach*
  - Need detrended background model for consistency
  - Messy details…

  - Cafiero, C., Eugenio S.A. Bobenrieth H., Juan R.A. Bobenrieth H., and Brian D. Wright 2015. "Maximum likelihood estimation of the Standard Commodity Storage Model. Evidence from Sugar Prices." *American Journal of Agricultural Economics.* doi: 10.1093/ajae/aau068

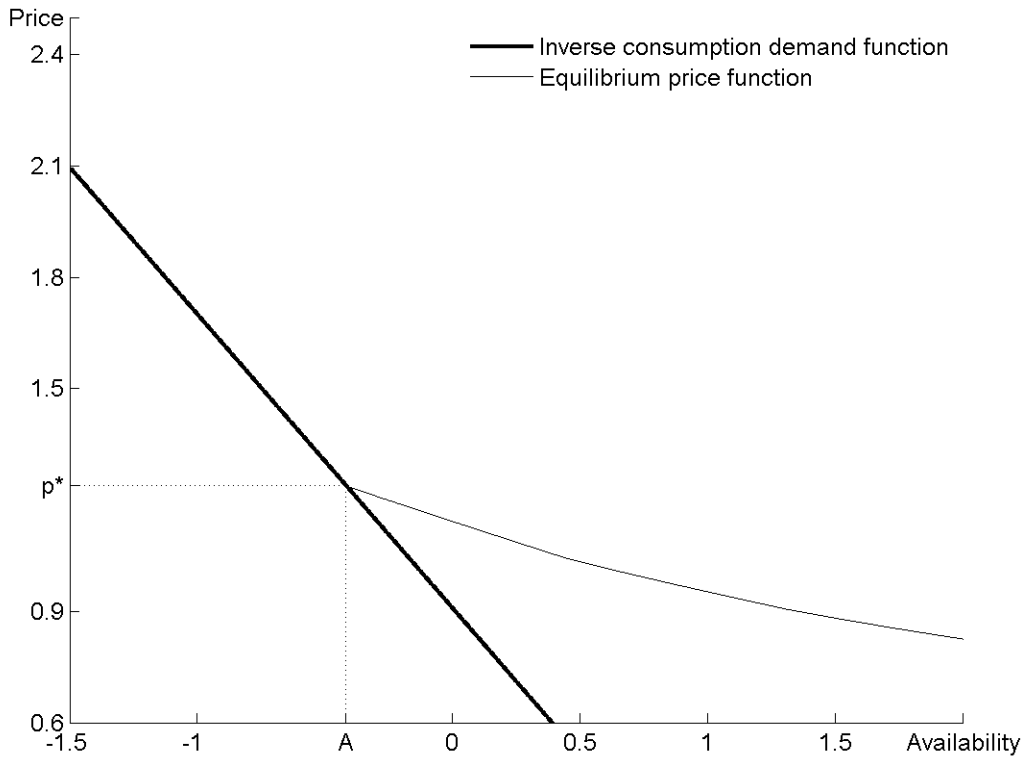
Econ 101: Consumption demand curve



Add demand for stocks (non-negative) generated by model using prices and essential stock calibration

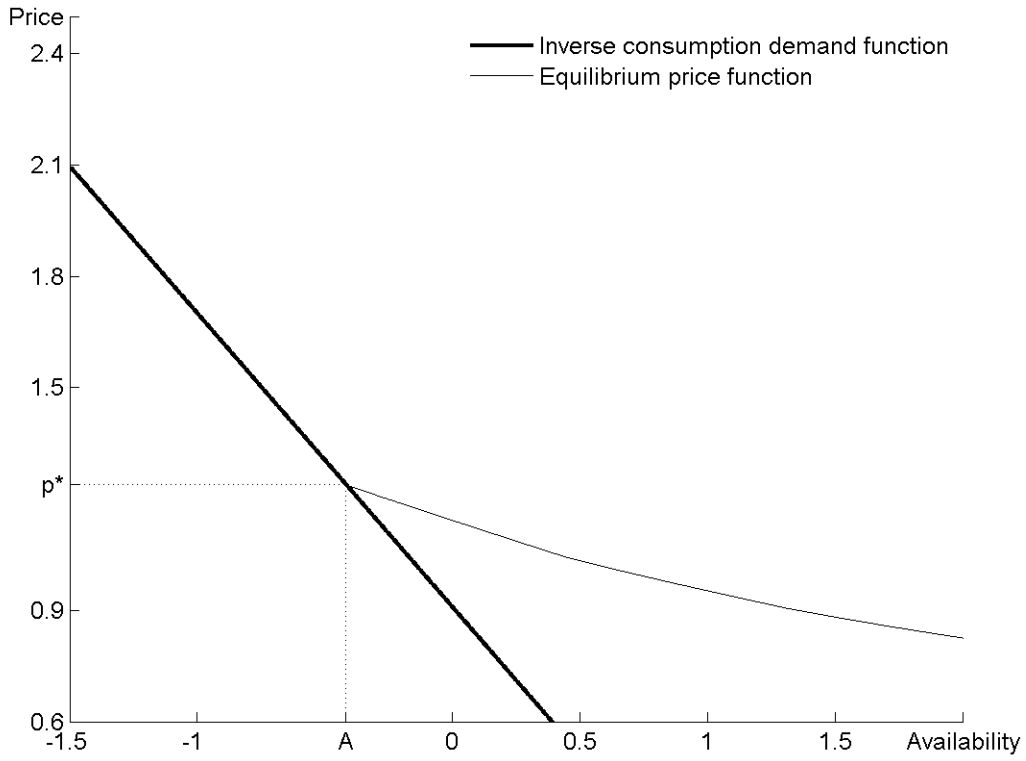


Demand for consumption plus stocks



Note: ***Not*** like a constant elasticity consumer demand

We got results like this, (for wheat)



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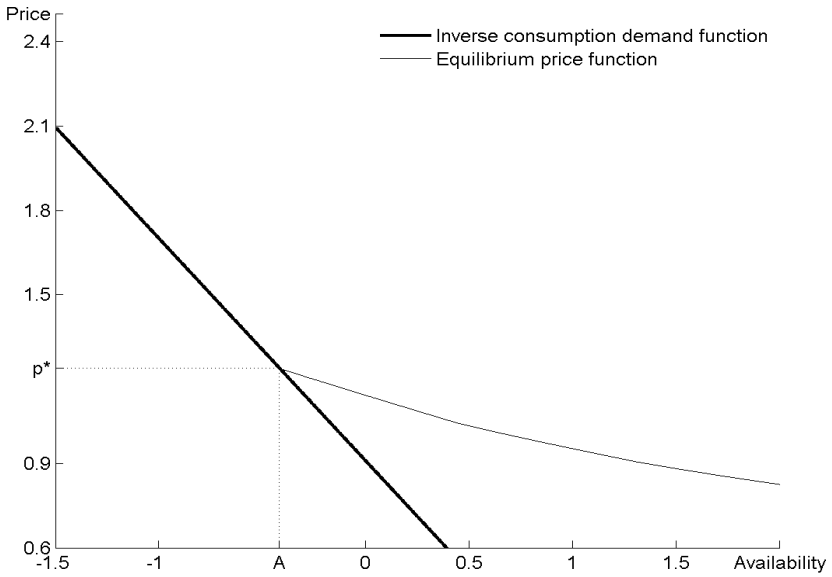
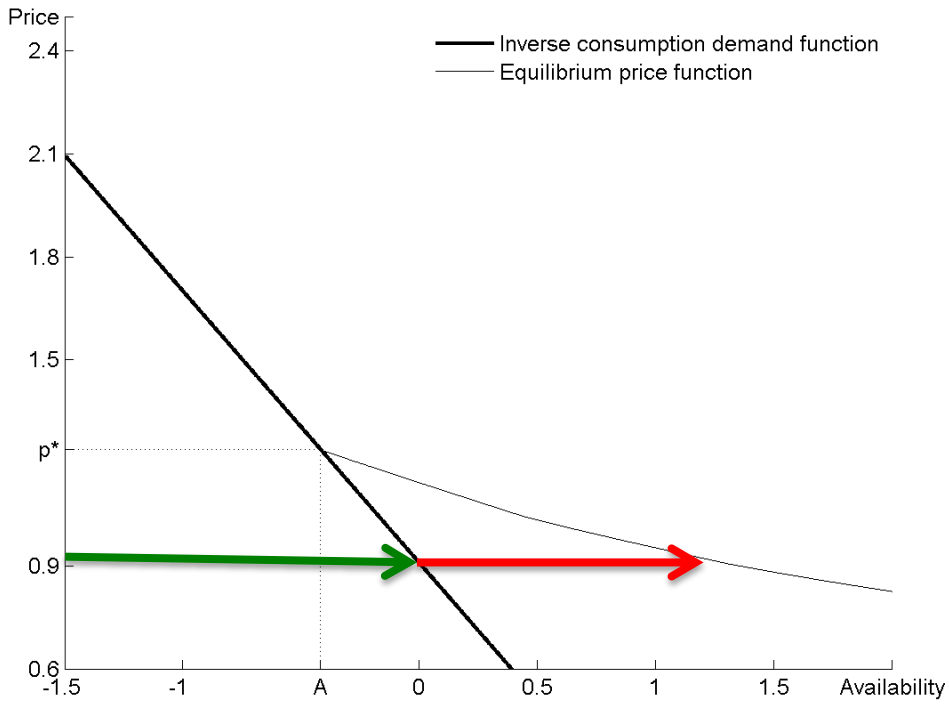


- Then we reconstructed stocks and consumption at each price

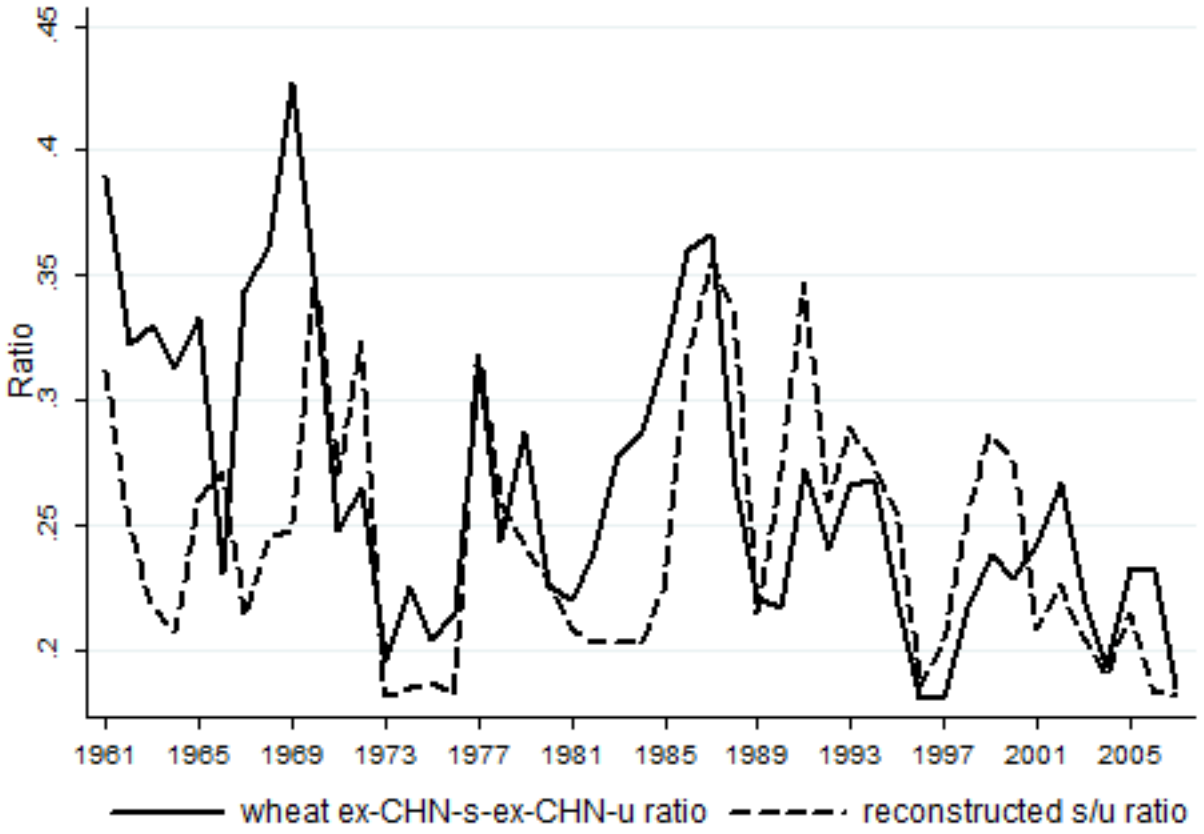
We got results like this (for wheat)



e.g. RED/GREEN = Stocks/Use at Price=0.9

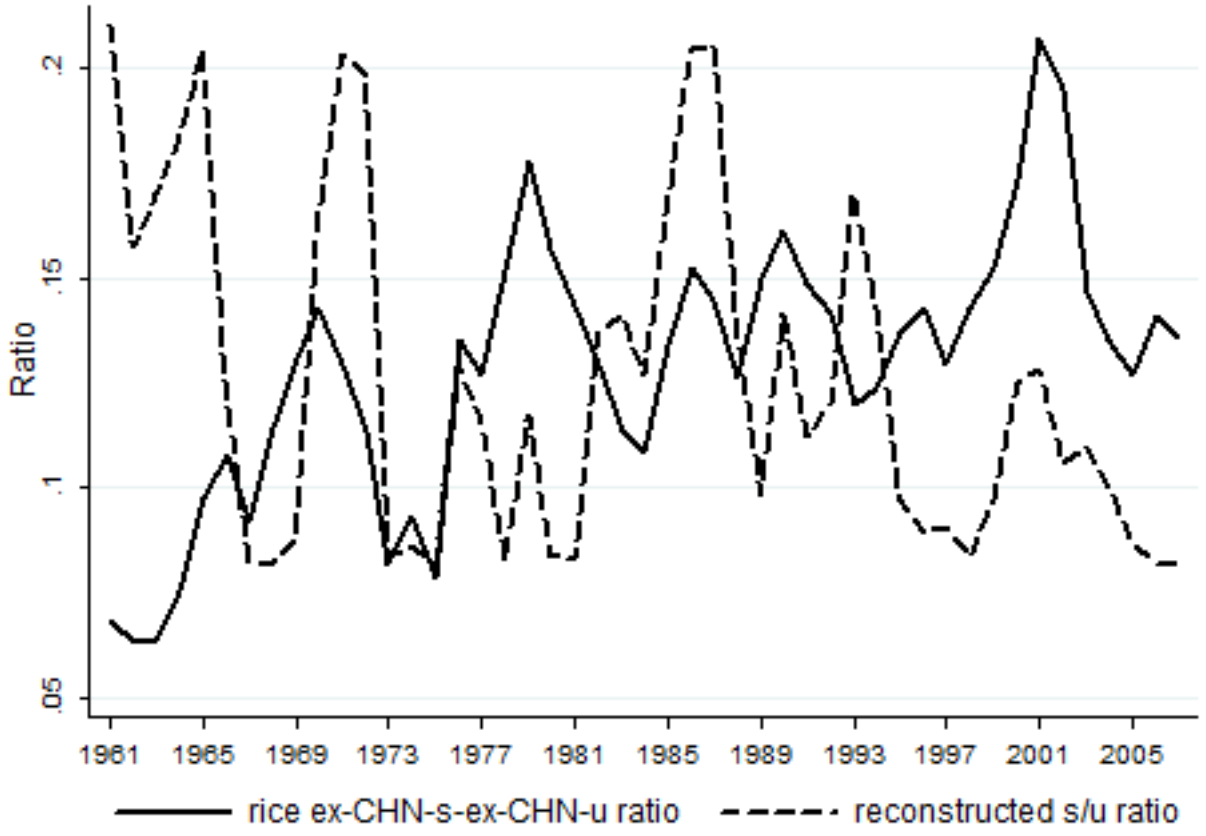
Wheat SUR and reconstruction from model:

- recalibrated for mean (to include essential working stocks) and range



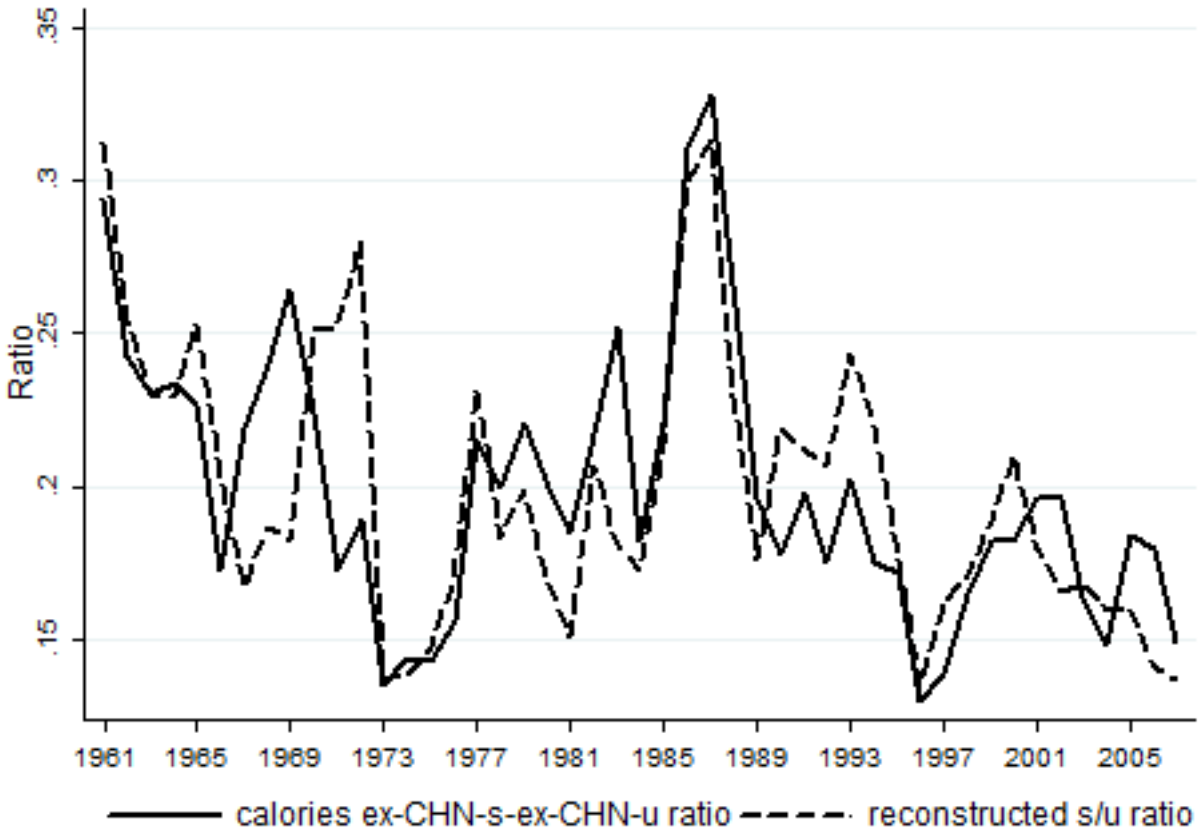
Rice SUR and reconstruction from model:

- a less good fit



Calorie SUR and reconstruction from model:

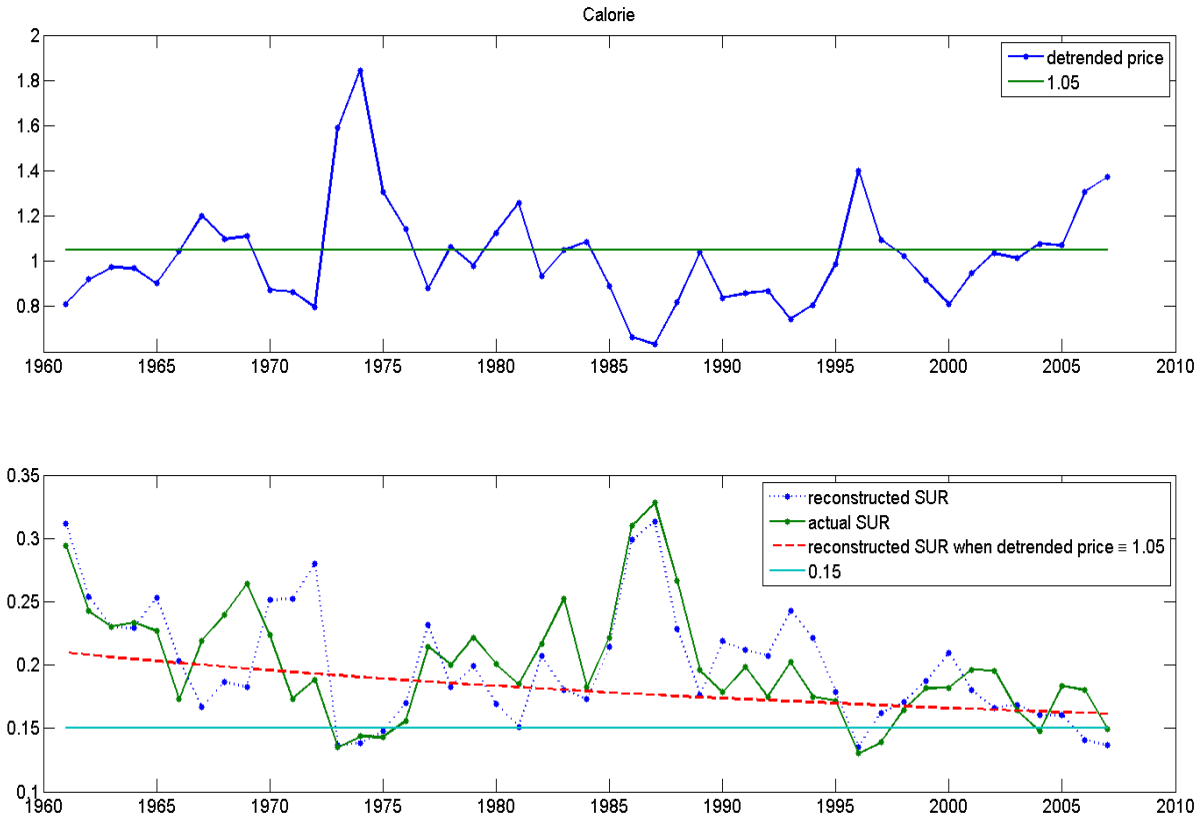
- fits much better



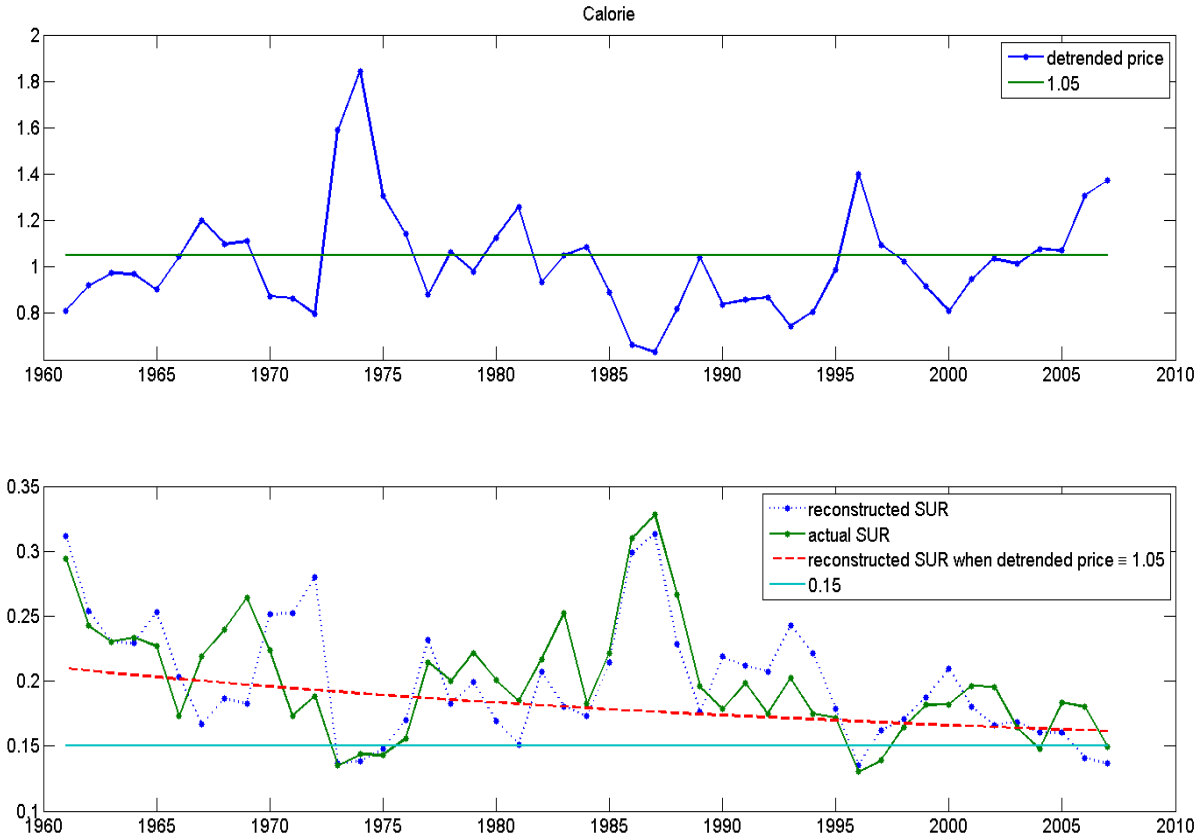
But SUR reconstruction from price is not perfect

- Can observed SUR help improve projections based on price alone?

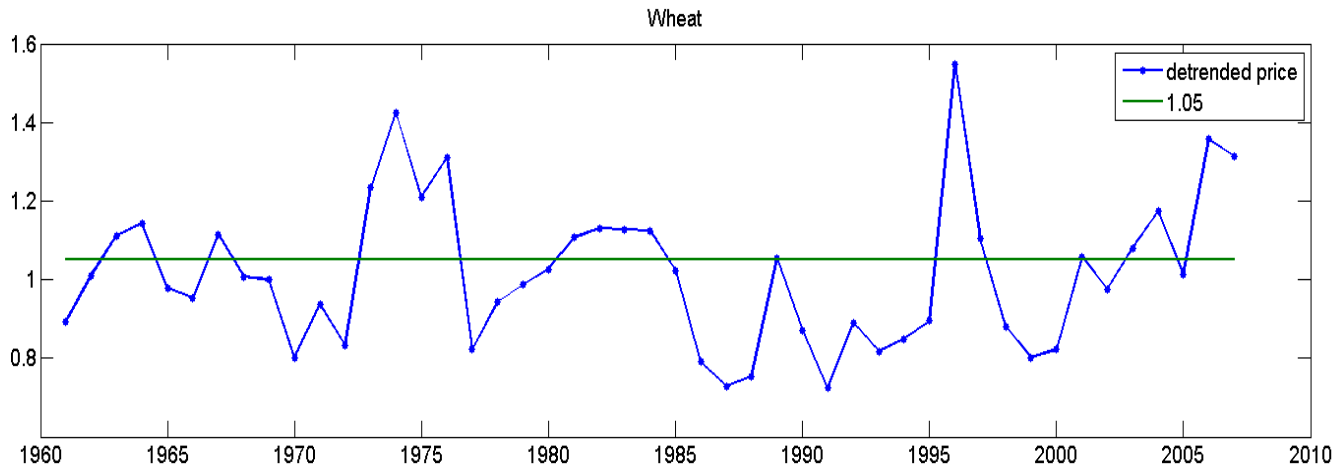
Evidence of relationship: De-trended price vs. SUR for Calories versus SUR implied from Price

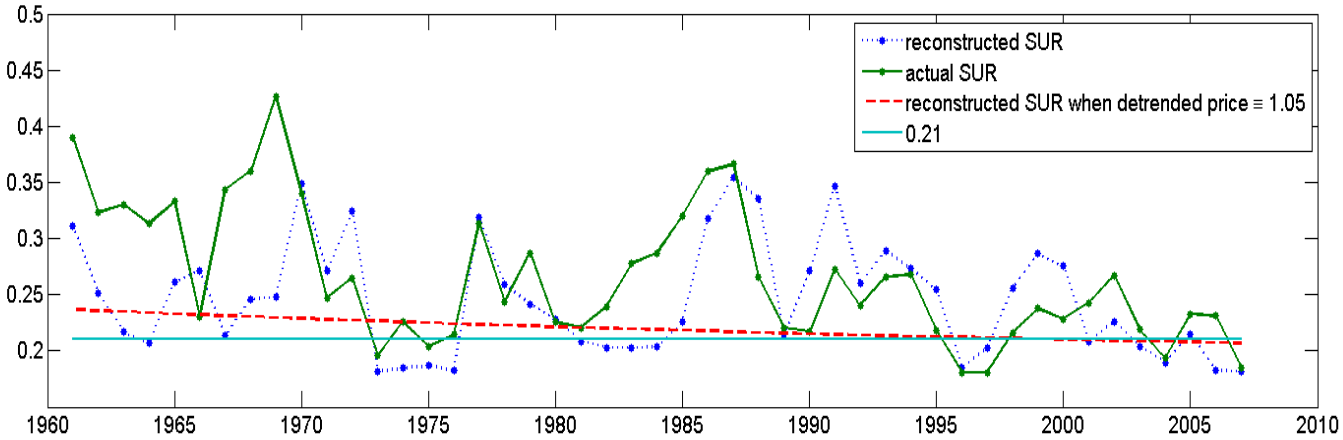


SUR sometimes a better warning indicator than price (e.g. 1972)

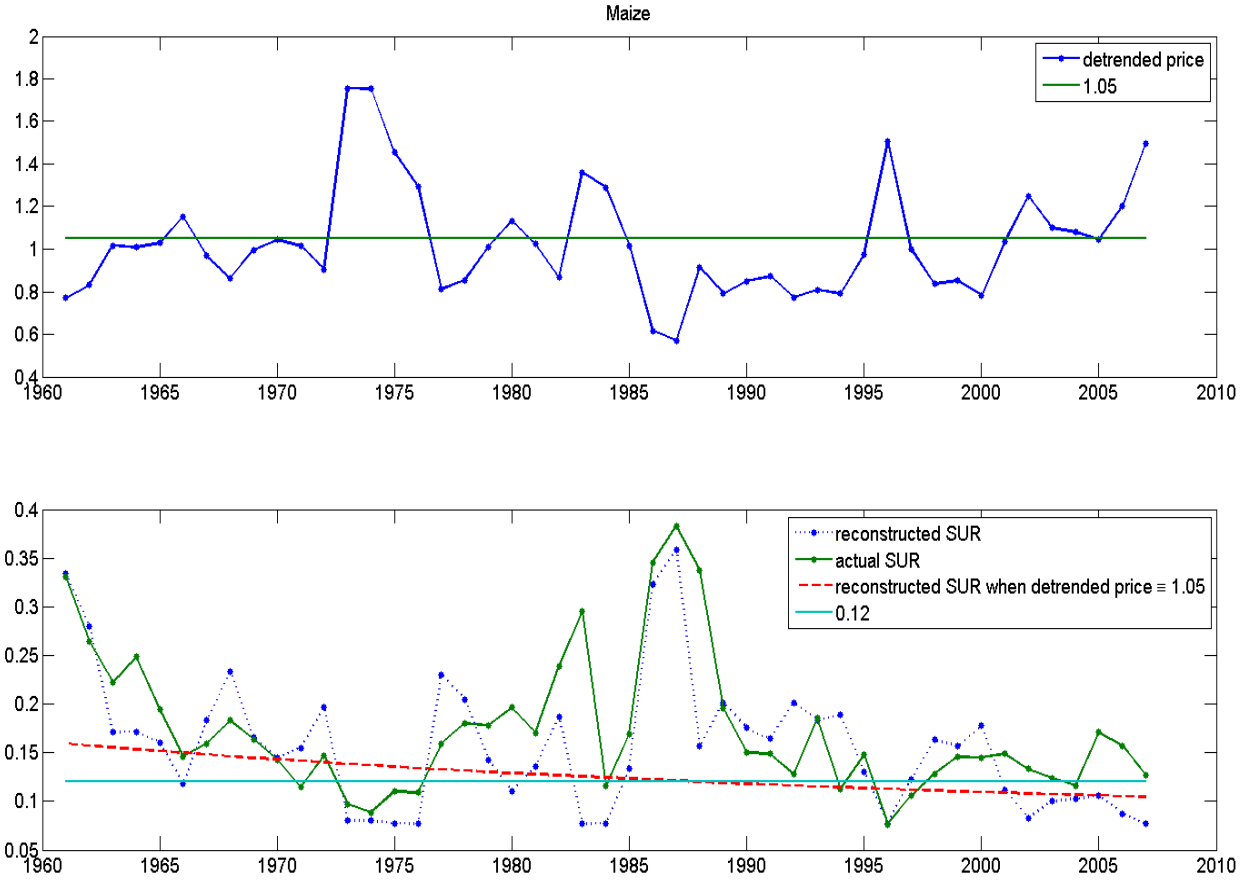


Wheat price and SUR

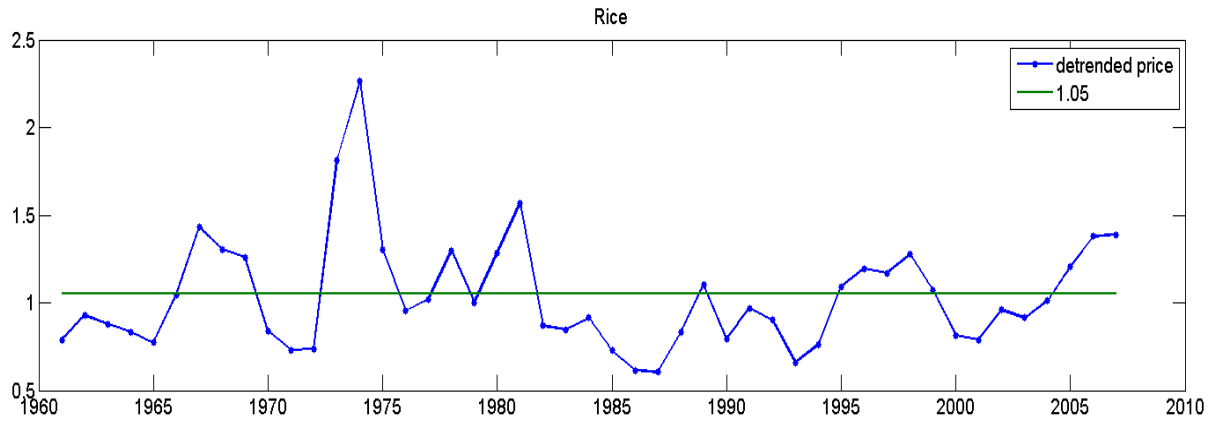


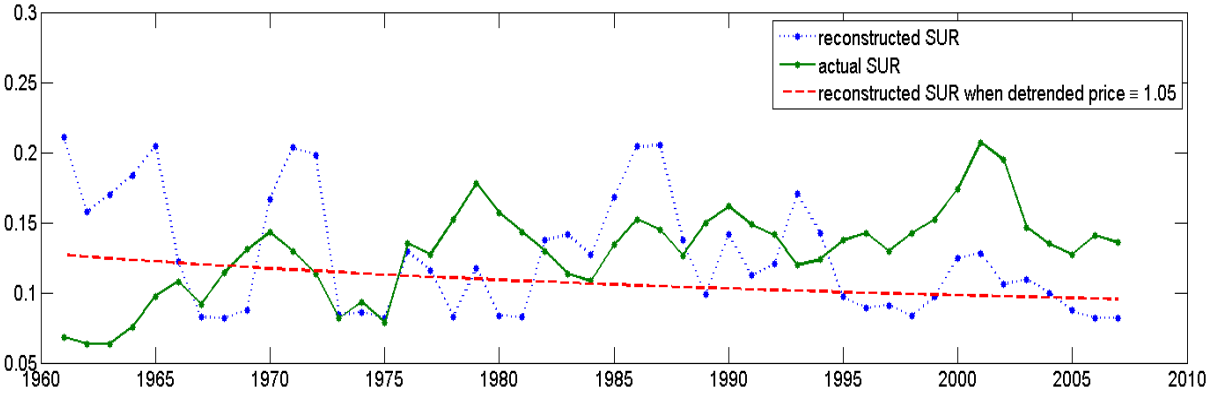


Maize


Maize
detrended price
1.05
reconstructed SUR
actual SUR
reconstructed SUR when detrended price ≡ 1.05
0.12

Rice


Rice
detrended price
1.05
2.5
2
1.5
1
0.5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


reconstructed SUR
actual SUR
reconstructed SUR when detrended price ≡ 1.05
0.3
0.25
0.2
0.15
0.1
0.05
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

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