Reconciling High Food Prices with Engel and Prebisch-Singer

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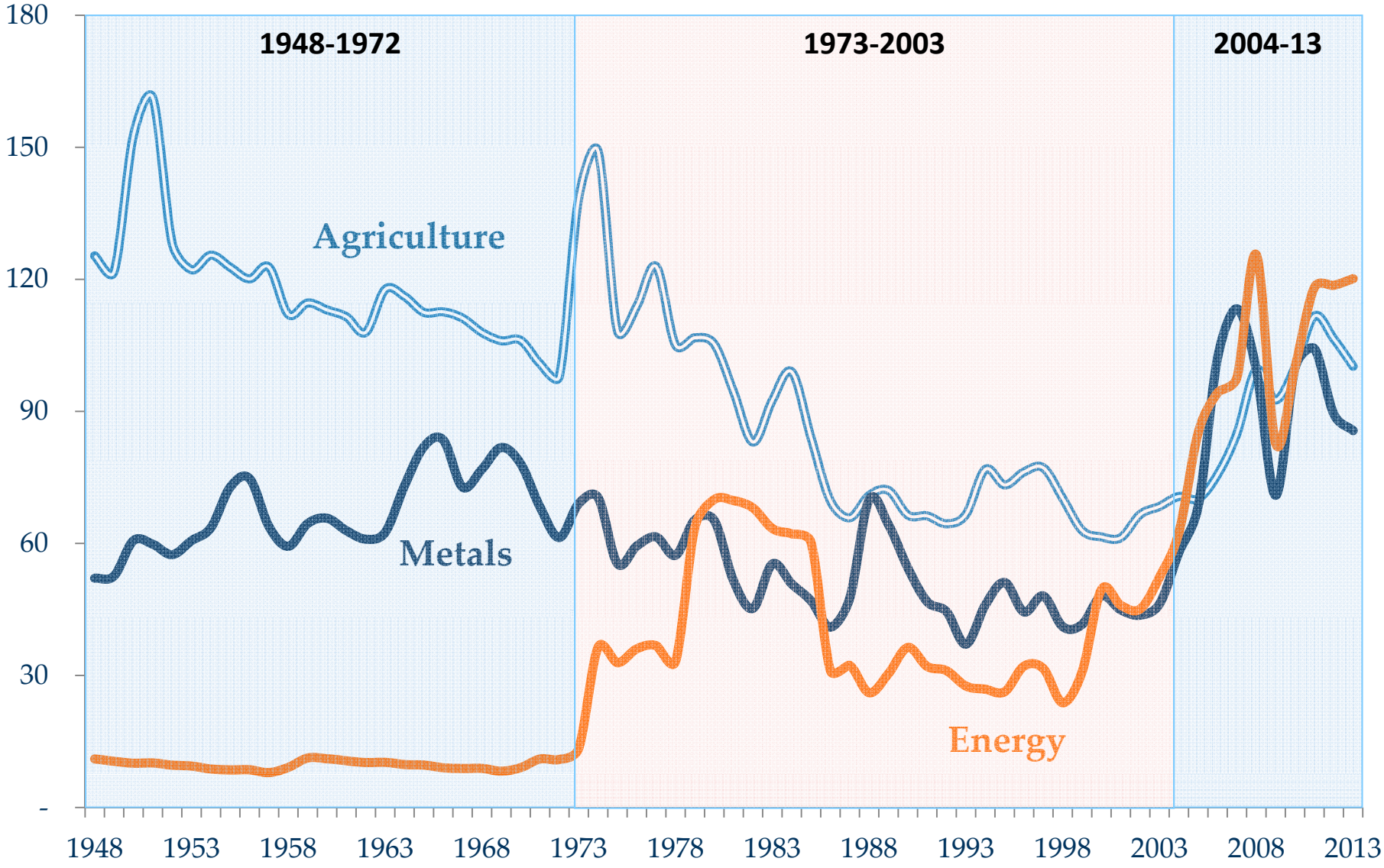
The context

- After declining for nearly 3 decades, food prices doubled during the past 10 years.
- Among the numerous factors, income growth in emerging economies has been often cited as the boom's key driver.
- However, historically the views on the relationship between income growth, food consumption, and food prices have not been so uniform, because of:
  - Engel's Law: Less than unity income elasticity
  - Kindleberger's thesis: Negative relationship between income terms-of-trade
  - Prebisch-Singer hypothesis: Empirical verification of the above by more than 40 other papers, including Prebisch, Singer, and Kindleberger.
- Thus, the (assumed) income growth-food price relationship is bounded by Engel's Law and Kindleberger's thesis.
- The objective of this paper is to reconcile the above views.
- This paper:
  - Confirms the negative income-ToT relationship;
  - Shows that income's impact on ToT operates mainly through the manufacture price channel.
  - Identifies energy costs, physical stocks, and (less so) monetary conditions as the main drivers of food prices.

Commodity price indices

(MUV-deflated, 2010 = 100)



Source: World Bank.

Numerous factors are behind the boom

	1997-2004	2005-12	Change (%)
Agricultural prices (nominal index, 2005 = 100)	89	154	73
Macroeconomic drivers			
GDP growth (low and middle income countries, % p.a.)	4.6	6.2	36
Industrial production (emerging economies, % p.a.)	*5.4*	*7.3*	*36*
Crude oil price (US$/barrel, nominal)	25	79	223
Exchange rates (US$ against a broad index of currencies)	118	104	-11
Interest rates (10-year US Treasury bill, percent)	5.2	3.6	-31
Funds invested in commodities ($ billion)	57	230	302
Sectoral drivers			
Stocks (total of maize, wheat, and rice, months of consumption)	3.5	2.5	-27
Biofuel production (thousand of barrels per day equivalent)	230	890	287
Fertilizer prices (nominal index, 2005 = 100)	69	207	201
Growth in yields (% change per annum, average)	1.4	0.5	-63
Yields (average of wheat, maize, and rice, tons/hectare)	*3.7*	*4.0*	*10*
Natural disasters (droughts, floods, and extreme temperatures)	174	207	19
OECD policies (Producer NPC, %)	1.3	1.1	-13

Sources: BarclayHedge, CRED, FRED, IEA, IMF, USDA, World Bank, and authors' calculations

Placing the modern view of the food price-income relationship …

Among the numerous causes of the post-2004 food price boom, income growth by emerging economies has been mentioned by many influential authors and reports

- Krugman (2008) argued that the upward pressure on grain prices is due to the growing number of people in emerging economies, especially China, who are becoming wealthy enough to emulate Western diets.
- Wolf (2008) concluded that strong income growth by China, India, and other emerging economies, which boosted demand for food commodities, was the key factor behind the post-2007 increases in food prices.
- The June 2009 issue of *National Geographic* noted that demand for grains has increased because people in countries like China and India have prospered and moved up the food ladder.
- Other authors have assumed similar impact; see, for example, Roberts and Schlenker (2013) and Hochman et al. (2011).

… in a historical context

Yet, historically the views on the income growth-food consumption-food price relationship has been somewhat different (though not inconsistent)

- Based on expenditures of 153 Belgian families in 1853, Engel (1857) noted that *"[t]he poorer a family, the greater the proportion of its total expenditure that must be devoted to the provision of food"* and concluded that *"… the wealthier a nation, the smaller the proportion of food to total expenditure."*
- Following Engels' observation, at least three competing views attempted to explain the long term behavior of the ToT faced by developing countries.
  - A supply-side view predicted that primary commodity prices will increase faster than manufacture prices due to resource constraints of the former and technological improvements of the latter—to a certain extent, this view was consistent with a Malthusian path.
  - A second view assumed that ToT will follow investment cycles. Investment expansion will induce supply response in manufacture goods, leading to lower prices, thus increasing the ToT. Conversely, investment contraction would lead to declining ToT.
  - Proponents of a third view argued that ToT will follow a downward path because income growth leads to smaller demand increases in primary commodities than manufacture products, an outcome which is consistent with Engel's Law.

And the winner is …

In 1943, Kindleberger, who sided with the view that income and ToT are wrote:

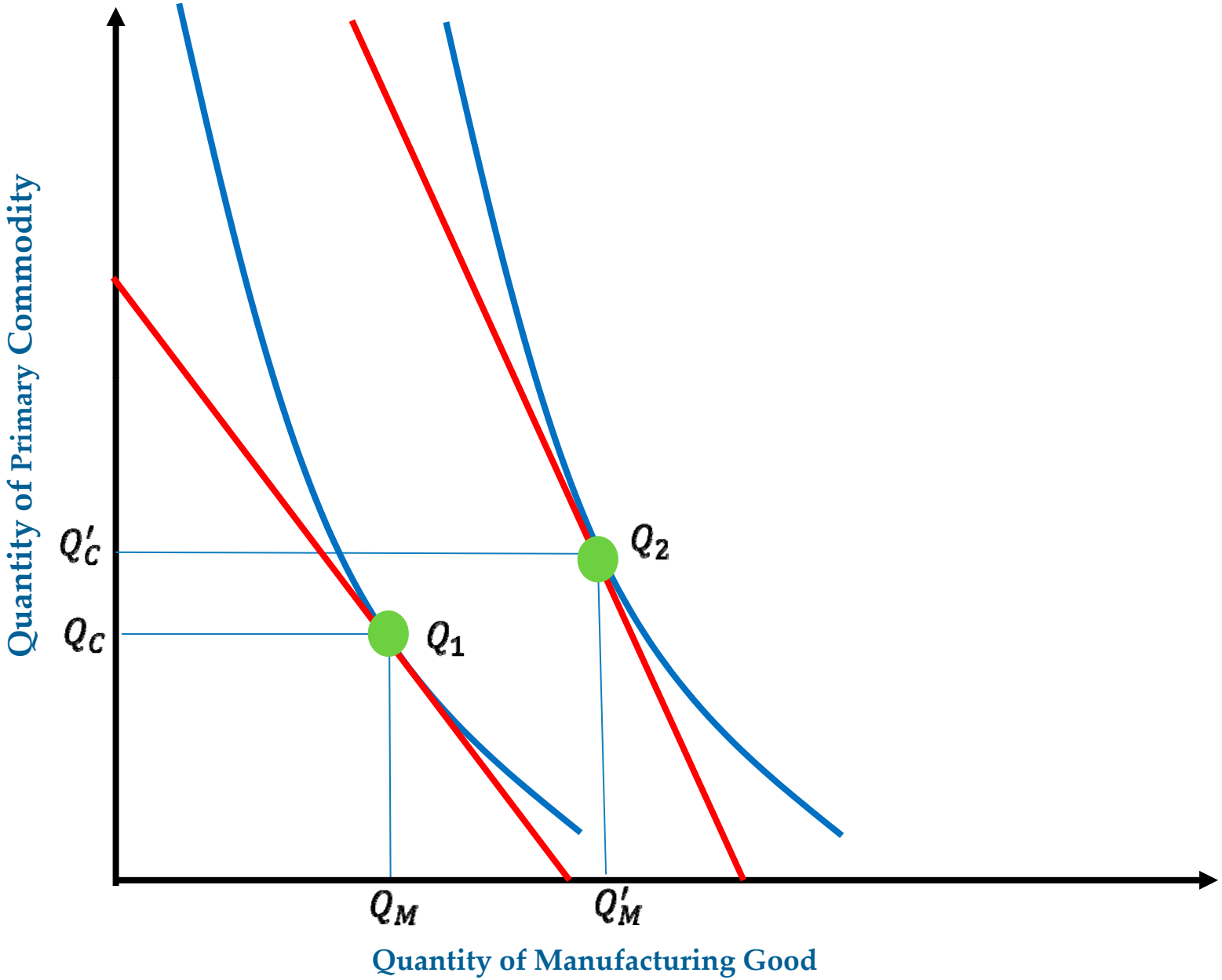
- *"The terms of trade [ToT] move against agricultural and raw material countries as the world's standard of living increases (except in time of war) and as Engel's Law of consumption operates. The elasticity of demand for wheat, cotton, sugar, coffee, and bananas is low with respect to income."*
- *"If the agricultural and raw material countries of the world want to share the increase in the world's productivity, including that in their own products, they must join in the transfer of resources from agriculture, pastoral pursuits, and mining to industry."*

Kindleberger's influence on world economic affairs should not be surprising. In addition to being a leading architect of the Marshall Plan, he voiced an early opinion on the nature of post-war development lending operations:

- *"If time permitted, it might be stimulating to analyze a number of knotty aspects of an international development loan operation: how would productivity be defined in order to qualify for a loan from the international development authority or whatever institution was created to perform that function?"*

The Bretton Woods institutions (International Monetary Fund and the World Bank) became operational two years later.

A 2-sector model



Paying attention to ToT … again

The long term behavior of ToT received renewed attention in 1980s for, at least, three reasons:

- **Prices:** After the 1970s boom, commodity prices experienced large declines, subsequently stabilizing at much lower levels. Thus, the Prebisch-Singer hypothesis began fitting the data well.
- **"Intellectual" shift:** Numerous authors questioned industrialization policies. Bauer (1976) and Lal (1985) criticized government controlled pricing policies. Bates (1981) argued that developing government policies must change for rural communities to prosper. The 1985 *World Development Report*, highlighted the problems associated with policy interventions in agricultural commodity markets. Krueger, Schiff and Valdès (1992) gave a detailed assessment of distortions affecting primary commodity sectors of developing countries.
- **Econometrics and data:** Research on long term behavior of ToT was further aided by two influential papers. Engle and Granger (1987) introduced improved testing procedures that enabled researchers to separate meaningful long term relationships from spurious correlations. Grilli and Yang (1988) compiled a data base of 24 internationally-traded primary commodity prices since 1900 that was utilized (and updated) by numerous authors.

Kindleberger *versus* Prebisch-Singer

Kindleberger's thesis in a regression (it requires that $\beta_1 < 0$):

$$\log\left(\frac{P_t^i}{P_t^M}\right) = \beta_0 + \beta_1 \log(Y_t) + \varepsilon_t$$

Prebisch-Singer hypothesis in a regression (it requires that $\alpha_1 < 0$):

$$\log\left(\frac{P_t^i}{P_t^M}\right) = \alpha_0 + \alpha_1 t + \varepsilon_t$$

P_t^i:	Price of primary commodity
P_t^M:	Price of manufacture goods
Y_t:	Income
t:	Time trend
B_i, α_i:	Parameters to be estimated
ε_t:	Error term

The contribution of this paper (1)

We extend the literature in the following ways:

(i) Using income instead of time trend as our explanatory variable

(ii) Including two sectoral and two macroeconomic fundamentals

$$\log\left(\frac{P_t^i}{P_t^M}\right) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \beta_3 \log(X_t) + \beta_4 \log(S_{t-1}^i) + \beta_5 \log(P_t^E) + \varepsilon_t.$$

P_t^i: Price of primary commodity
P_t^M: Price of manufacture goods
Y_t: Income
R_t: Interest rate
X_t: Exchange rate
S_{t-1}^i: Lagged stock-to-use ratio
P_t^E: Crude oil price
β_is: Parameters to be estimated; β_1^-, β_2^-, β_3^-, β_4^-, β_5^+
ε_t: Error term

The contribution of this paper (2)

We also identify the channel through which income affects the ToT by reparameterizing the earlier relationship as follows:

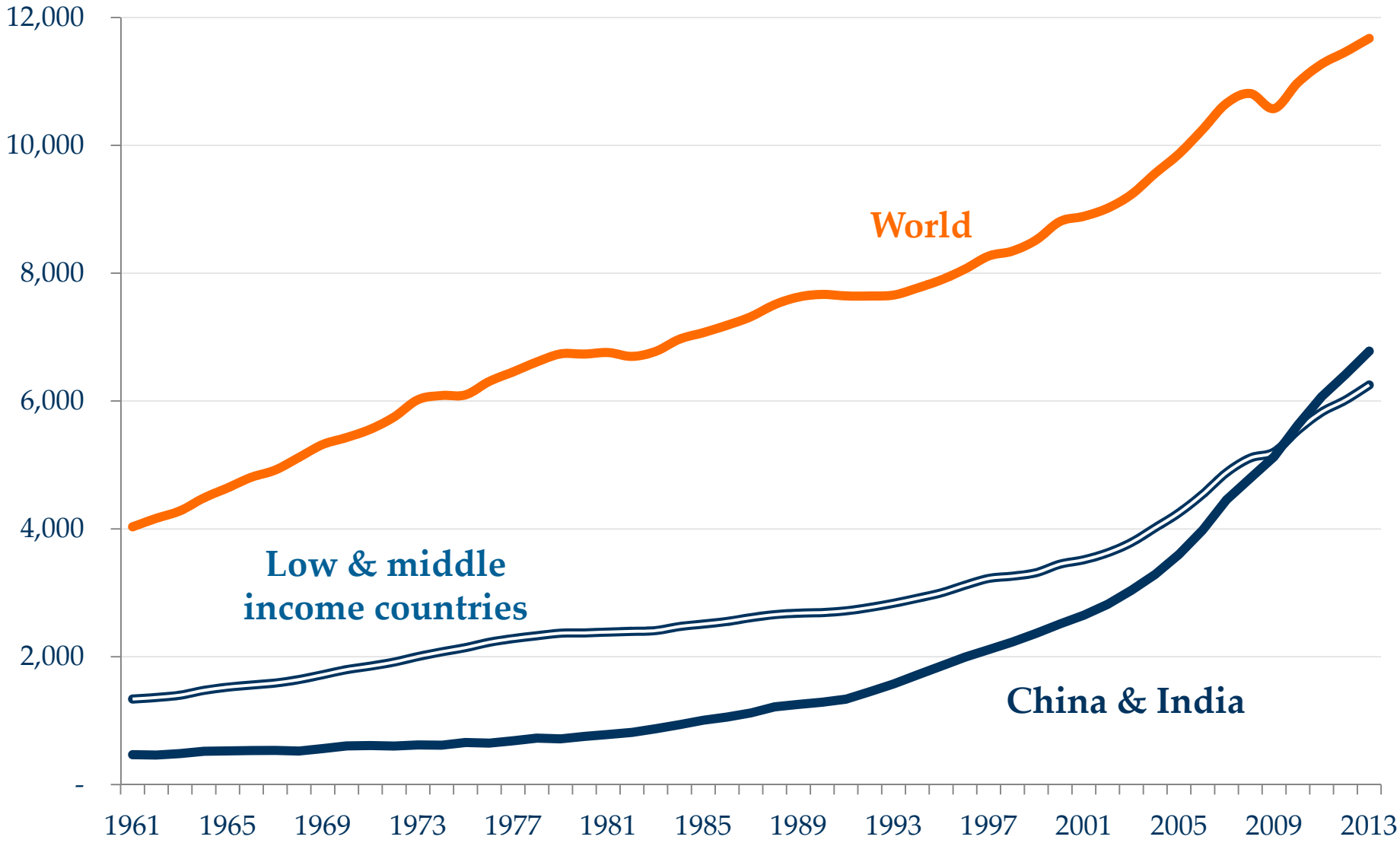
$$\log(P_t^i) = \beta_0 + \beta_1 \log(Y_t) + \beta_2 \log(R_t) + \beta_3 \log(X_t) + \beta_4 \log(S_{t-1}^i) + \beta_5 \log(P_t^E) + \beta_6 \log(P_t^M) + \varepsilon_t.$$

The reparameterization implies:

- $0 < \beta_1 < 1$, consistent with Engel's Law.
- $\beta_6 < 1$, if manufacture prices increase faster than agricultural prices, as the Prebisch-Singer hypothesis would require.
- The parameter estimate of the exchange rate should be larger in the above (nominal price regression) than in the previous (ToT regression).

Indeed, income grew a lot …

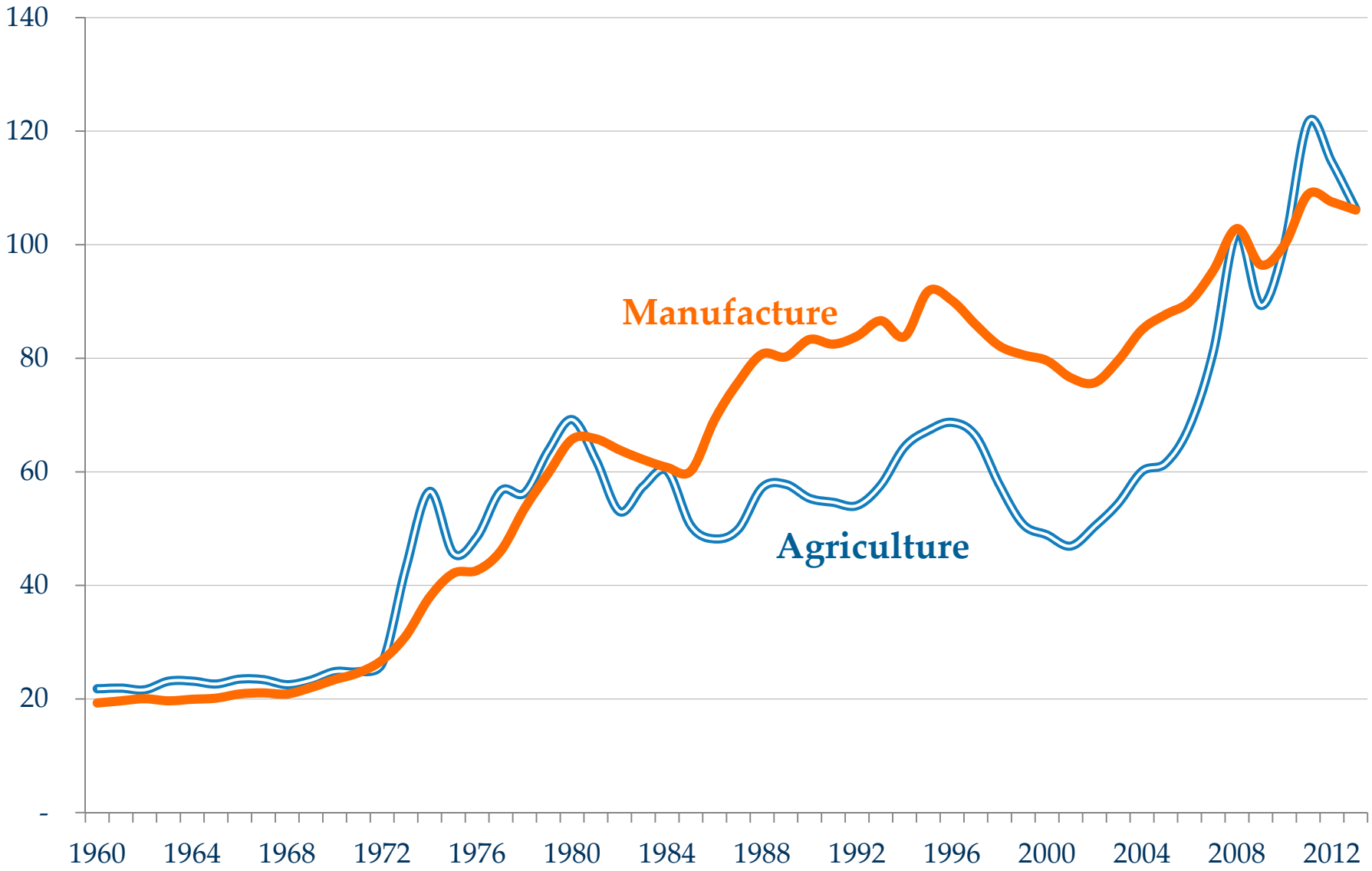
(per capita GDP in US$, PPP)



Source: World Bank

.. but so did manufacture and agriculture prices

(Nominal, 2010 = 100)



Source: World Bank

Data and estimation

- Annual data, 1960-2013 (54 observations).
- Five food commodities (maize, soybeans, wheat, rice, palm oil) and cotton. Our intention is to account for as much of world's arable land as possible.
- Tested for unit roots (DF-GLS and PP statistics)--all series are difference stationary.
- Used Seemingly Unrelated Regressions (SUR) for efficiency gains.
- Applied 12 (=3*2*2) measures of income:
  - World, Low & Middle Income countries, and China & India.
  - Evaluated at market prices and PPP terms
  - Total and per capita.
- Estimated the model in 3 steps:
  - Univariate OLS regressions of individual price ToT first on income, then on time trend (these results were supplemented by indices).
  - SUR of price ToT on all fundamentals.
  - SUR of nominal price on fundamentals and manufacture prices.

OLS parameter estimates, ToT (prices)

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
Regression of ToT on income						
Income	-0.33***	-0.29**	-0.26***	-0.42***	-0.39***	-0.48***
R^2	0.29	0.28	0.25	0.33	0.29	0.60
DF-GLS	-1.70*	-1.87*	-2.17**	-2.21**	-1.27	-3.45***
PP	-1.73	-1.89	-2.09	-2.33	-2.61*	-3.47**
Regression of ToT on time trend						
Time trend	-0.16***	-1.05***	-0.92***	-1.50***	-1.38***	-1.72***
R^2	0.30	0.30	0.25	0.33	0.30	0.63
DF-GLS	-1.68*	-1.87*	-2.14**	-2.26**	-1.25*	-3.69***
PP	-1.64	-1.82	-2.05	-2.30	-2.59	-3.62***

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. DF-GLS and PP denote the Dickey-Fuller (GLS) and Phillips-Perron statistics for unit root.

OLS parameter estimates, ToT (indices)

	Food	Raw Materials	Beverages	Energy	Metals	Precious Metals
Regression of ToT on income						
Income	-0.27***	-0.10**	-0.38***	1.29***	-0.00	0.75***
R^2	0.28	0.12	0.32	0.71	0.00	0.58
DF-GLS	-0.89	-1.26	-2.26**	-1.84*	-1.94*	-2.23**
PP	-1.56	-1.73*	-2.41	-2.09	-1.89	-1.78
Regression of ToT on time trend						
Time trend	-0.94***	-0.29**	-1.41***	-4.33***	0.01	2.51***
R^2	0.30	0.08	0.36	0.67	0.00	0.54
DF-GLS	-1.88	-2.75*	-2.32**	-1.81**	-1.94*	-2.16*
PP	-1.49	-1.89	-2.47	-1.91	-1.89	-1.72

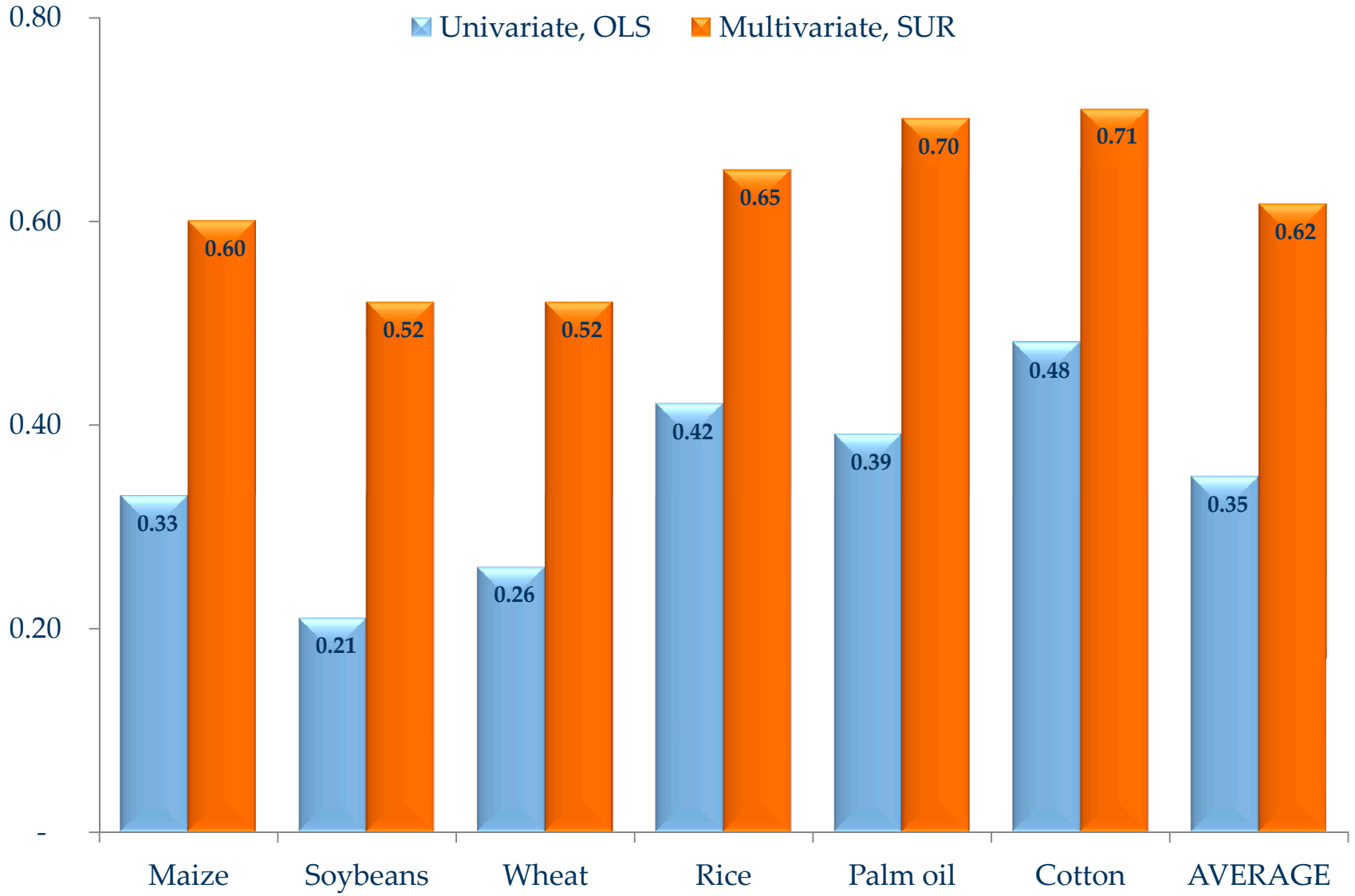
Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. DF-GLS and PP denote the Dickey-Fuller (GLS) and Phillips-Perron statistics for unit root.

SUR parameter estimates, ToT model

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
Income	-0.60***	-0.52***	-0.52***	-0.65***	-0.70***	-0.71***
S/U ratio	-0.43***	-0.17***	-0.42***	-0.32***	-0.35***	-0.41***
Real oil price	0.19***	0.18***	0.16***	0.17***	0.34***	0.15***
Real ex. rate	-0.46	-0.31	0.05	-1.41***	-0.20	-0.21
Real int. rate	-0.01	-0.05***	0.04***	-0.03*	-0.05**	-0.03**
R^2	0.75	0.60	0.61	0.73	0.61	0.71
DF-GLS	-2.72***	-2.95***	-3.48***	-1.57	-2.31**	-2.46**
PP	-3.01***	-3.32***	-3.21***	-3.95***	-4.08***	-3.61***

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. DF-GLS and PP denote the Dickey-Fuller (GLS) and Phillips-Perron statistics for unit root.

Income elasticities (absolute values)



SUR parameter estimates for various income measures, ToT model

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
GDP, PPP, Total						
World	-0.60***	-0.52***	-0.52***	-0.65***	-0.70***	-0.71***
LMI countries	-0.41***	-0.34***	-0.35***	-0.45***	-0.48***	-0.51***
China & India	-0.22***	-0.18***	-0.18***	-0.23***	-0.25***	-0.28***
GDP, PPP, per capita						
World	-1.16***	-0.93***	-0.98***	-1.23***	-1.34***	-1.39***
LMI countries	-0.63***	-0.46***	-0.51***	-0.68***	-0.73***	-0.80***
China & India	-0.25***	-0.20***	-0.20***	-0.26***	-0.30***	-0.33***
GDP, market prices, US $2010, Total						
World	-0.64***	-0.56***	-0.56***	-0.70***	-0.74***	-0.75***
LMI countries	-0.43***	-0.36***	-0.37***	-0.47***	-0.50***	-0.52***
China & India	-0.21***	-0.17***	-0.17***	-0.22***	-0.24***	-0.27***
GDP, market prices, US $2010, per capita						
World	-1.34***	-1.12***	-1.15***	-1.42***	-1.54***	-1.57***
LMI countries	-0.68***	-0.50***	-0.56***	-0.73***	-0.78***	-0.84***
China & India	-0.24***	-0.19***	-0.19***	-0.25***	-0.28***	-0.31***

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. LMI denoted Low and Middle Income countries.

SUR parameter estimates, nominal price model

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
Income	-0.10	0.11	0.02	-0.25	-0.20	-0.32**
S/U ratio	-0.26***	-0.14***	-0.40***	-0.21	-0.24*	-0.43***
Real oil price	0.31***	0.33***	0.29***	0.29***	0.43***	0.23***
Real ex. rate	-1.21***	-1.33***	-0.93***	-2.13***	-1.05*	-0.81**
Real int. rate	-0.02	0.01	0.00	0.00	-0.01	0.00
MUV	0.30*	0.16	0.28**	0.36	0.31	0.49***
R^2	0.86	0.88	0.90	0.78	0.74	0.81
DF-GLS	-3.27***	-3.62***	-5.37***	-1.62	-3.45***	-2.26*
PP	-3.84***	-4.70***	-4.06***	-4.10***	-4.23***	-3.74***

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. DF-GLS and PP denote the Dickey-Fuller (GLS) and Phillips-Perron statistics for unit root.

SUR parameter estimates for various income measures, nominal price model

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
GDP, PPP, Total						
World	-0.10	0.11	0.02	-0.25	-0.20	-0.32**
LMI countries	-0.00	0.09	0.03	-0.15	-0.08	-0.19*
China & India	-0.01	0.02	0.01	-0.09	-0.05	-0.12**
GDP, PPP, per capita						
World	-0.14	0.30	0.06	-0.40	-0.33	-0.55*
LMI countries	0.05	0.18	0.07	-0.20	-0.06	-0.25
China & India	-0.00	0.03	0.01	-0.10	-0.05	-0.14**
GDP, market prices, US $2010, Total						
World	-0.16	0.09	0.01	-0.28	-0.24	-0.37**
LMI countries	-0.00	0.09	0.03	-0.16	-0.08	-0.19*
China & India	-0.01	0.02	0.01	-0.08	-0.05	-0.11**
GDP, market prices, US $2010, per capita						
World	-0.36	0.29	0.03	-0.49	-0.46	-0.70**
LMI countries	0.06	0.21	0.08	-0.21	-0.05	-0.25
China & India	-0.00	0.03	0.01	-0.09	-0.05	-0.13**

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%. LMI denoted Low and Middle Income countries.

Comparing parameter estimates: ToT *versus* nominal model

	Maize	Soybeans	Wheat	Rice	Palm oil	Cotton
Y_t – ToT	-0.60***	-0.52***	-0.52***	-0.65***	-0.70***	-0.71***
Y_t – Nominal	-0.10	0.11	0.02	-0.25	-0.20	-0.32**
S_t^i – ToT	-0.43***	-0.17***	-0.42***	-0.32***	-0.35***	-0.41***
S_t^i – Nominal	-0.26***	-0.14***	-0.40***	-0.21	-0.24*	-0.43***
P_t^E – ToT	0.19***	0.18***	0.16***	0.17***	0.34***	0.15***
P_t^E – Nominal	0.31***	0.33***	0.29***	0.29***	0.43***	0.23***
X_t – ToT	-0.46	-0.31	0.05	-1.41***	-0.20	-0.21
X_t – Nominal	-1.21***	-1.33***	-0.93***	-2.13***	-1.05*	-0.81**
R_t – ToT	-0.01	-0.05***	0.04***	-0.03*	-0.05**	-0.03**
R_t – Nominal	-0.02	0.01	0.00	0.00	-0.01	0.00

Notes: Asterisks indicate levels of significance: (*) for 10%, (**) for 5%, and (***) for 1%.

Conclusions

- A univariate regression of ToT indices on income or time, gives mixed evidence on the Prebisch-Singer hypothesis (it does for some indices it does not for others). The evidence on food commodities is in favor of the hypothesis. However, based on conventional and cointegration statistics, neither income not time trend can adequately explain food price movements.
- When all fundamentals accounted for, the Prebisch-Singer hypothesis is confirmed for all food prices while the fundamentals adequately explain the behavior of ToT. These results hold regardless of the measure of income used.
- However, the nominal price model shows that income exerts no effect on nominal prices, a results consistent with Engel's Law. Thus, the negative impact of income on ToT operates through the manufacture price channel.
- Crude oil price is the most important driver of food prices. An elasticity of 0.25 implies that the 200 percent increase in energy costs during the past decade could explain more than half of food price increases.
- Despite the larger size of the stock-to-use ratio elasticities, its effect on food prices is much smaller because the ratios declined much less during the boom.
- US$ depreciation induces food price increases as expected in the nominal price model. There no effect in the ToT model--the ToT is currency-free unit.
- The interest rate effect is small a mixed.

Thank you!

The World Bank's quarterly commodity market analysis and price forecasts will be published in the third week of April 2014

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