BANCO CENTRAL
DE LA REPÚBLICA ARGENTINA

Financialization of Commodity Markets:

Non-linear Consequences from Heterogeneous Agent Behavior

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Outline

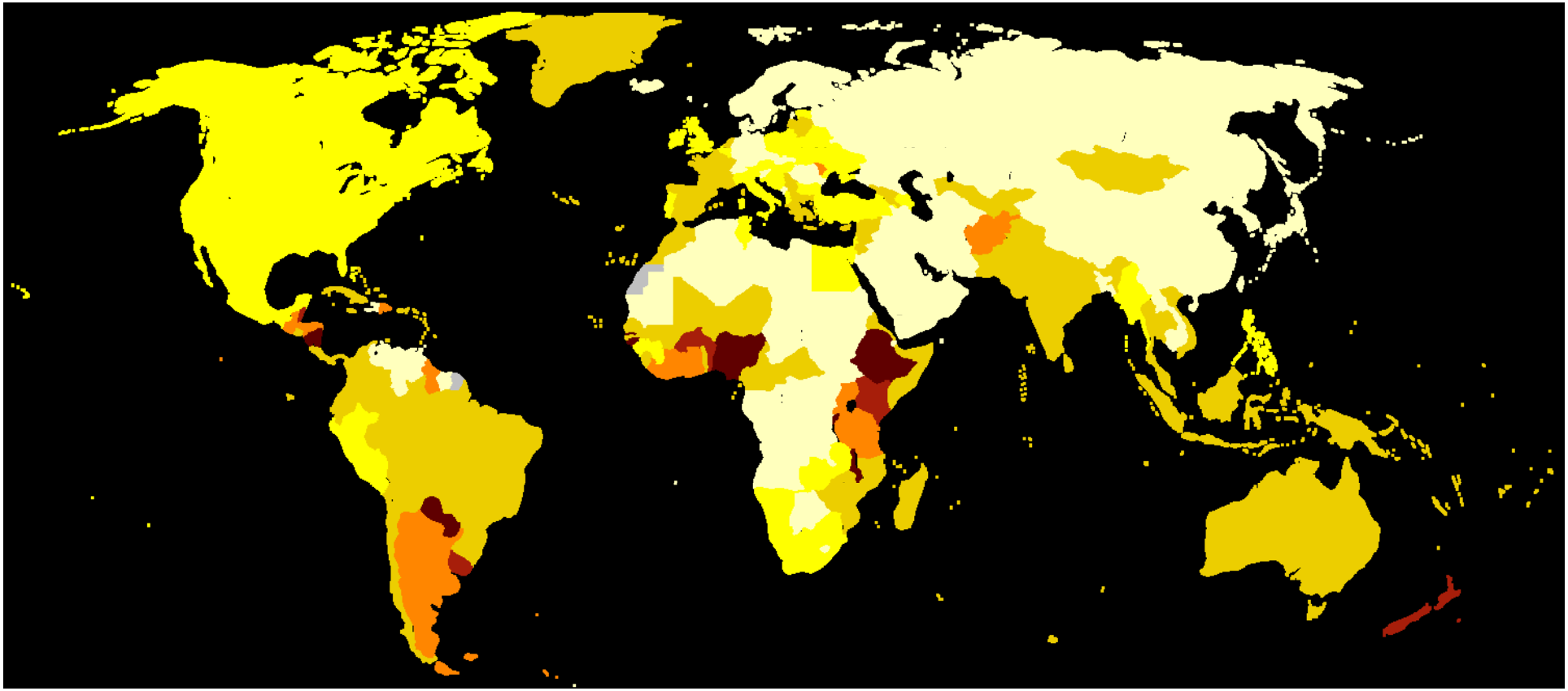
1. Motivation
2. Commodity Prices: Recent developments and long run trends
3. Long-run drivers of commodity prices
4. Financialization of commodity markets
5. A heterogeneous agent model
6. Econometric results
7. Open questions: Structural changes
8. Conclusions

1) Motivation

Agricultural exports represent a very significant share in total exports for several Latin American countries.

Agricultural exports

(as % of total exports)

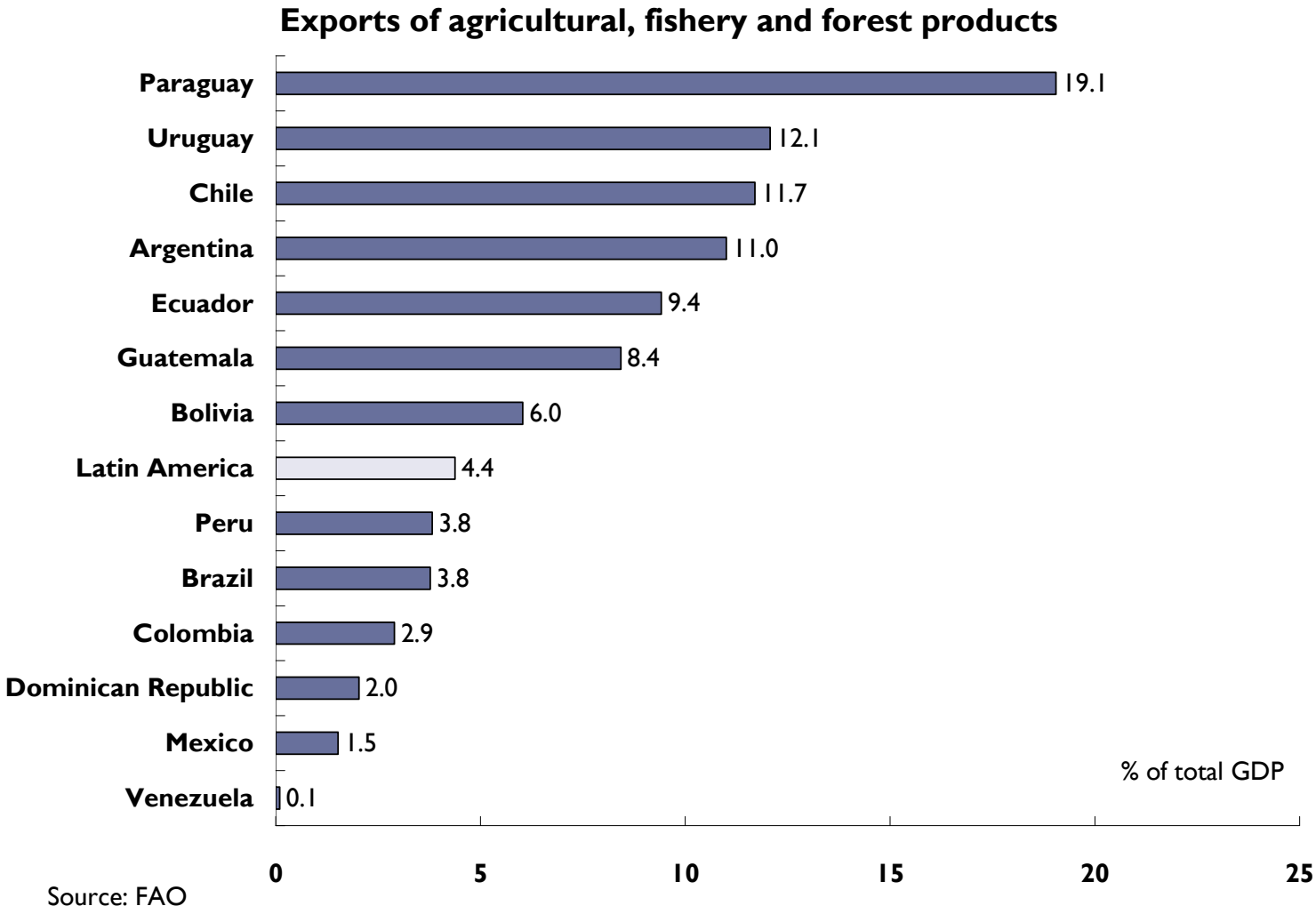


Source: FAO

(2007)

1) Motivation

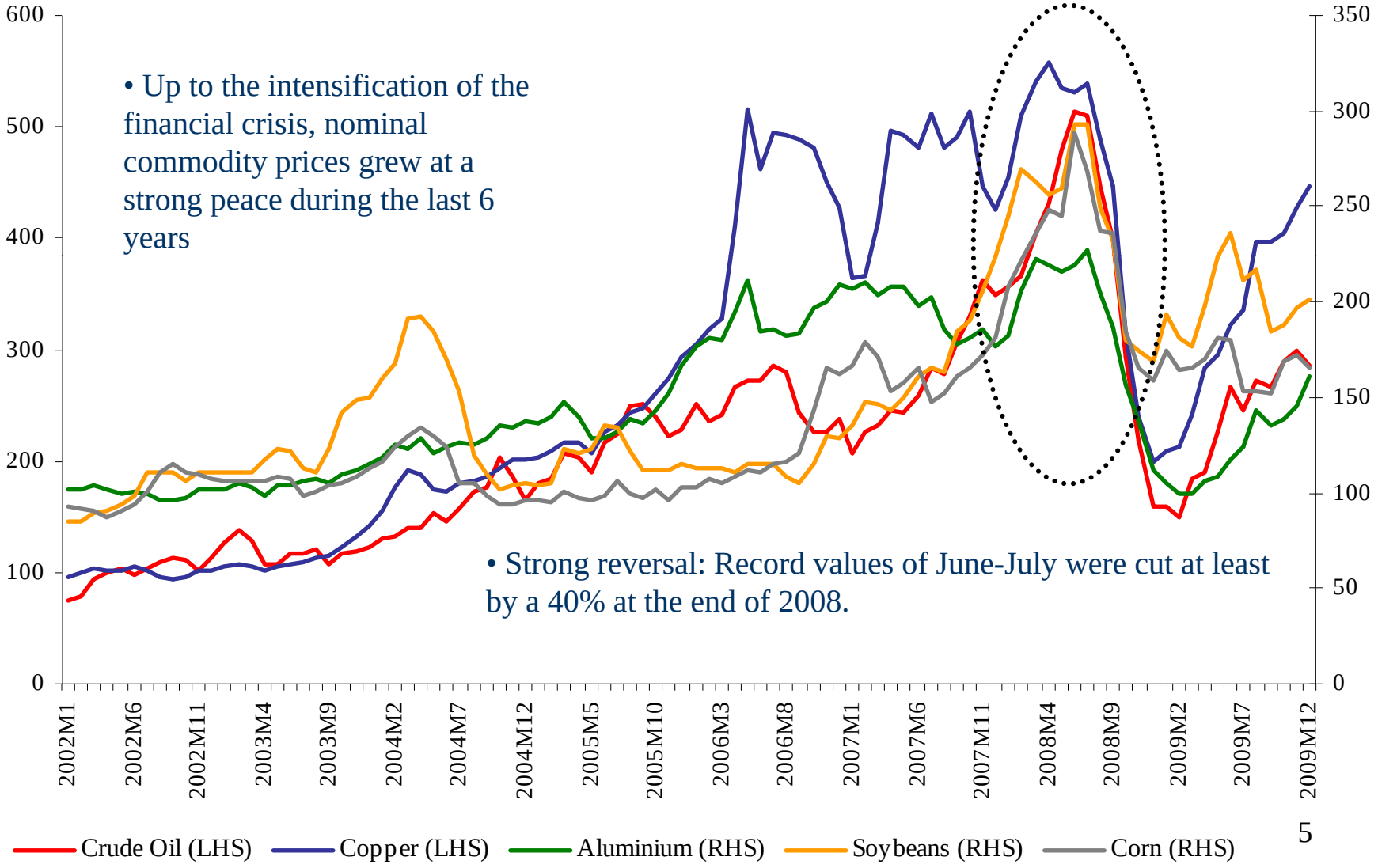
… and a very significant portion of the GDP.



Source: FAO

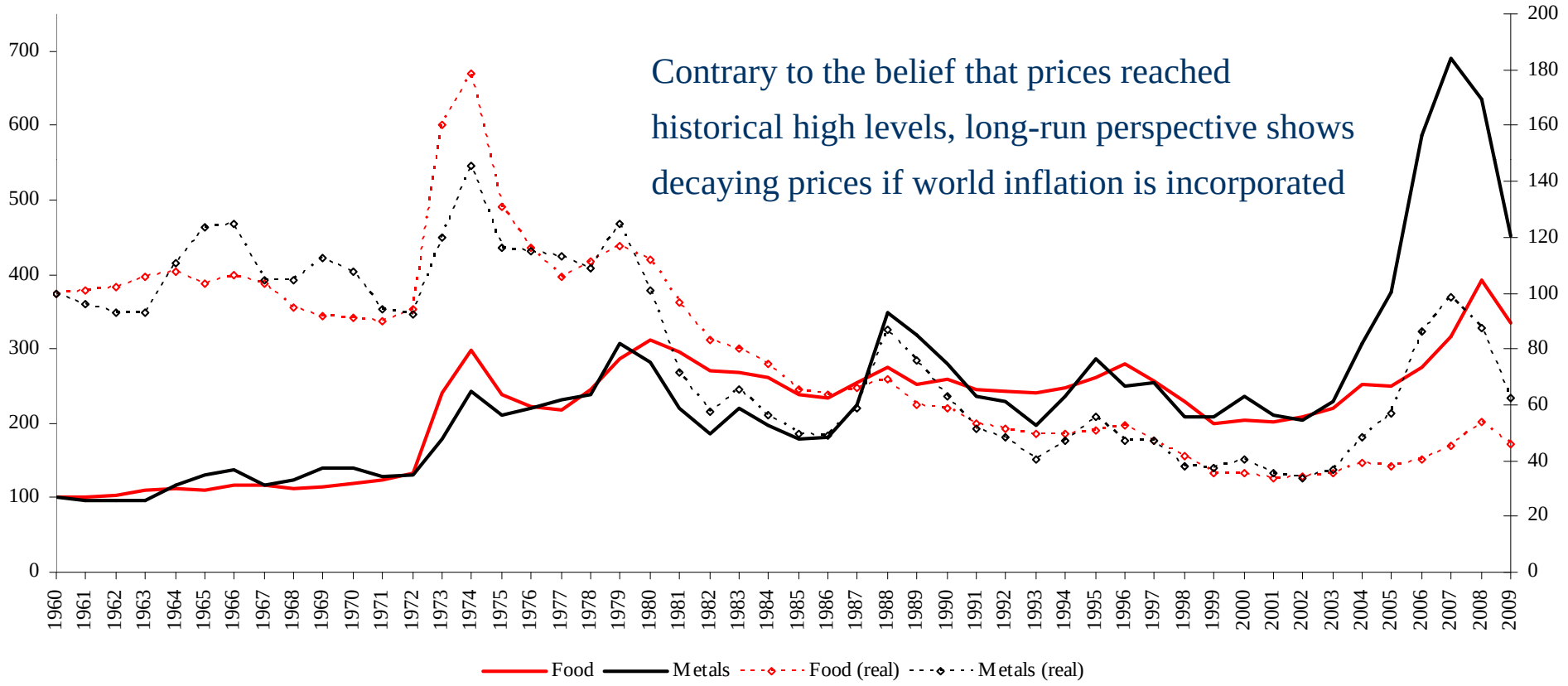
2) Commodity Prices: recent developments and long run trends

Key commodity price indexes, 2002M1-2009M12 (2002=100)



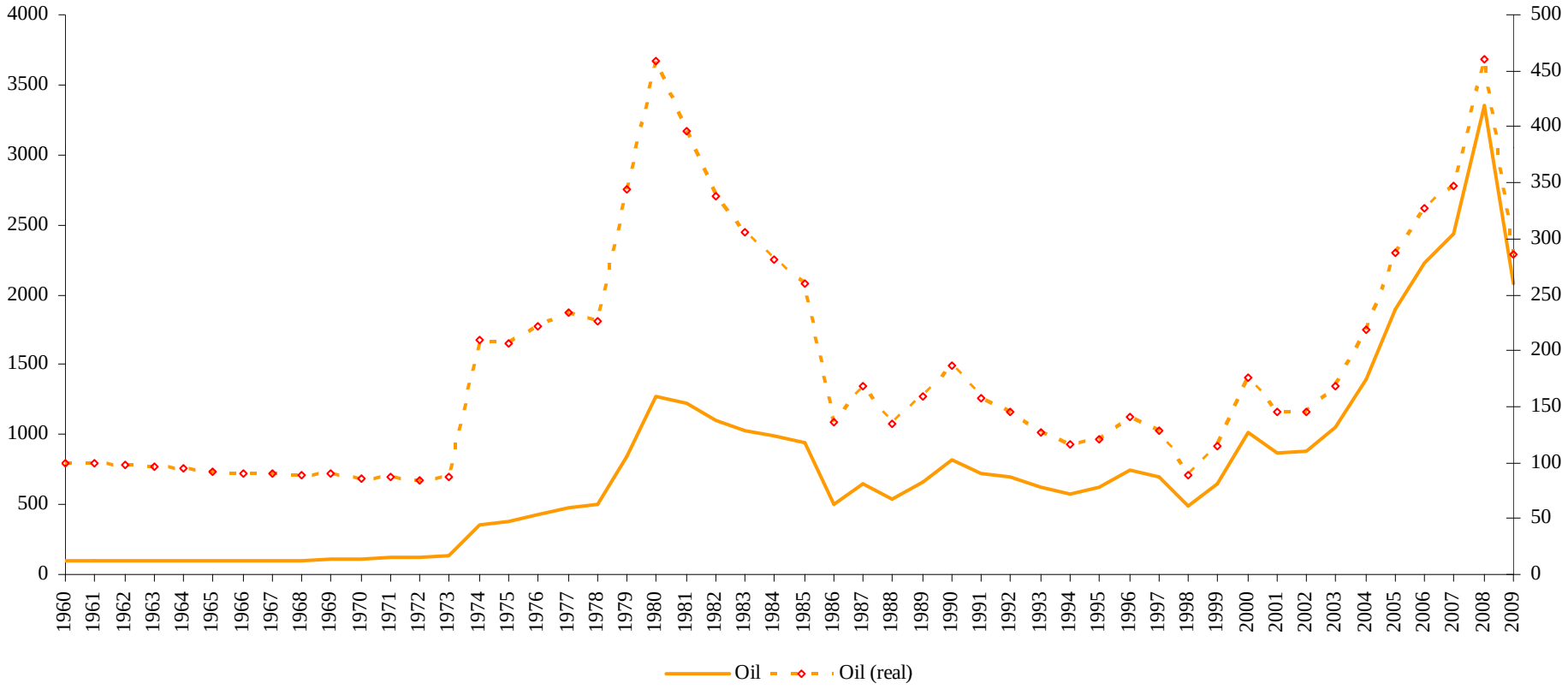
2) Commodity Prices: recent developments and long run trends

Food and metal price IMF indexes (nominal and real, 1960=100)

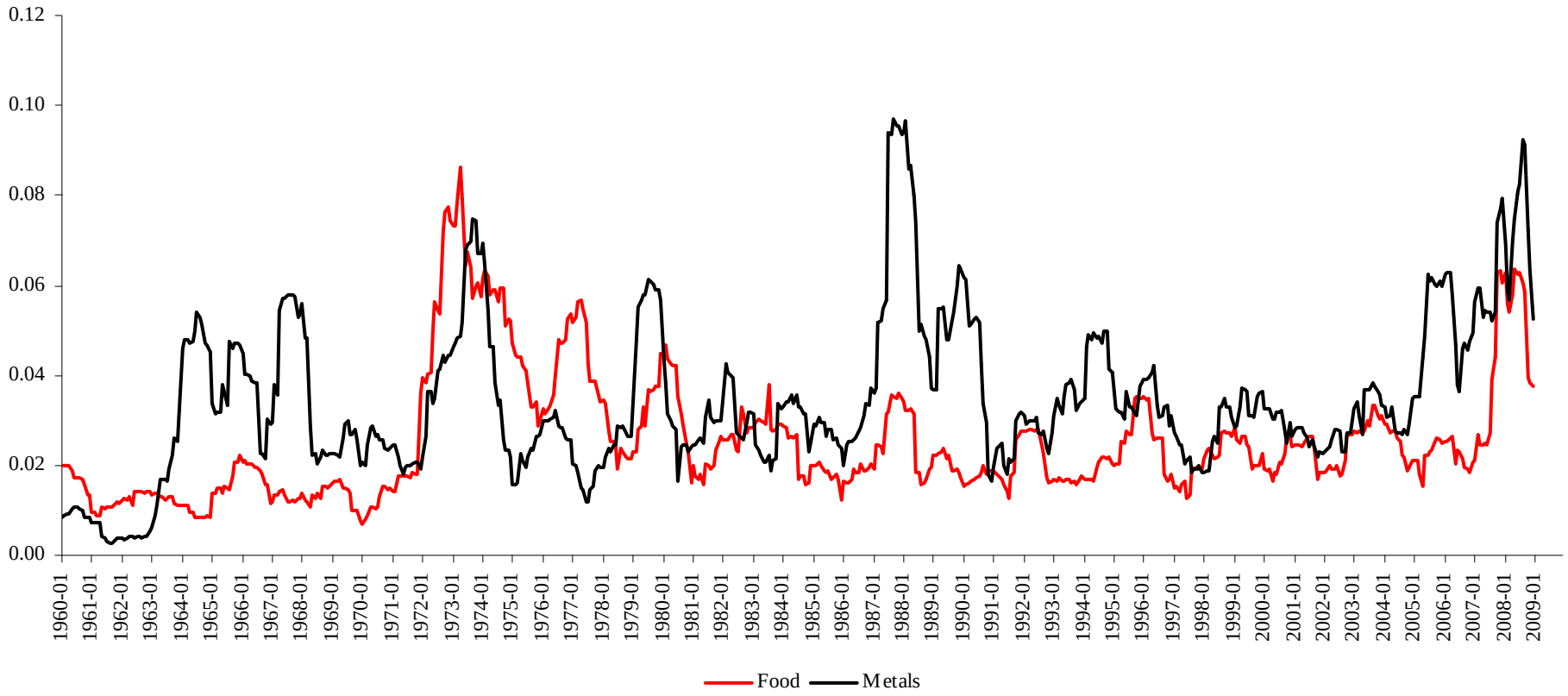


Oil (nominal and real, 1960=100)

The history of oil is different…

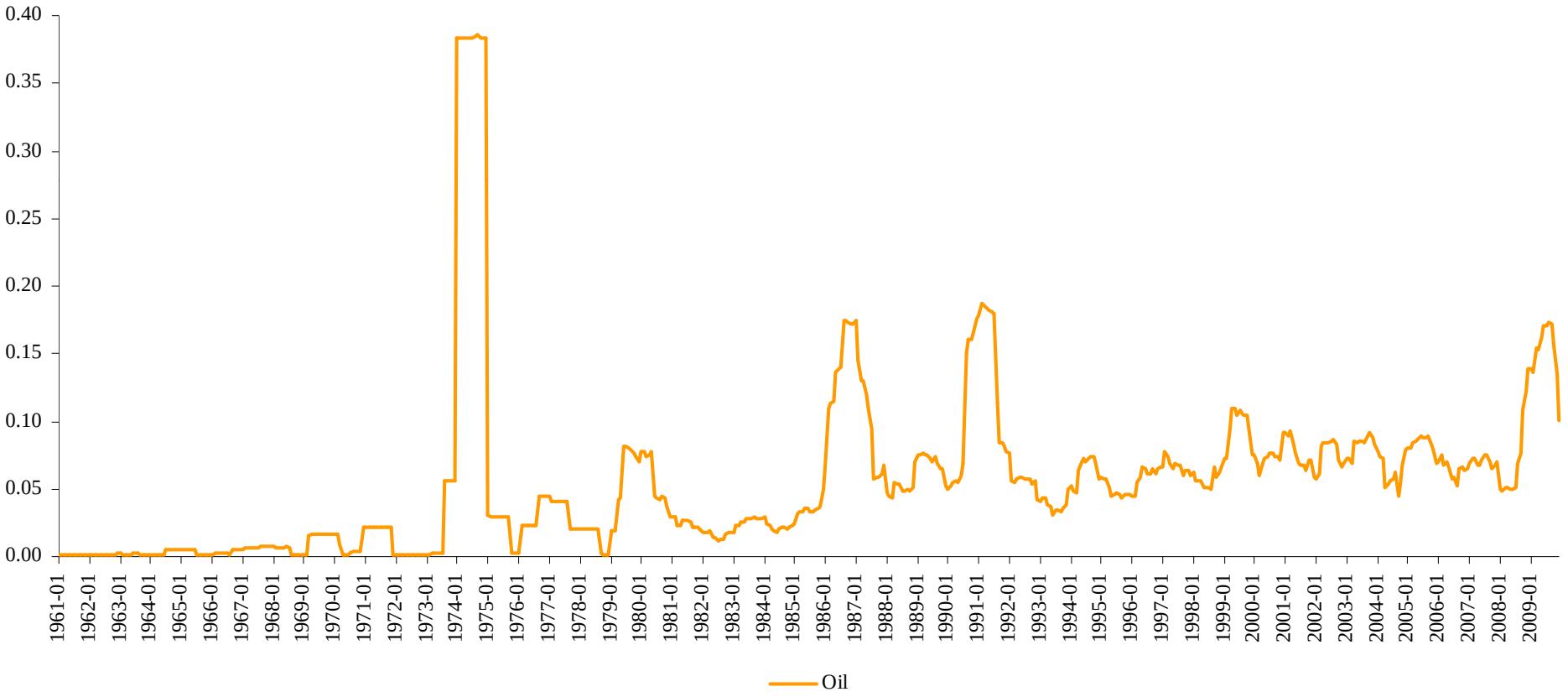


Real Price Volatility (1960-2009)



2) Commodity Prices: recent developments and long run trends

Real Price Volatility (1960-2009)



3) Long-run drivers of commodity prices

• Prebisch (1950) and Singer (1950) claimed that, contrary to the classical view, commodity prices would fall relatively to those of the industry goods. The influence of this hypothesis on empirical research has been significant: univariate models to study long-run trends.

• A different approach for studying commodity prices starts asking which **macroeconomic factors could act as determinants** of them.

• **US Multilateral Real Exchange Rate:**

- Pioneering single-good model of Ridler and Yandle (1972) demonstrates that a real exchange rate appreciation induces a fall in dollar commodity prices.

- Commodity Price elasticity to Dollar Multilateral RER should lie between 0 and -1 (Dornbusch, 1985).

3) Long-run drivers of commodity prices

- **World demand:**

i) Food:

- Engel's law is an accurate framework to predict the impact of income on food commodities (Houthakker, 1987; Hamilton, 2001).
- Income-elasticity decreases as long as the transit to development is completed.

ii) Metals:

- Inverse U-shape relationship between its use and income level. Consumption increases up to 15,000 or 20,000 per capita GDP in PPP dollars (IMF, 2006).

- **Interest rate:**

Interest rate increases reduce commodity prices through 3 channels (Frankel, 2006):

i) by increasing the incentive for extraction (or production) today rather than tomorrow; ii) by decreasing the desire of firms to carry inventories; and iii) by encouraging speculators to shift out of commodity contracts into treasury bills.

The **3 transmission channels work to reduce spot prices**.

4) Financialization of commodities

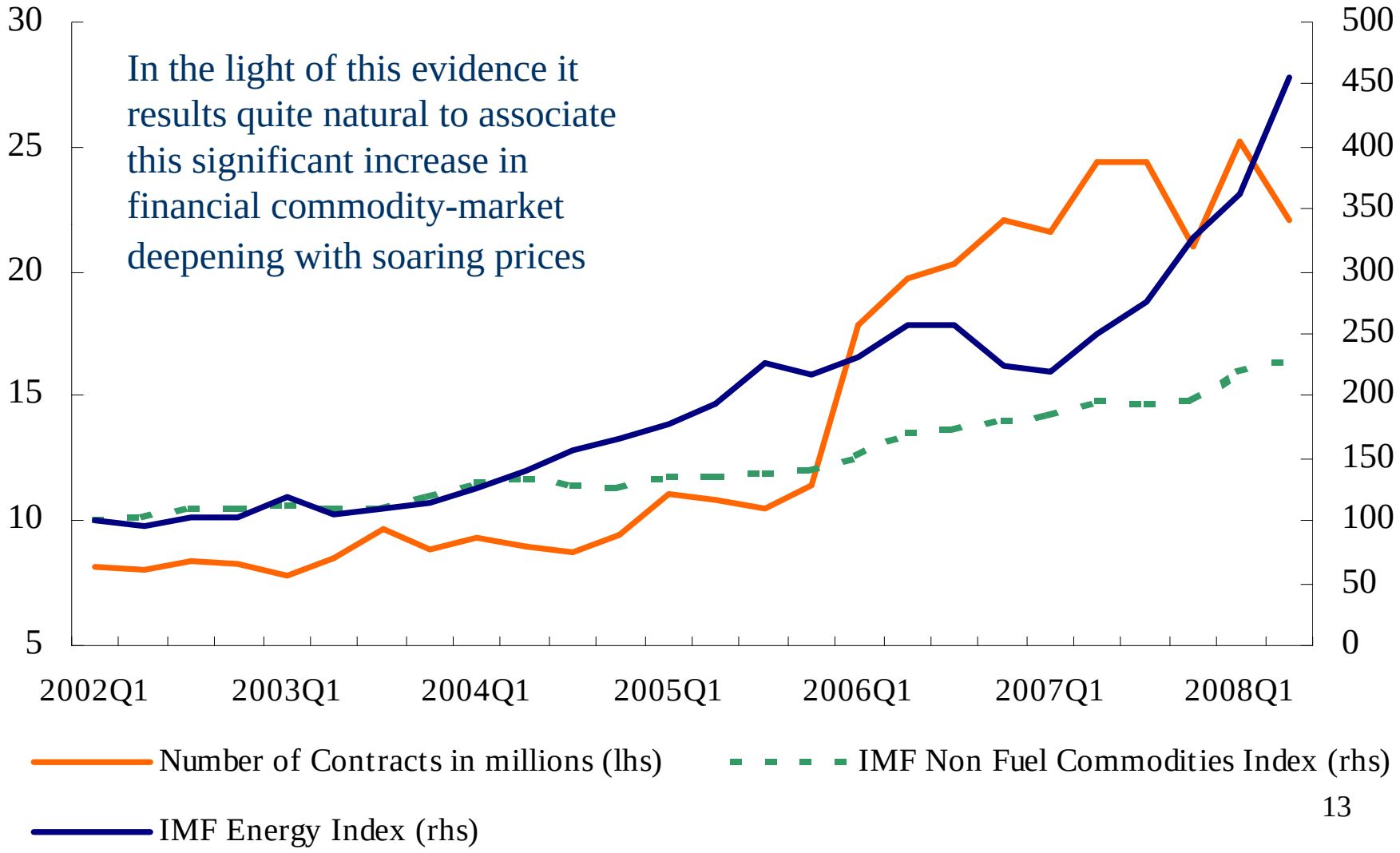
• Intense debate regarding financialization in commodity markets. Some authors have blamed financial markets as the only source of violent price ups and downs. Others have neglected any influence on prices.

• By "**financialization of commodities**" we usually refer to two linked facts: i) **recent impressive growth of derivative market activity**; ii) **increasing participation of financial investors in commodity future markets**.

• Why to believe there is a connection between prices and speculative activity? Casual empirical evidence: **Commodity prices soared** jointly with a **rapid increase in turnover on commodity-linked instruments** since 2002.

4) Financialization of commodities

Derivative commodity contracts and commodity prices, 2002Q1 to 2008Q2



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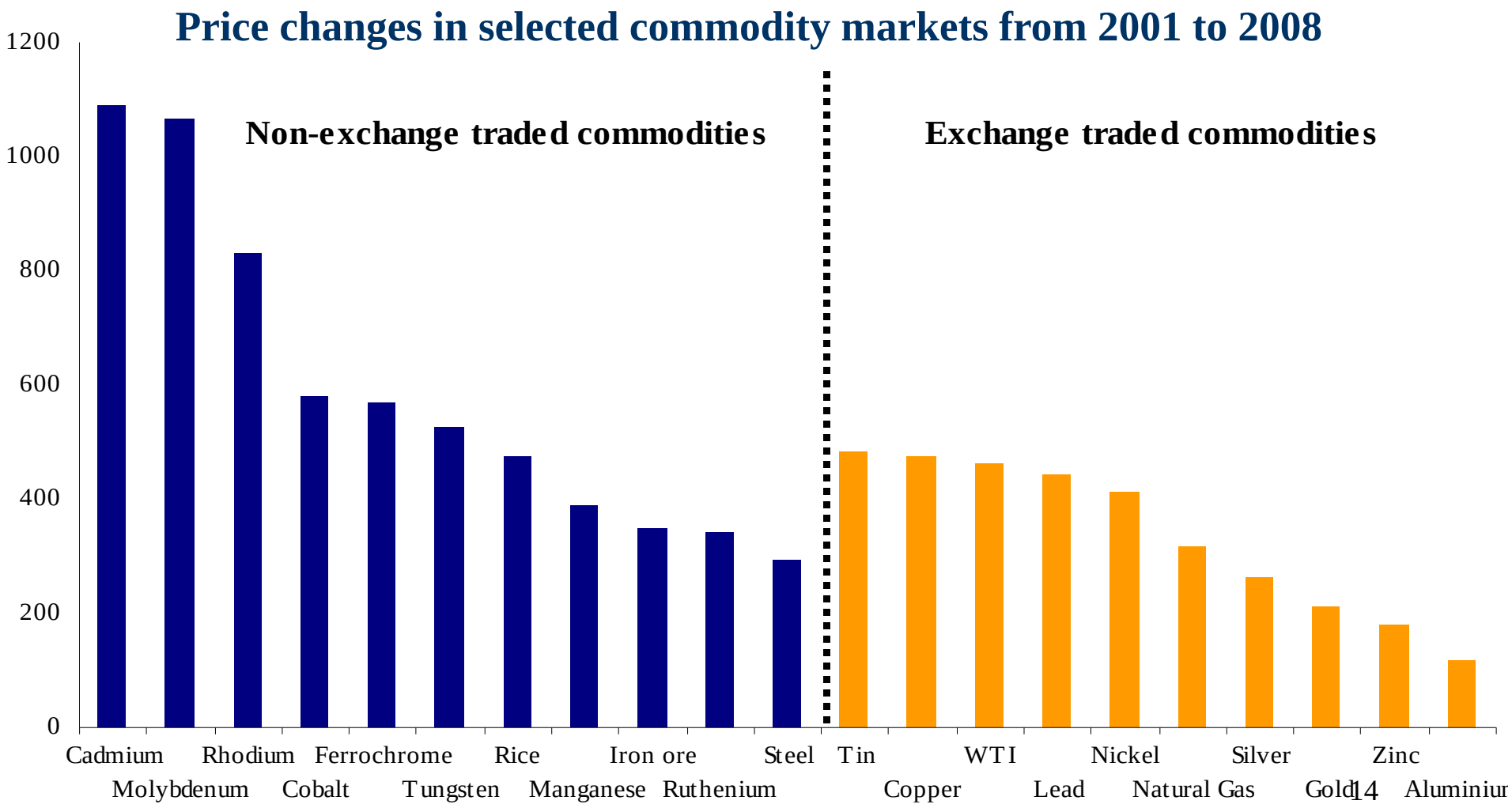
4) Financialization of commodities

• Caveat: if financialization has played a fundamental role in boosting prices, we would expect lower growth rates for those commodities that lack derivative markets. But…



Source: Deustche Bank (2008)

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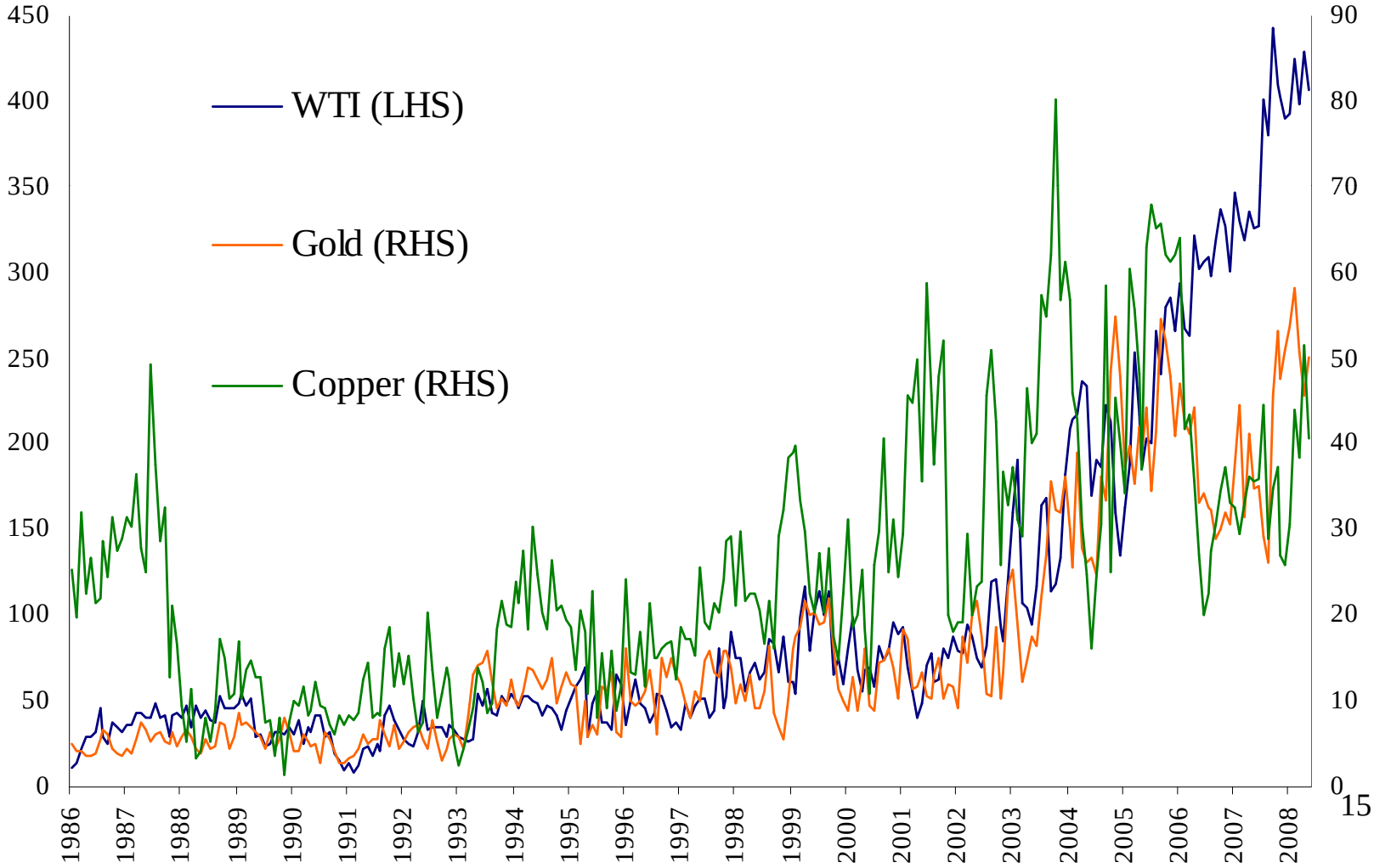
4) Financialization of commodities

- Microstructure of derivative markets: commercial hedgers vs. financial investors.
- Strong increase in financial open positions in oil, gold and copper since 2002. But…

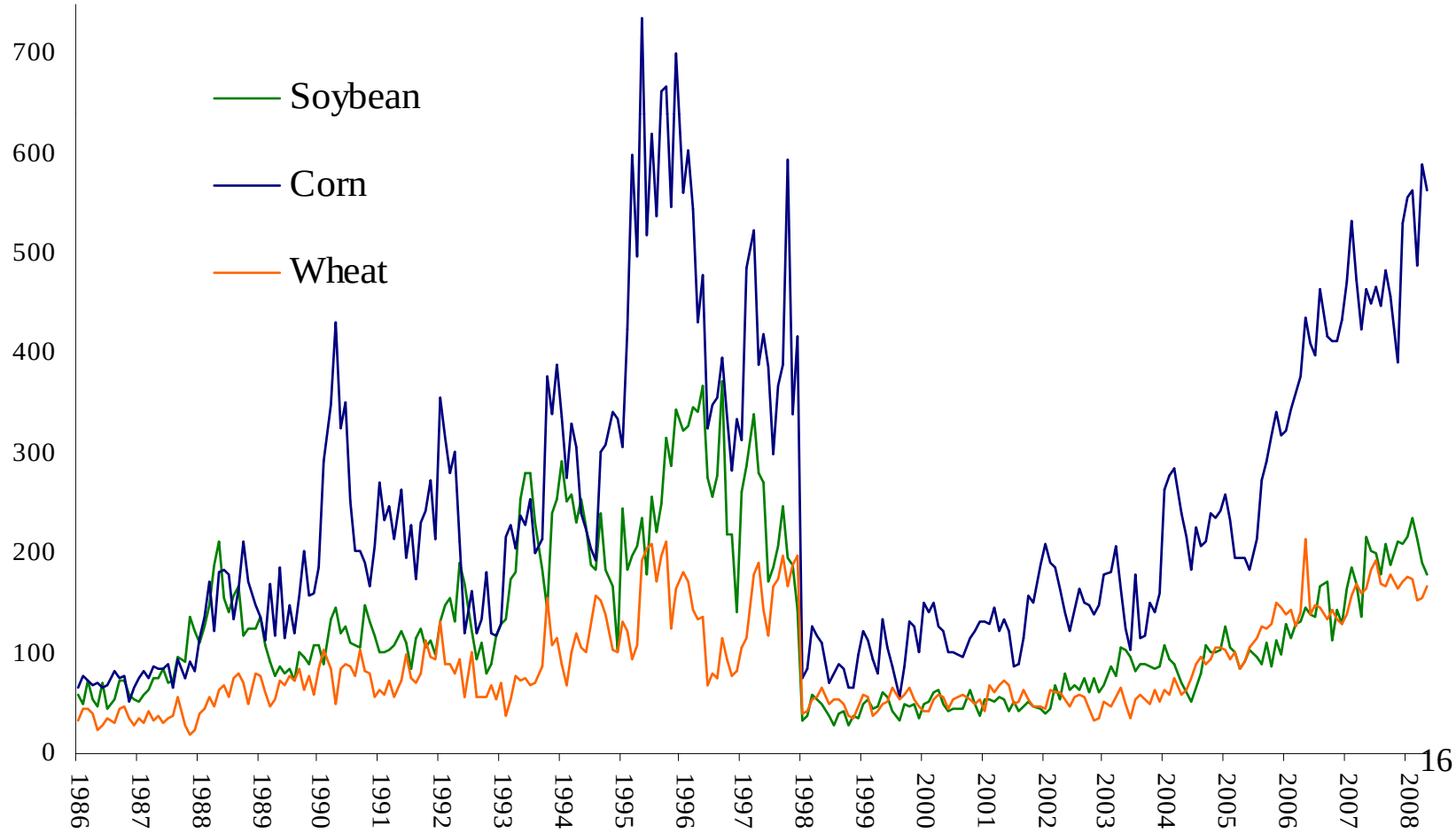
Non-commercial open positions in oil, gold and copper, 1986M1-2008M5



4) Financialization of commodities

• The picture is different for soft agricultural commodities. Open financial positions for these commodities have increased recently but they are lower than those of the mid-nineties. **Financial investor activity is not totally a new phenomenon.**

Non-commercial open positions in soybeans, corn and wheat, 1986M1-2008M5



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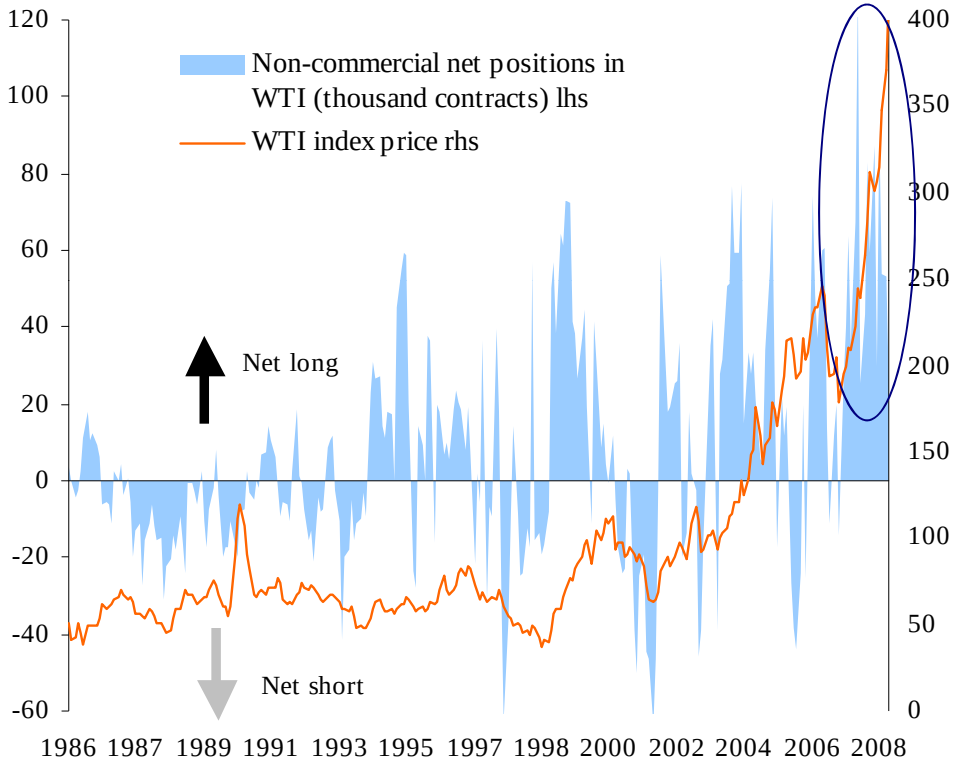
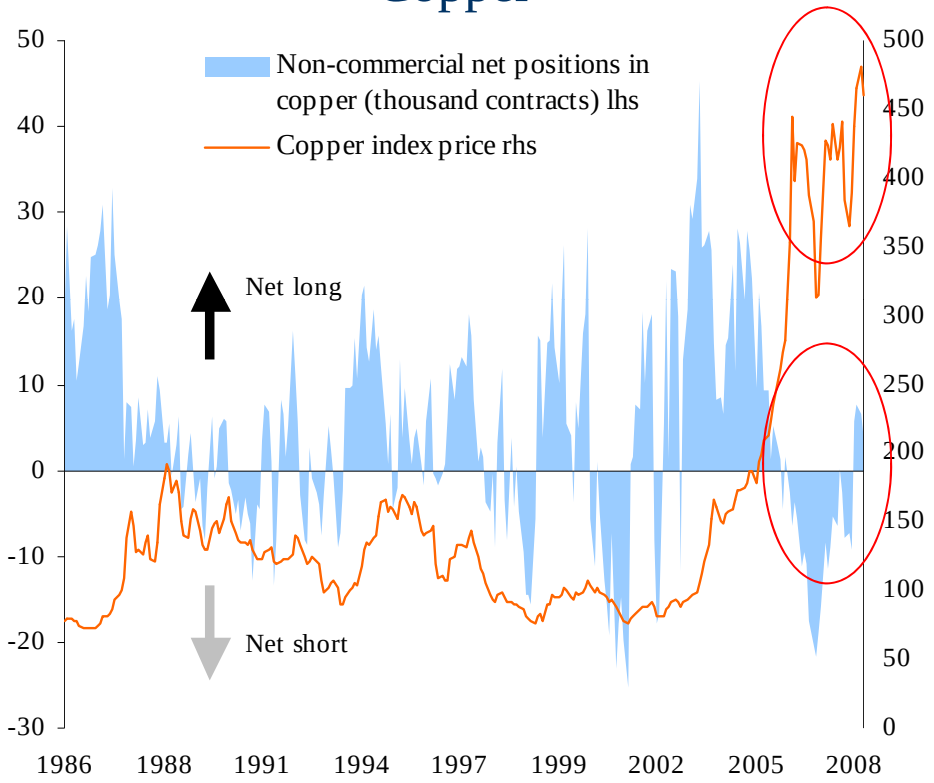
4) Financialization of commodities

The impact of speculative activity on prices could depend on net positions…

Oil



Copper



- **Not all net long positions correspond to high prices.**
- **It is not necessary to have neither commodity derivative markets nor strong net long positions of financial participants to experience a commodity price boom or a bust.**

5) A heterogeneous agent model

Commodity price change in next period is determined by the interaction of 3 agents: fundamentalists (*F*), chartists (*C*) and portfolio managers (*PM*) in accordance to:

$$\Delta P_{t+1} = a_1 E\left(\Delta P_{t+1}^{C}\right) + a_2 E\left(\Delta P_{t+1}^{F}\right) + a_3 E\left(\Delta P_{t+1}^{PM}\right)$$

Expectations of the fundamentalists are based on the notion of commodity price reversion towards long run equilibrium

$$\longrightarrow \quad E\left(\Delta P_{t+1}^{F}\right) = -\alpha \underbrace{\left(P_t - F_t\left(X_t\right)\right)}_{M_t}$$

Chartists employ technical analysis and follow the current trends in prices

$$\longrightarrow \quad E\left(\Delta P_{t+1}^{C}\right) = \delta\left(P_t - P_{t-1}\right)$$

Portfolio Managers have an information advantage and adjust their expectations employing a weighted average of Fundamentalist and Chartist expectations

$$\longrightarrow \quad E\left(\Delta P_{t+1}^{PM}\right) = \left(1 - w_t\right) E\left(\Delta P_{t+1}^{C}\right) + w_t E\left(\Delta P_{t+1}^{F}\right)$$

$$0 \le w_t \le 1$$

5) A heterogeneous agent model

• w_t plays a crucial role because it governs the weight given to F and C expectations by PM at time *t*.

Exponential specification $$w_t = 1 - exp\left(-\gamma\left(P_{t-d} - F_{t-d}\left(X_{t-d}\right)\right)^2\right)$$

This variable adjusts endogenously according to the size of past misalignment. It is the source of non-linearity in the model.

• Parameter γ determines the speed in which portfolio managers adjust their expectations.

• General expression of commodity price change is obtained by replacing equations and rearranging terms. Thus,

Price dynamics depends on several factors

$$\Delta P_{t+1} = (a_1 + a_3)\delta\Delta P_t - a_2\alpha M_t - a_3\delta\left[1 - exp\left(-\gamma M_{t-d}{}^2\right)\right]\Delta P_t - a_3\alpha\left[1 - exp\left(-\gamma M_{t-d}{}^2\right)\right]M_t$$

5) A heterogeneous agent model

1) Terms that we find in a standard ECM: a purely autoregressive term and an error correction factor.

$$\Delta P_{t+1} = (a_1 + a_3)\delta\Delta P_t - a_2\alpha M_t - a_3\delta\left[1 - exp\left(-\gamma M_{t-d}^{\ 2}\right)\right]\Delta P_t - a_3\alpha\left[1 - exp\left(-\gamma M_{t-d}^{\ 2}\right)\right]M_t$$

2) Terms which generate the non-linear adjustment pattern. We will focus the empirical analysis in the non-linear error correction factor.

$$\Delta P_{t+1} = (a_1 + a_3)\delta\Delta P_t - a_2\alpha M_t - a_3\delta\left[1 - exp\left(-\gamma M_{t-d}^{\ 2}\right)\right]\Delta P_t - a_3\alpha\left[1 - exp\left(-\gamma M_{t-d}^{\ 2}\right)\right]M_t$$

Outcome of the model: Equilibrium price adjustment is non-linear. **The higher the gap between actual and equilibrium price is, the faster the price adjustment will be.**

• STAR model is suitable for testing this hypothesis once the long run equilibrium is estimated.

6) Econometric results

- **Operational steps to implement a STAR model**:

1) Linear model: it serves as a benchmark to contrast the non-linearity hypothesis. The estimation follows common techniques of time series analysis.

2) Linearity test: Teräsvirta (1994) suggests using a first order Taylor expansion to obtain an auxiliary regression to contrast the null hypothesis of linearity.

3) Estimation: It is done by a non-linear method. The use of proper initial conditions will increase the probability of reaching a maximum in the likelihood function.

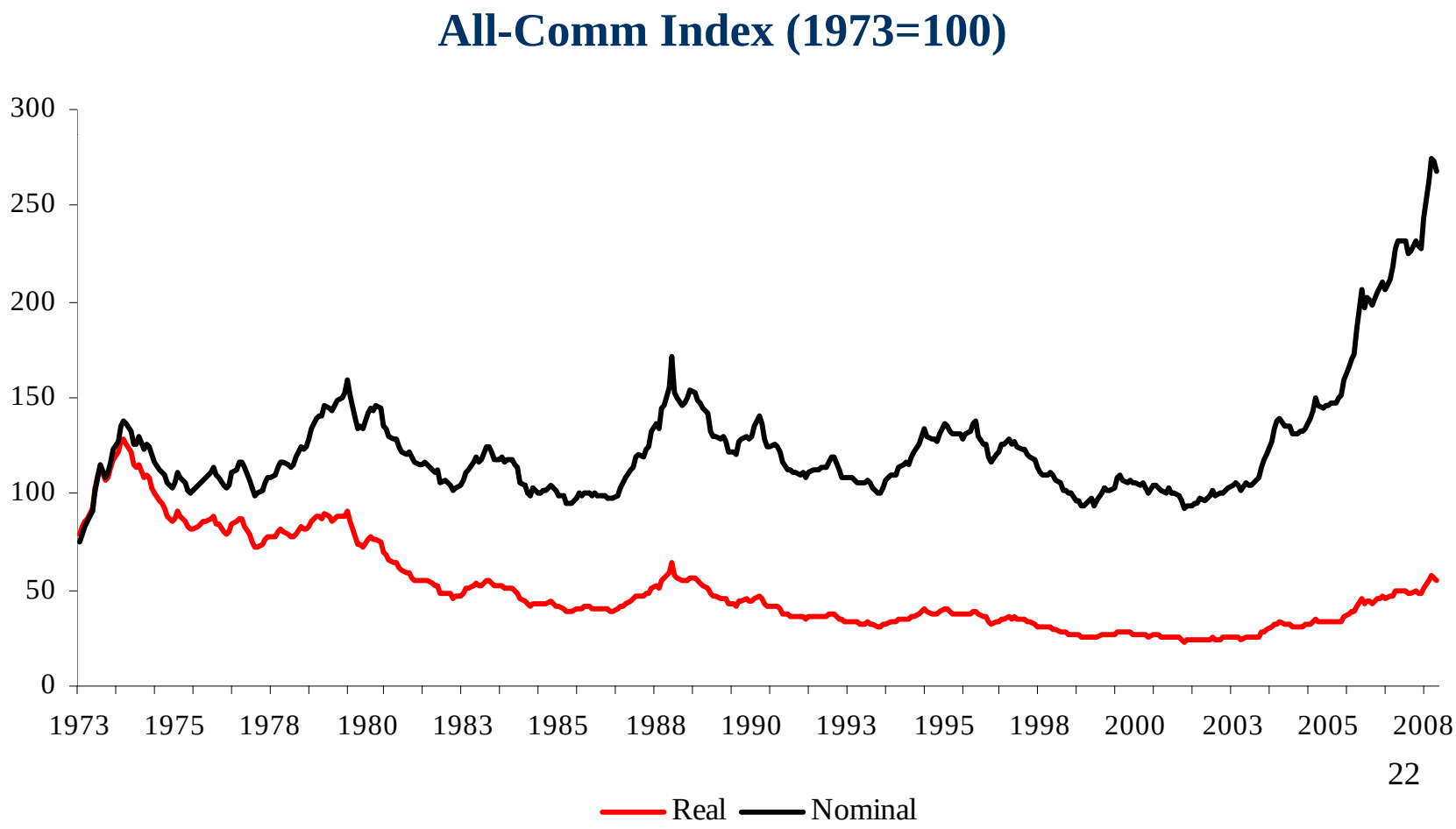
4) Non-linear I-R analysis: Useful tools in STAR systems are the generalized I-R functions.

Intuition: effects of shocks depend on the history, size and sign of disturbances.

6) Econometric results

- **Variables**

- All-Comm Index: Food and Metal indexes from IFS (IMF). USA CPI is the deflator



6) Econometric results

- **Drivers**

- **US Real Exchange Rate (RER):** Broad multilateral version published by the Federal Reserve Bank of New York**.**

- **Real International Interest Rate (IR):** one-year Treasury constant maturity rate from the Board of Governors of the Federal Reserve System.

- **Industrial Production Index (PRO):** IPIs of developed countries plus 4 emerging Asian economies (Korea, India, Malaysia and China) weighted using industrial value added of each country.

- **Real Dow Jones Index (DOW):** Are there substitution or complementary effects between commodities and stock markets? Gorton and Rouwenhorst (2004) and Deutsche Bank (2005) find a negative non-conditional correlation between them.

- **Time trend**

6) Econometric results

- **Empirical model: ESTAR**

Exponential TVF

$$\Delta P_t = \beta_{11} + \alpha_{11}(M_{t-1}) + \sum_{j=1}^{p} \Pi_{11,j} \Delta X_{t-p} + \left(\beta_{12} + \alpha_{12}(M_{t-1}) + \sum_{j=1}^{p} \Pi_{12,j} \Delta X_{t-p} \right) \left(1 - exp\left(-\left(\gamma (TV_{t-d})^2\right)\right)\right) + \varepsilon_t^P$$

Non-linear term

$$\Delta RER_t = \beta_2 + \alpha_2 (M_{t-1}) + \sum_{j=1}^{p} \Pi_{2,j} \Delta X_{t-p} + \varepsilon_t^{RER}$$

$$\Delta IR_t = \beta_3 + \alpha_3 (M_{t-1}) + \sum_{j=1}^{p} \Pi_{3,j} \Delta X_{t-p} + \varepsilon_t^{IR}$$

$$\Delta PRO_t = \beta_4 + \alpha_4 (M_{t-1}) + \sum_{j=1}^{p} \Pi_{4,j} \Delta X_{t-p} + \varepsilon_t^{PRO}$$

$$\Delta DOW_t = \beta_5 + \alpha_5 (M_{t-1}) + \sum_{j=1}^{p} \Pi_{5,j} \Delta X_{t-p} + \varepsilon_t^{DOW}$$

Where:

$X = [P, RER, IR, PRO, DOW]$

$M_t = P_t - F(X_t)$ is the misalignment and $F(X_t)$ is the long-run equilibrium

TV_{t-d} is the Transition Variable lagged d periods

6) Econometric results

- **Empirical model: ESTAR**

- Econometric strategy adopted is in line with the Engle and Granger proposal.

- We estimate in a first stage the long run equation for commodity prices and test for cointegration.

- Then, if a cointegration relationship is found, the whole error correction system will be estimated using as regressor the misalignment obtained in the first step.

6) Econometric results

- **Estimation of the long-run equation (equilibrium prices)**

- We apply the Dynamic OLS (DOLS) (Stock and Watson, 1993). It deals with potential simultaneity among the regressors and small sample bias by the inclusion of leads and lags of the explanatory variable differences.

$$P_t = \beta_1 + \beta_2 X_t + \sum_{j=-p}^{p} \beta_3 \Delta X_{t-p} + \beta_4 t + \varepsilon_t$$

- Monte Carlo experiments show that DOLS performs better, particularly in small samples, compared to alternative estimators of long-run parameters as those proposed by Engle and Granger (1987), Johansen (1988), and Phillips and Hansen (1990).

- Standard statistical inference remains valid when heteroskedastic and autocorrelation consistent (HAC) standard errors are employed.

6) Econometric results

- **Estimation of the long-run equation (equilibrium prices)**

Variable	OLS	DOLS	
	Coefficient	Coefficient	p-value
Industrial Production Index	3.6124	4.1368	0.0000
US Real Exchange Rate	-0.7270	-0.5994	0.0000
Real International Interest Rate	-1.0907	-1.5452	0.0138
Real Down Jones Index	-0.1299	-0.1086	0.0163
Time Trend	-0.0097	-0.0111	0.0000
Constant	-4.1659	-6.9366	0.0000

- Few cointegration tests have been developed for DOLS: Shin (1994) and Choi et al (2008)

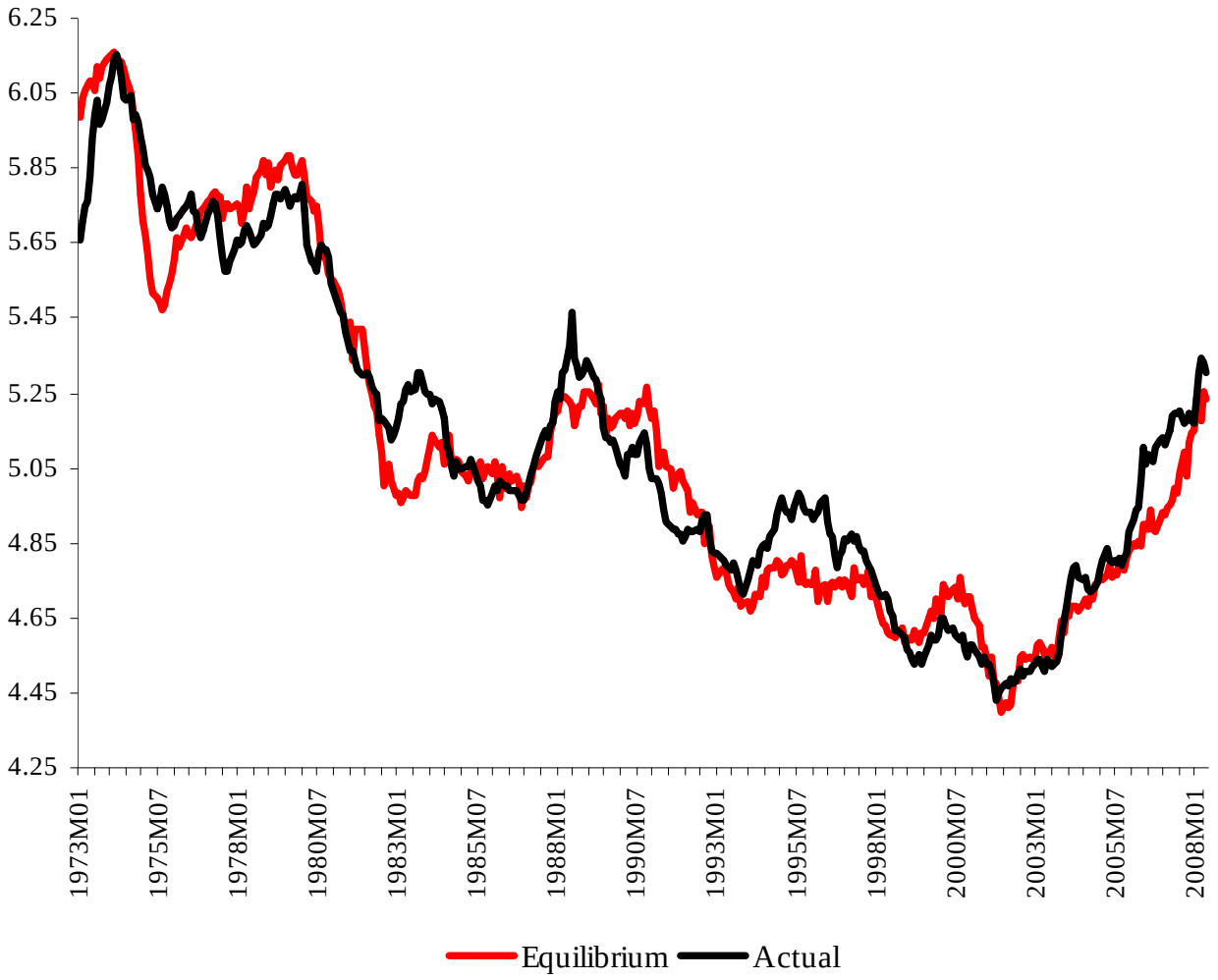
- We find evidence of cointegration applying Shin Test at 2.5% statistical significance.

- For robustness check, we carried out the standard ADF non-cointegration test based on OLS residuals and we rejected the null hypothesis of unit root residuals.

6) Econometric results

- **Estimation of the long-run equation (equilibrium prices)**

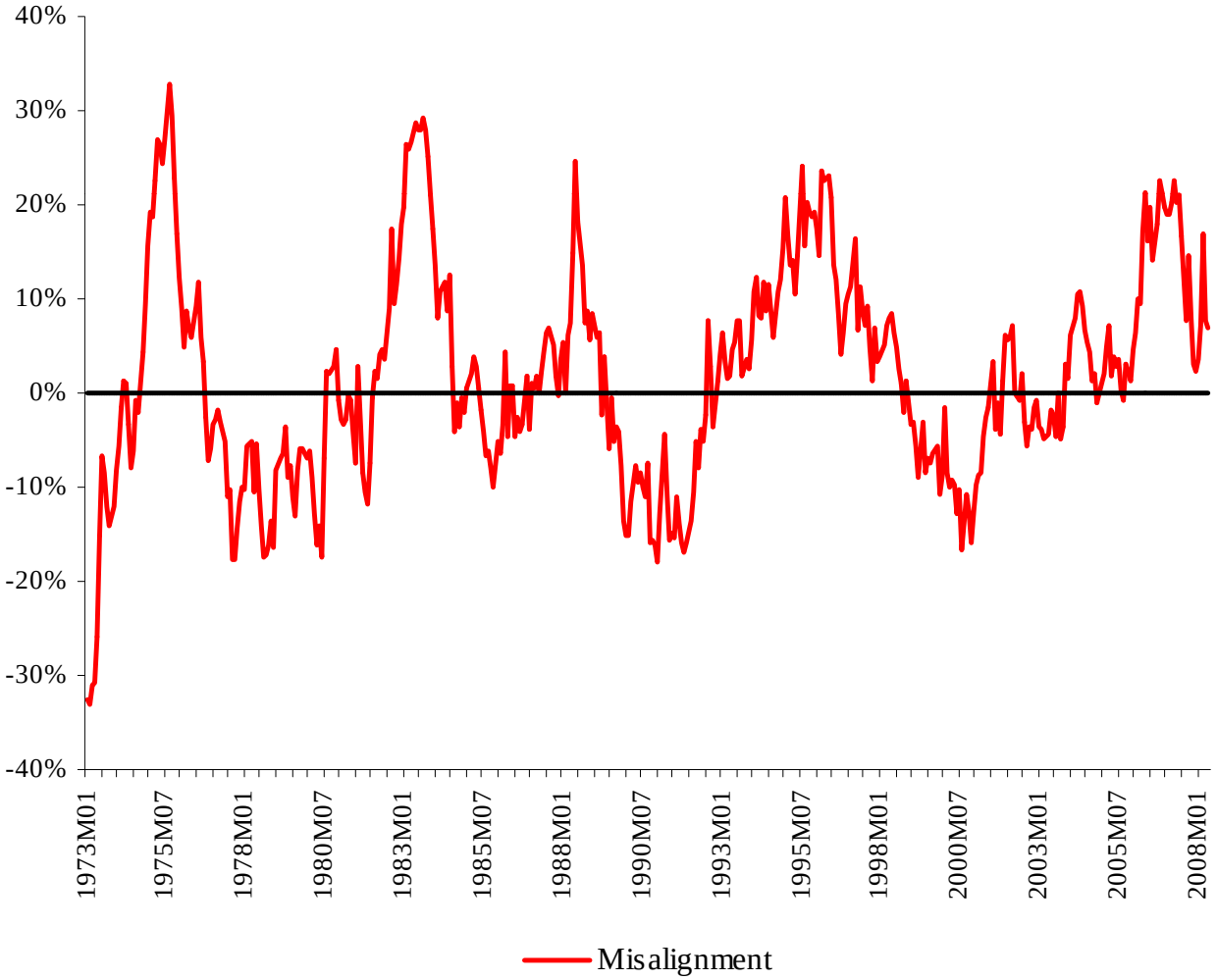
All-Comm Index (logarithmic scale)



6) Econometric results

- **Estimation of the long-run equation (equilibrium prices)**

All-Comm Index Misalignment



6) Econometric results

- **Linearity F-test results**

Transition Variable	Lag	LM Statistic	p-value
AV1	1	1.38647	0.04912
AV4	12	1.38309	0.05040
AV3	12	1.21178	0.16396
AV4	11	1.19485	0.18166
AV1	6	1.15964	0.22287
AV2	1	1.15512	0.22859
AV2	12	1.12511	0.26910
AV2	6	1.12423	0.27036
AV4	4	1.12396	0.27074
AV3	5	1.12106	0.27490

Potential Transition Variables

M_{t-d} Misalignment

AVj_{t-d} Average of the current misalignment and those of the previous j periods; j range from 1 to 4

6) Econometric results

- **Estimation results of non-linear ECM**

$$\Delta P_t = \beta_{11} + \alpha_{11}(M_{t-1}) + \sum_{j=1}^{p} \Pi_{11,j} \Delta X_{t-p} + \left(\beta_{12} + \alpha_{12}(M_{t-1}) + \sum_{j=1}^{p} \Pi_{12,j} \Delta X_{t-p} \right) \left(1 - exp\left(-\gamma TV_{t-d}^{\ 2} \right) \right) + \varepsilon_t^P$$

$\alpha_{11} = 0.035 \quad (p\text{-}value = 0.2914)$ $\alpha_{12} = -0.109 \quad (p\text{-}value = 0.0418)$ $\gamma = 55.22 \quad (p\text{-}value = 0.0292)$

Global Equilibrium Correction Factor (GEC) =-0.074

$$GEC = (0.035)M_{t-1} + (-0.109)M_{t-1} * w_t = \{(0.035) + (-0.109)w_t\}M_{t-1}$$

- Our findings support non-linear adjustment hypothesis due to heterogeneous agents in commodity markets.

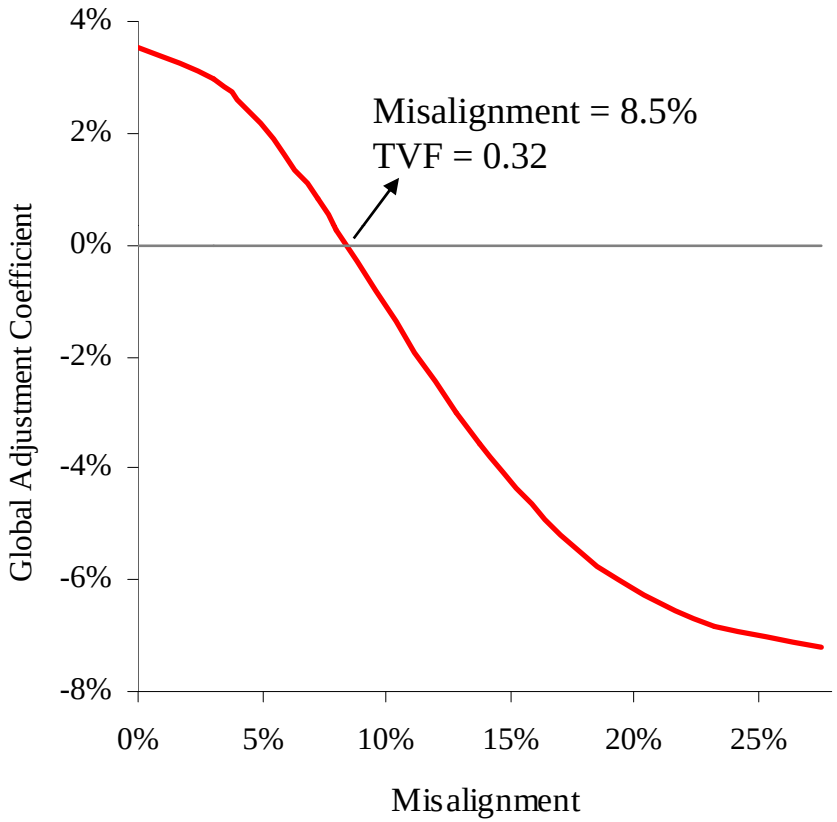
- When misalignment is low enough (low regime), w_t tends to 0 and second term vanishes. PM mimic chartist and initial misalignment is widened at a 3.5% monthly rate. In this case, there is not equilibrium correction.

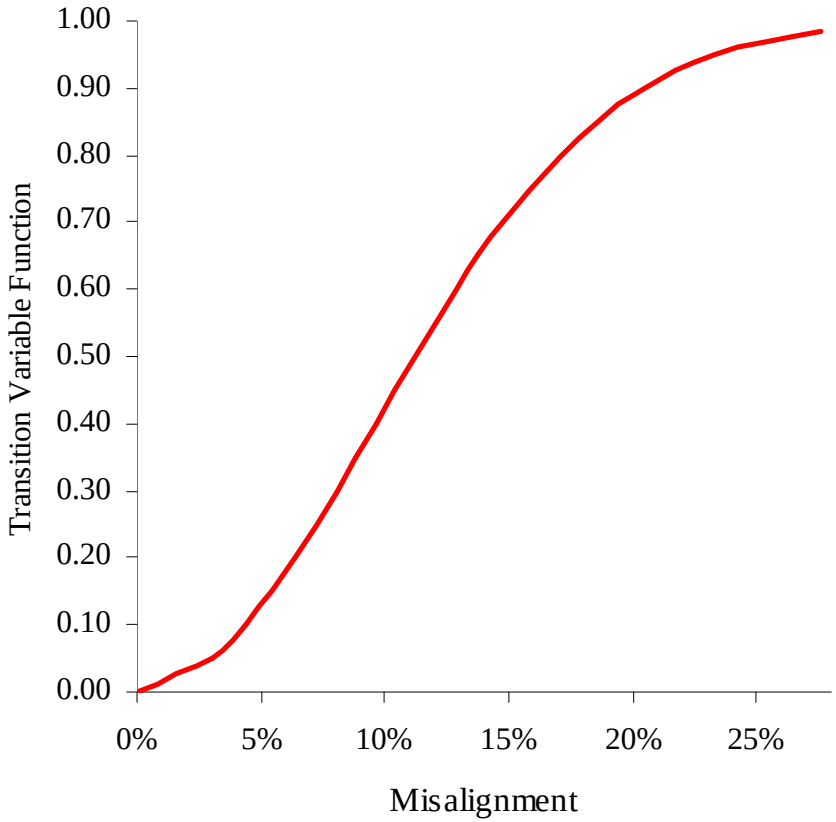
- When the misalignment reaches a sizable value (high regime), w_t tends to 1 and the GEC adjustment coefficient attains a maximum of -7.4% monthly rate. PM assign a larger weight to F expectations. Therefore, we will observe price reversion toward the equilibrium.

6) Econometric results

- **Estimation results of non-linear ECM**

Misalignment, transition function and global adjustment coefficient





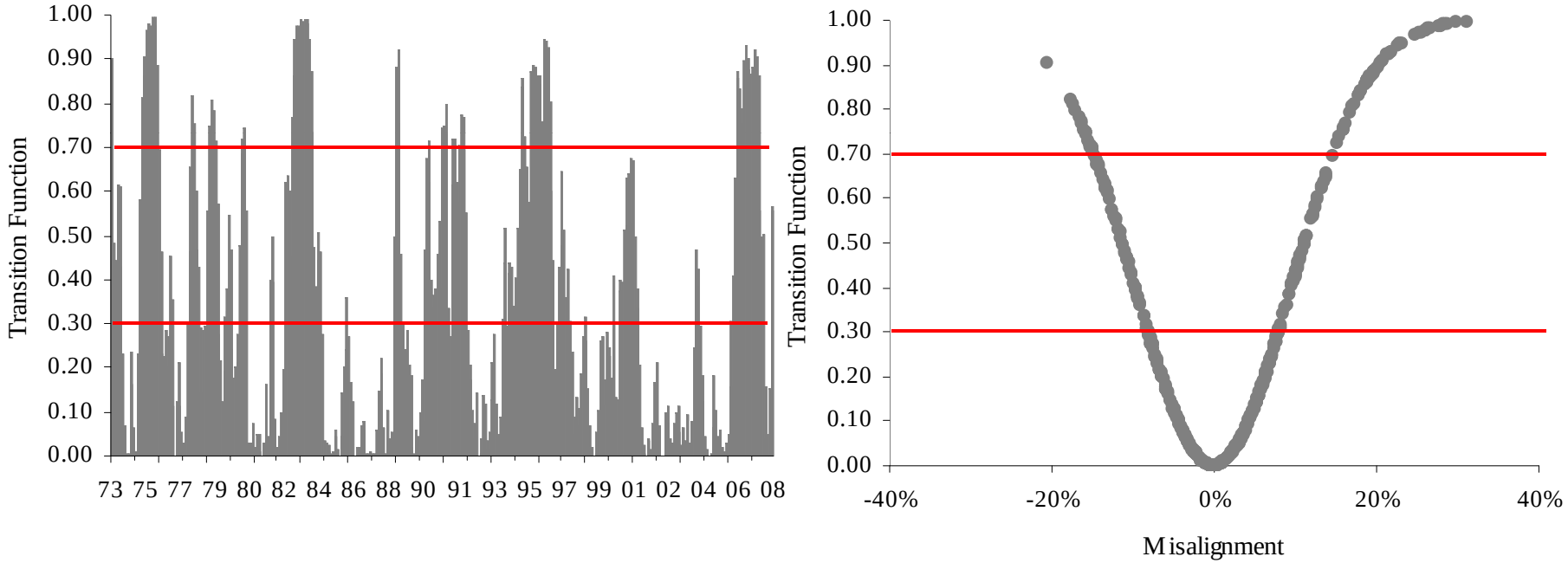
- Maximum reversion speed (-7.4% monthly) is attained when misalignment surpasses 25%.

- Corollary: higher misalignments in the past involve higher values of the transition function and this will indicate stronger price adjustments.

6) Econometric results

- **Estimation results of non-linear ECM**

Transition function in the 1973-2008 period



- We assign observations to low regime if transition function takes values lower than 0.30 while we will consider they belong to high regime every time transition function exceeds 0.70.

- **56%** of the time the market is dominated by **chartists** while **fundamentalists** only prevail about **18.85%**. The rest of the time (**25%**) corresponds to **transition periods**.

6) Econometric results

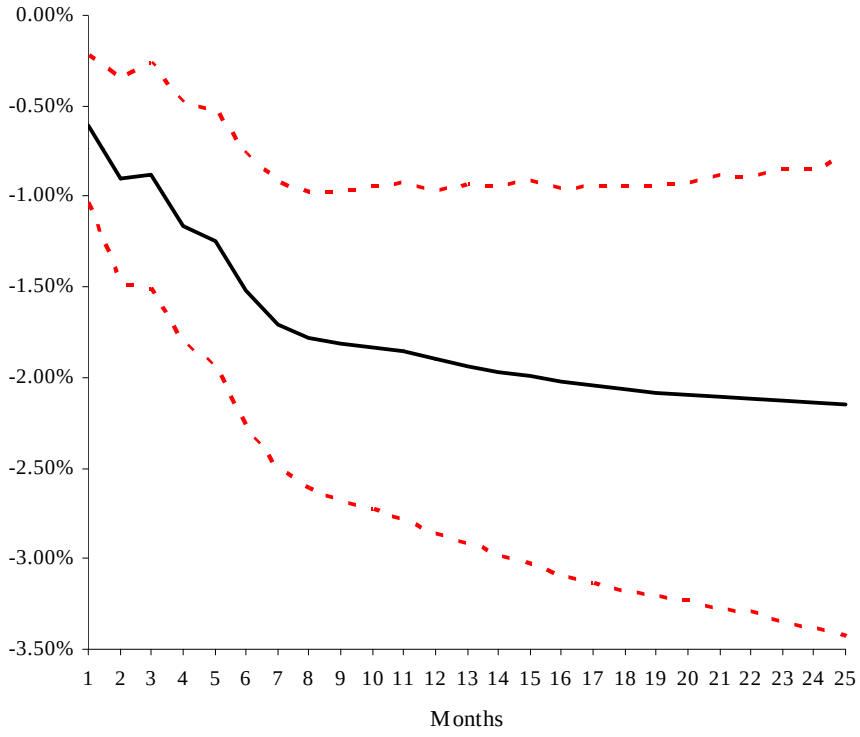
- **Estimation results of non-linear ECM**

Summarizing, results support the hypothesis that **high gaps** between actual and equilibrium prices tend to be **corrected relatively fast**, while **small misalignments tend to persist** over time without any endogenous correcting force taking place.

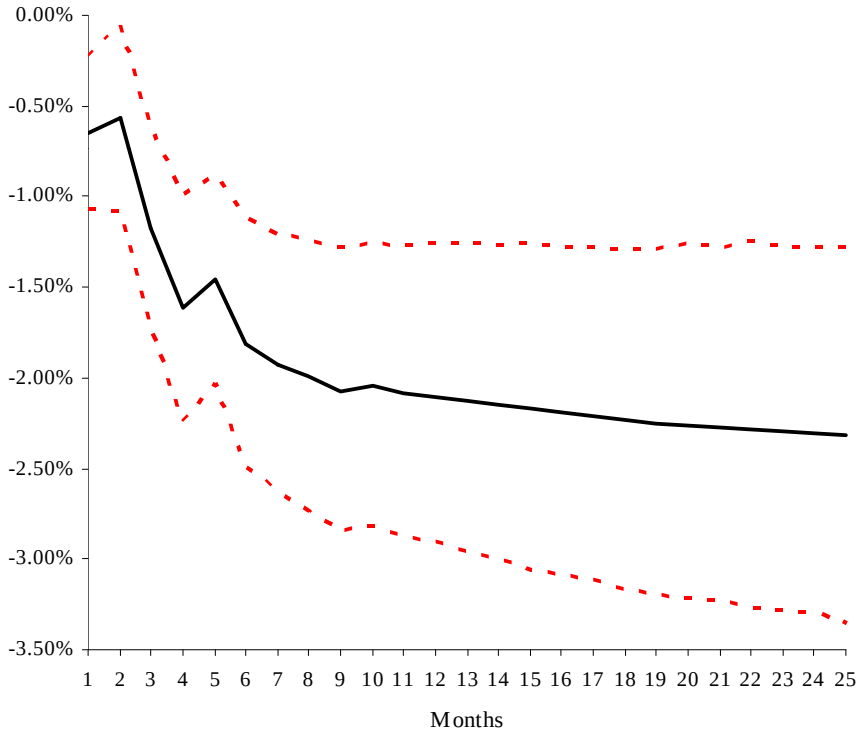
6) Econometric results

- **Non-linear impulse-response analysis (Koop et al., 1996)**

US effective real exchange rate shock (1-std deviation)



a) Low misalignment state

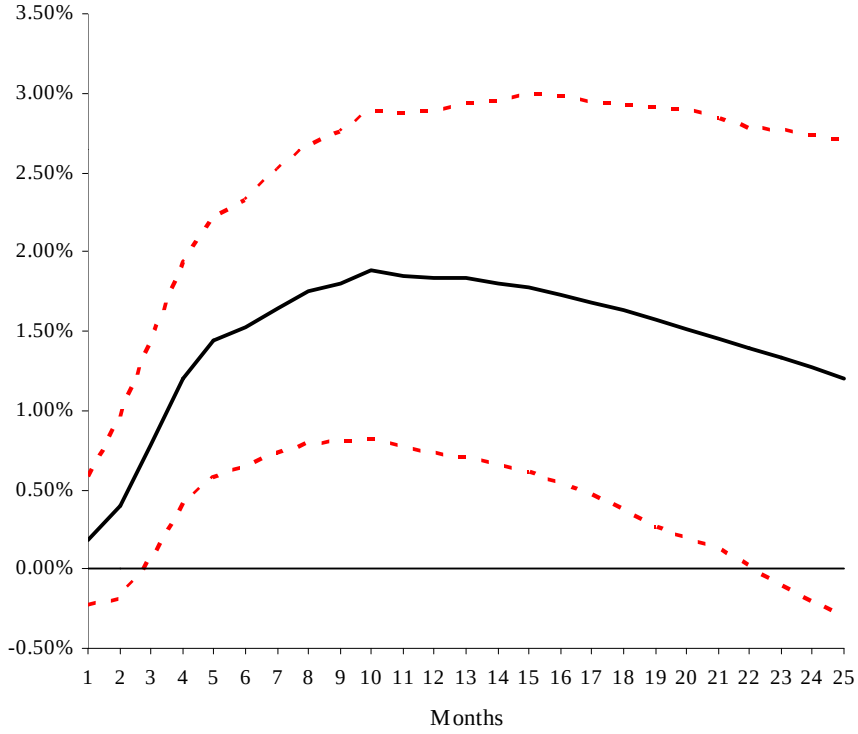


b) High misalignment state

6) Econometric results

- **Non-linear impulse-response analysis (Koop et al., 1996)**

Industrial production shock (1-std deviation)



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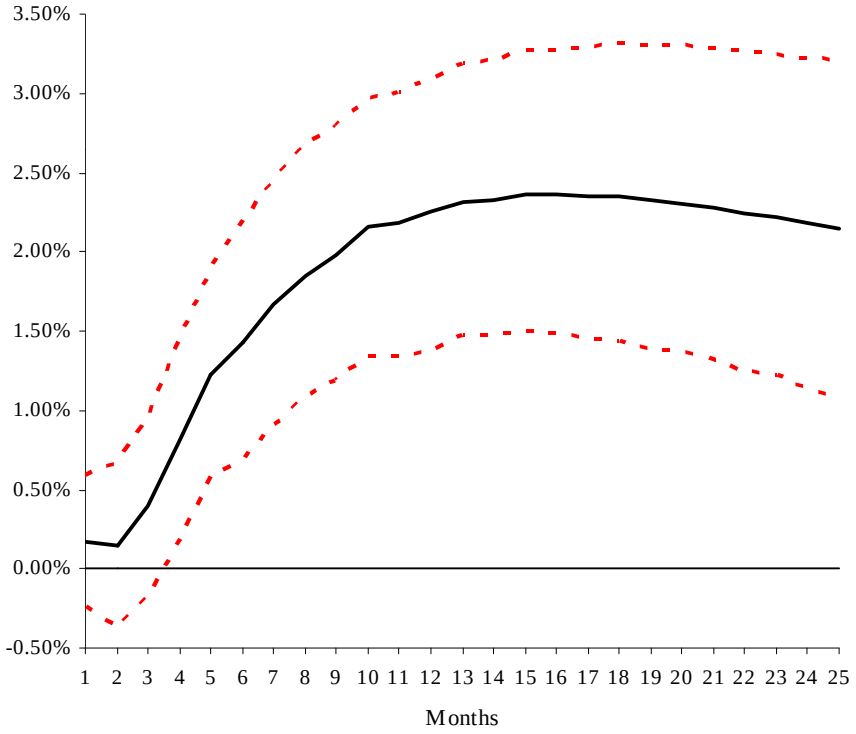
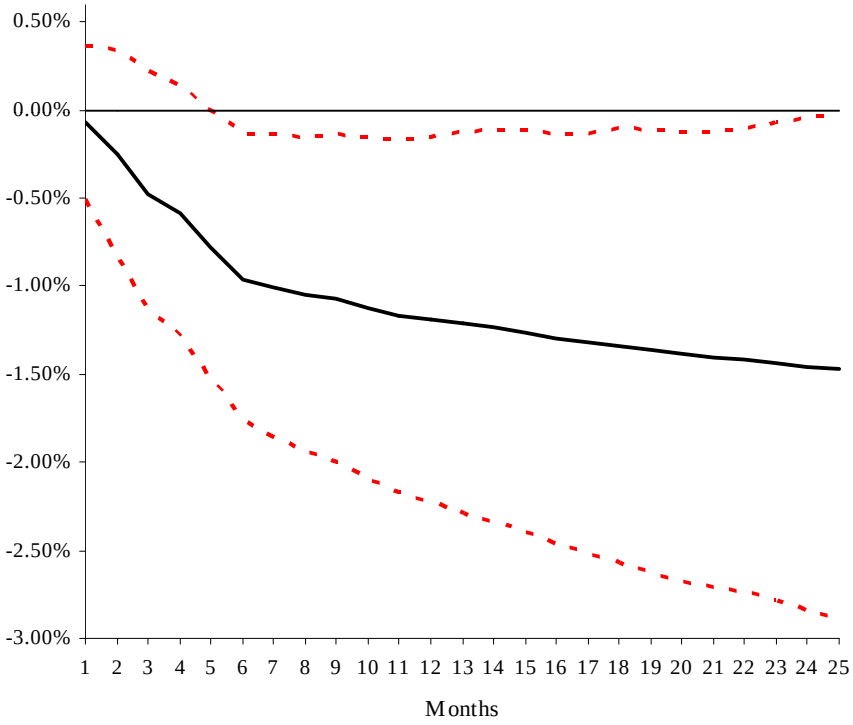


b) High misalignment state

6) Econometric results

- **Non-linear impulse-response analysis (Koop et al., 1996)**

US real interest rate shock (1-std deviation)



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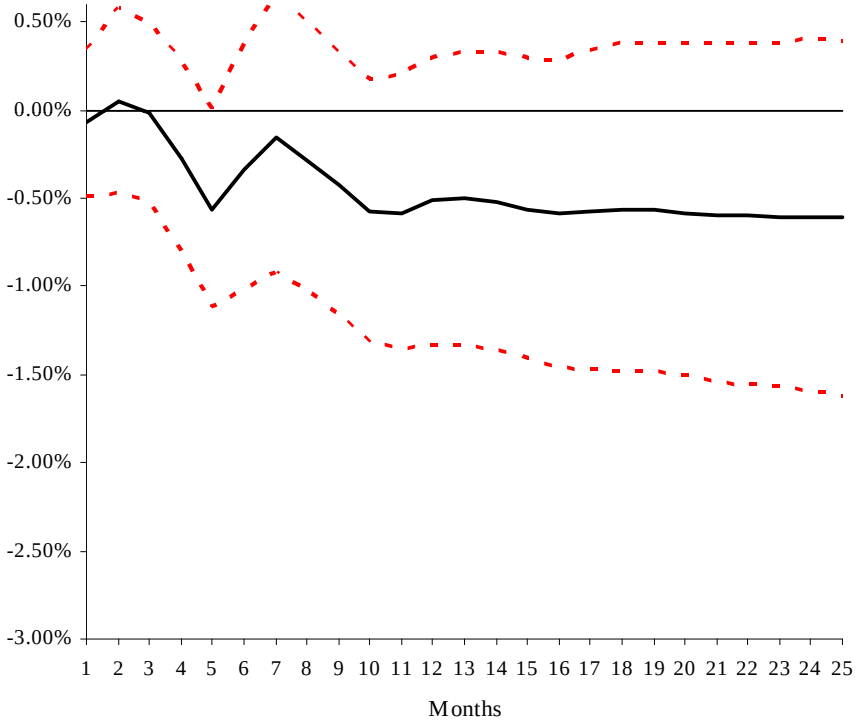
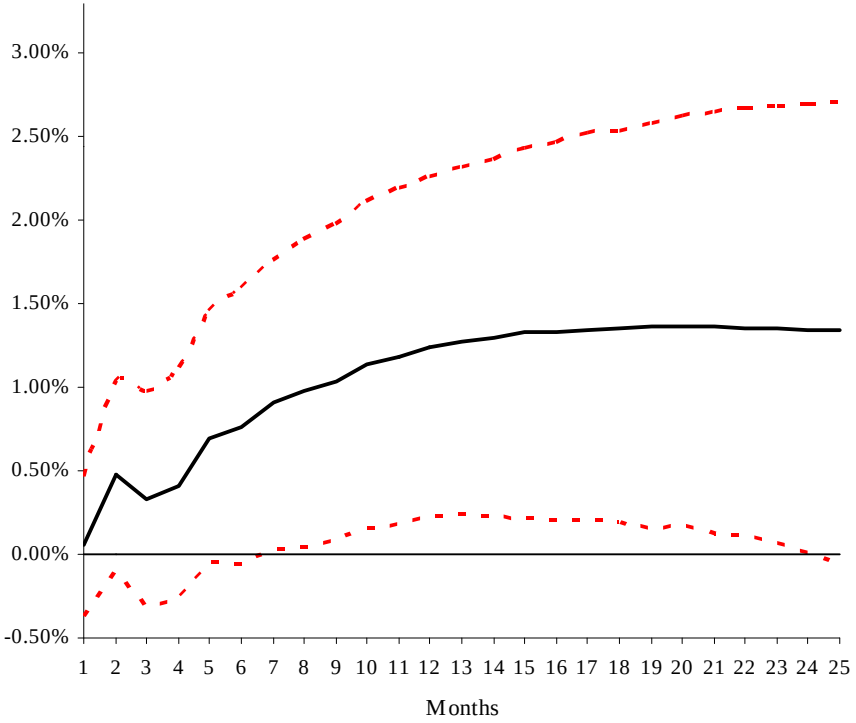


b) High misalignment state

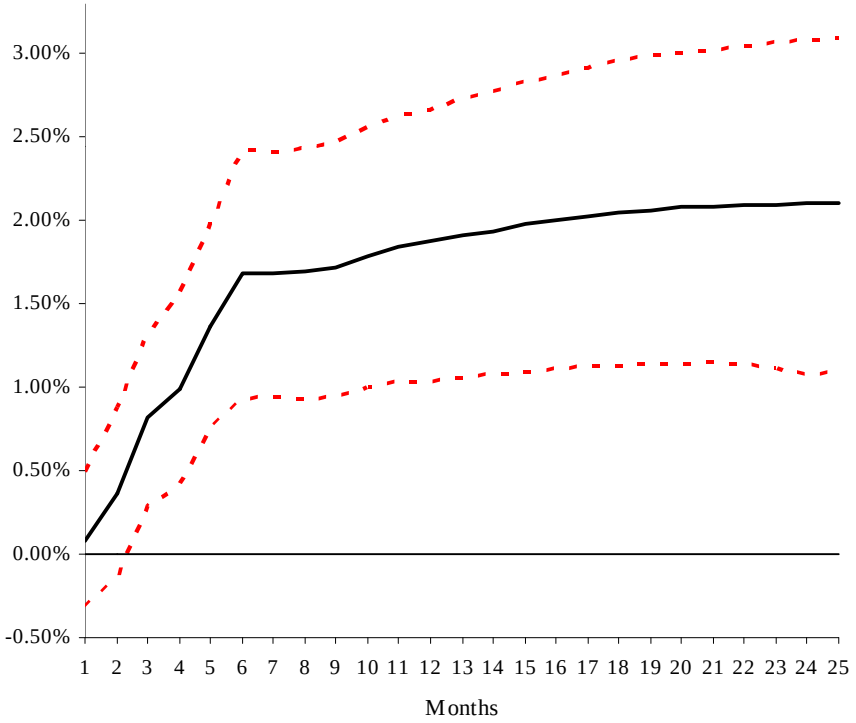
6) Econometric results

- **Non-linear impulse-response analysis (Koop et al., 1996)**

Real Dow Jones index (1-std deviation)



a) Low misalignment state



b) High misalignment state

7) Open questions: Structural changes

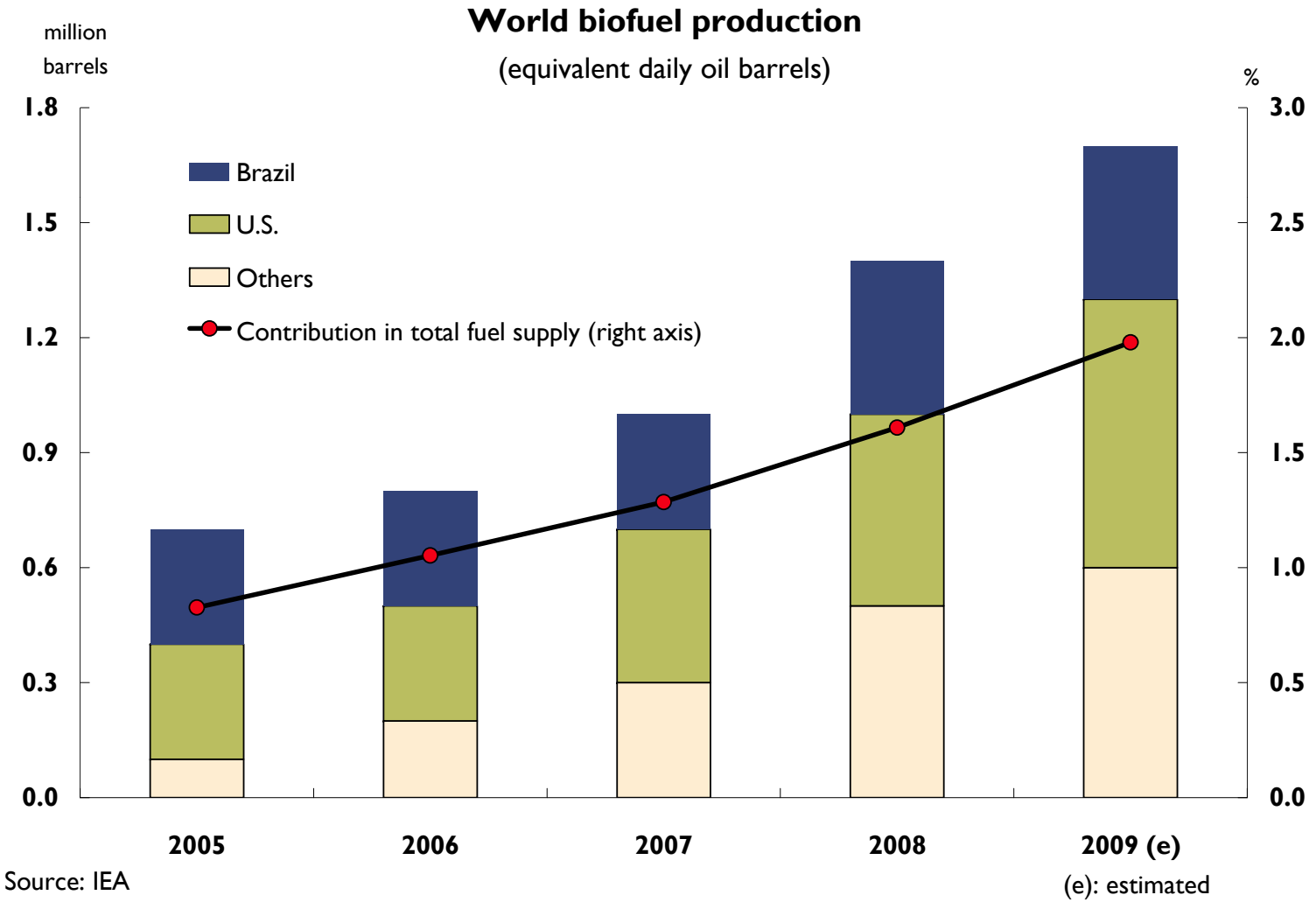
• There are two processes that have intensified from the 2000s and both should be taken into account when we use our empirical results to configure future scenarios for commodity prices:

- Biofuels

- Changes in international **demand pattern of commodities** due to structural transformations in big emerging economies such as China and India.

7) Open questions: Biofuels

• Higher petroleum prices and extended support policies have induced a rapid growth in biofuel production in recent years.

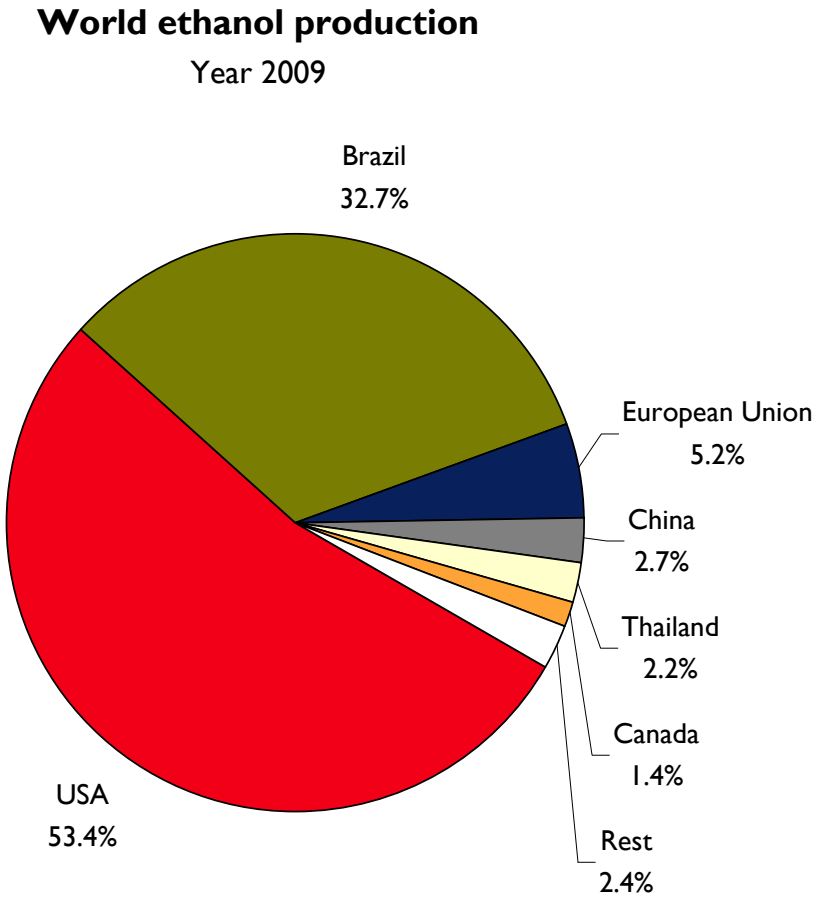


Source: IEA

(e): estimated

7) Open questions: Biofuels

• United States and Brazil dominate ethanol production and also constitute the main consumer markets.

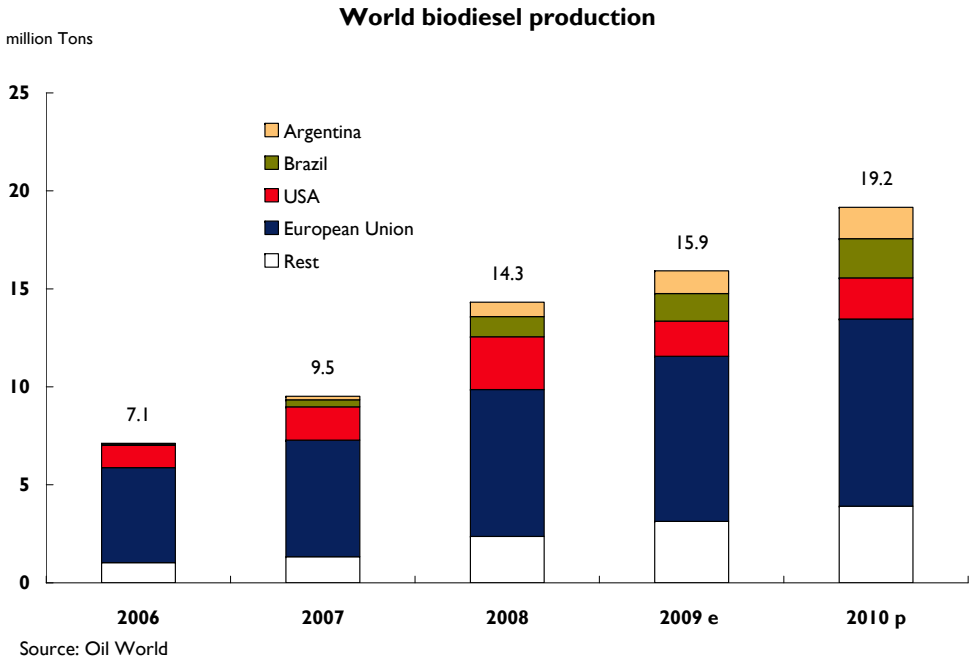


Producer	Feedstock
United States	Corn
Brazil	Sugarcane
European Union	Sugar beet, wheat, corn

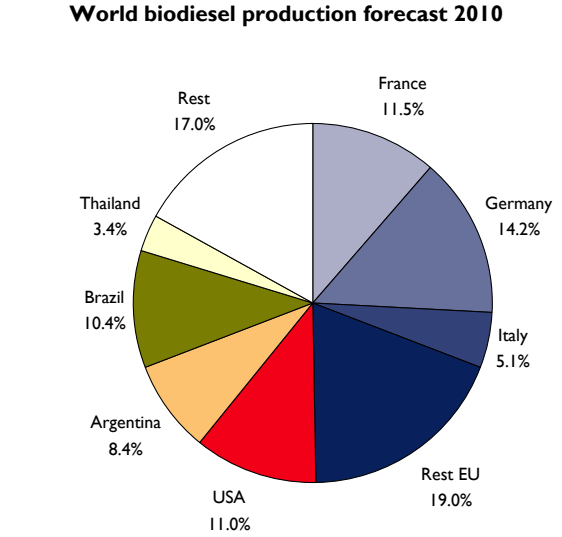
Source: Renewable Fuels Association

7) Open questions: Biofuels

• Biodiesel production has also experienced a pronounced expansion, with the European Union as the main producer and market.



Source: Oil World



Source: Oil World

Producer	Feedstock
European Union	Rapeseed
United States	Soybean
Argentina	Soybean
Brazil	Soybean
Thailand	Palm oil

7) Open questions: Changes in demand patterns

• Evidence shows a strong relationship between income per capita and the quantity and quality of the diet.

• **"Nutritional transition"** (Popkins, 1993; Popkins, Horton and Kim, 2001).

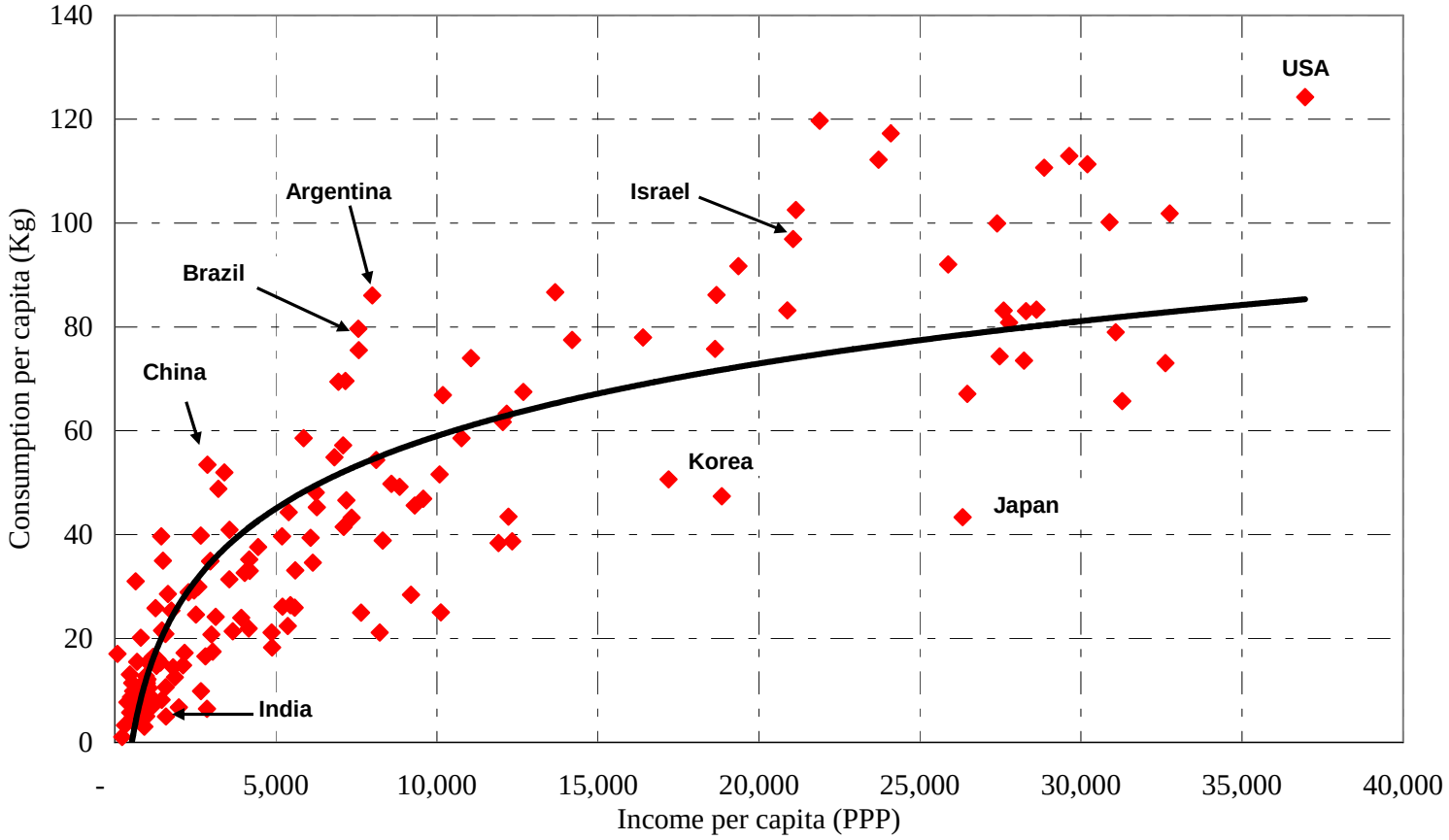
- **First stage:** income increases from very low levels elevate food consumption.

- **Second stage:** When income continues going up not only calory consumption increases but diet becomes more diversified: Cereals lose importance while meat, fish, fruits and vegetables gain shares.

7) Open questions: Changes in demand patterns

• However, China and India are going thorough this process at a higher speed than other countries in the past. This has a big impact on commodity demand.

Income per capita and meat consumption (2002)

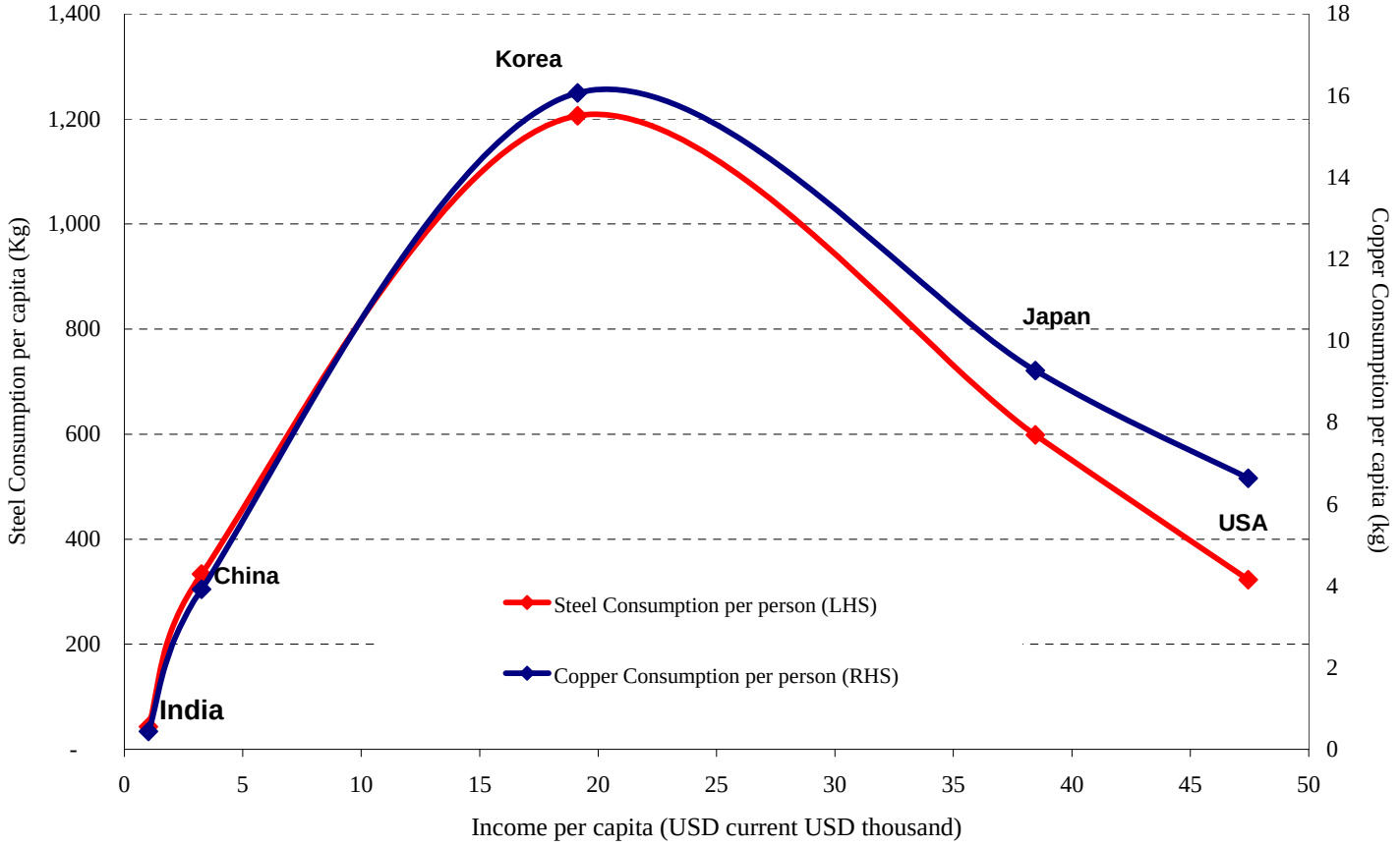


Source: Elaborated by the authors elaboration based on FAO data.

7) Open questions: Changes in demand patterns

- High growth performance of China and India had also a great effect on demand of metals.
- There exists an inverse U-shape relationship between metal consumption and income level. Consumption increases up to 15,000 or 20,000 per capita GDP in PPP dollars (IMF, 2006).

Income per capita and metals consumption (2005)



Source: Elaborated by the authors based on data from IMF, International Copper Study Group and World Steel Association data.

7) Open questions: Changes in demand patterns

- Structural changes were reflected in world trade.

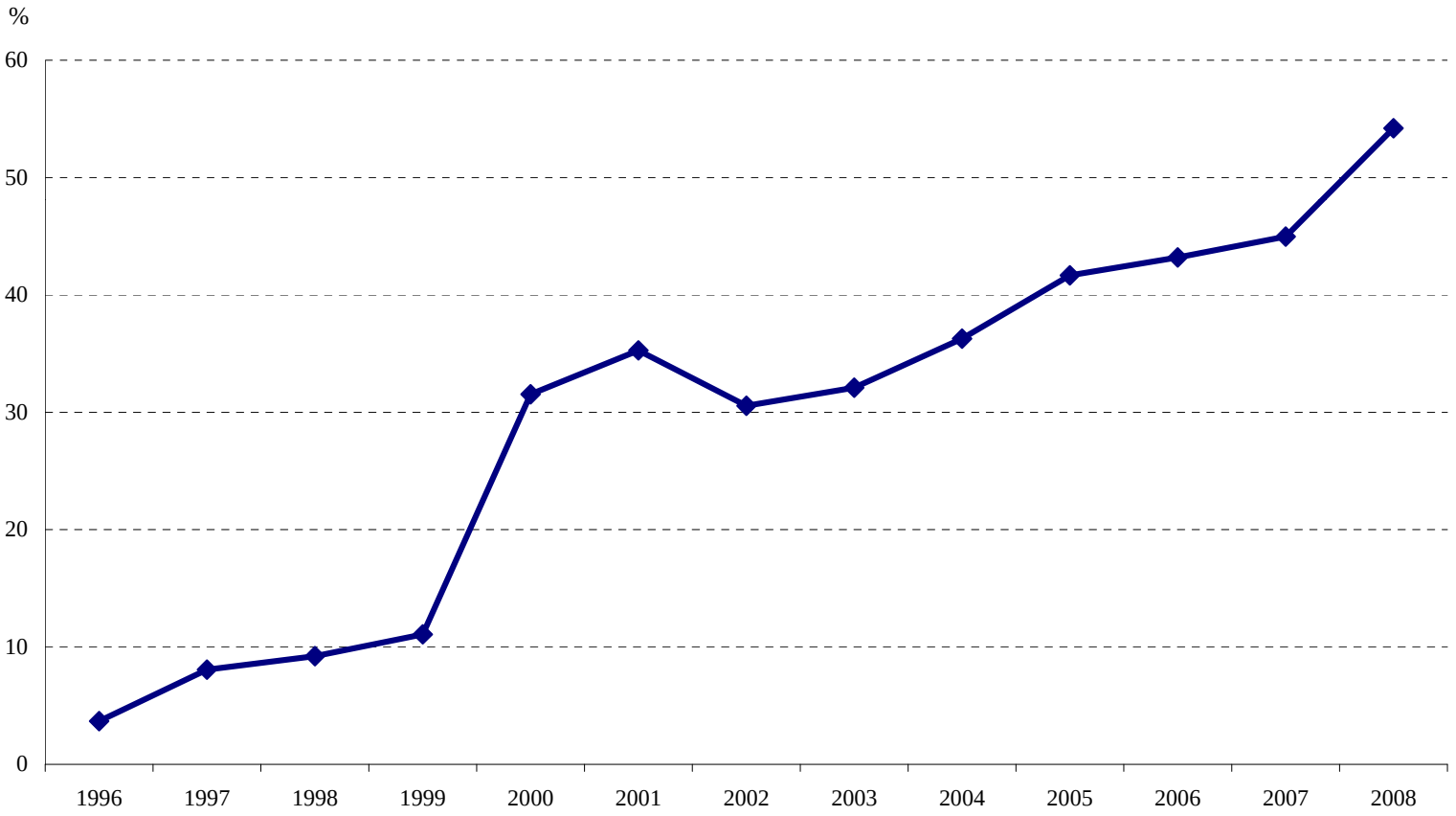
Source: Elaborated by the authors based on UN Comtrade

7) Open questions: Changes in demand patterns

- Mainly in commodity markets…

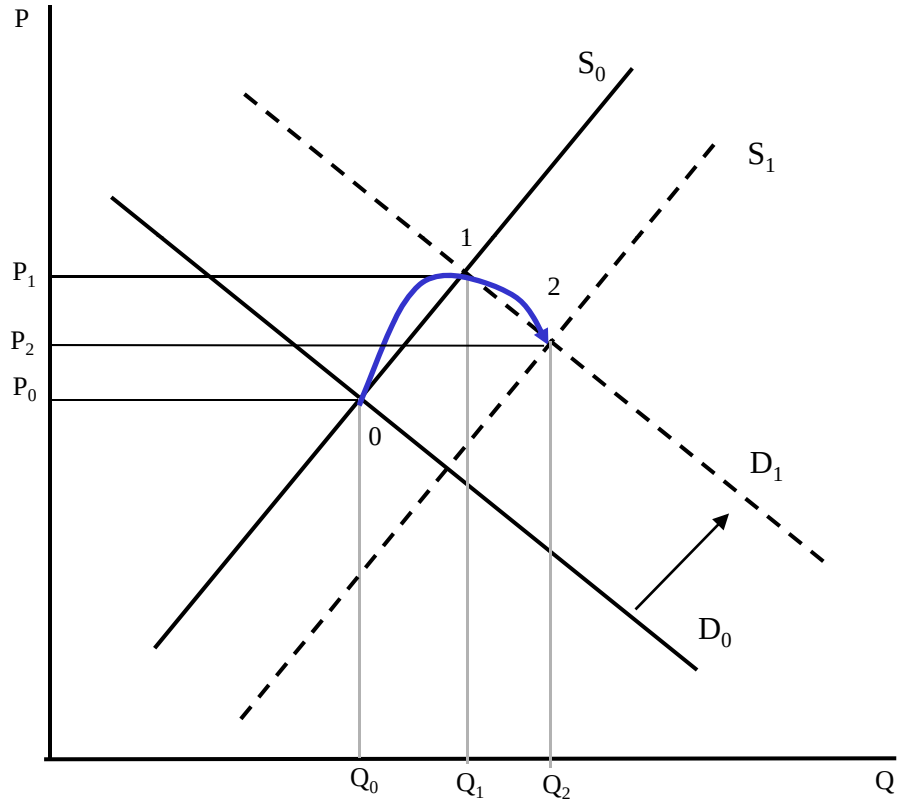
Soya beans imports -China and India-

as % of world imports



Source: Elaborated by the authors based on UN Comtrade

7) Open questions:

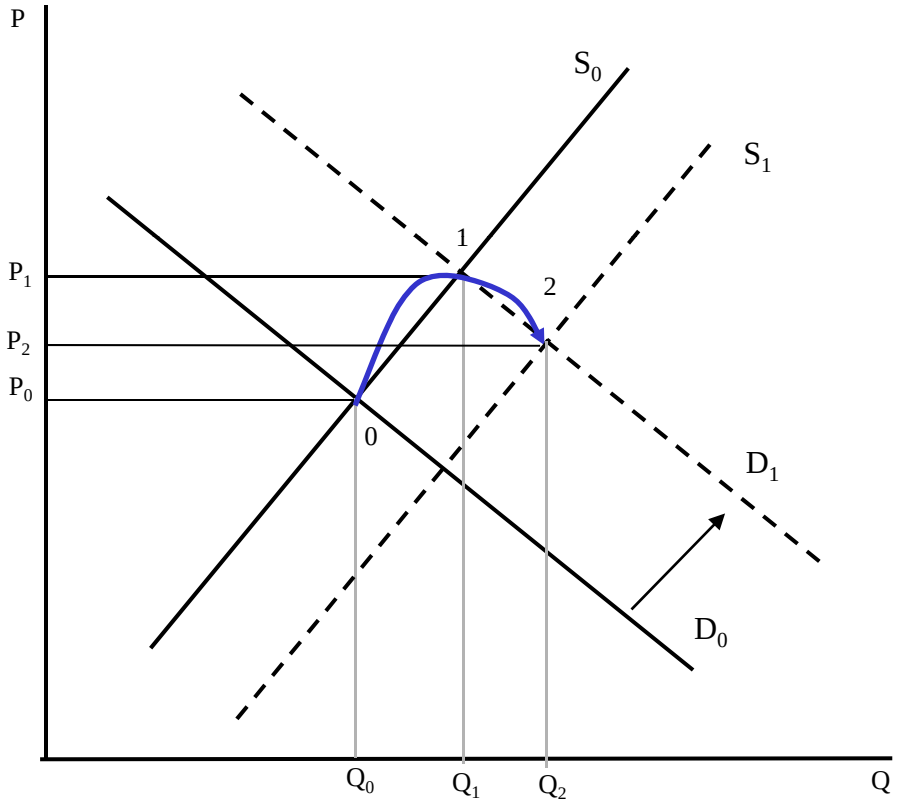


- Demands of US ethanol program alone account for over half the world´s unmet need for cereals (The Economist, Dec 6th, 2007)

- Prices will fall back if harvests increase.

- But harvests rise if new land is brought into cultivation or yields go up.

7) Open questions:



• Short run:

Response tends to be sticky: a 10% rise in prices yields a 1-2% increase in supply (IFPRI)

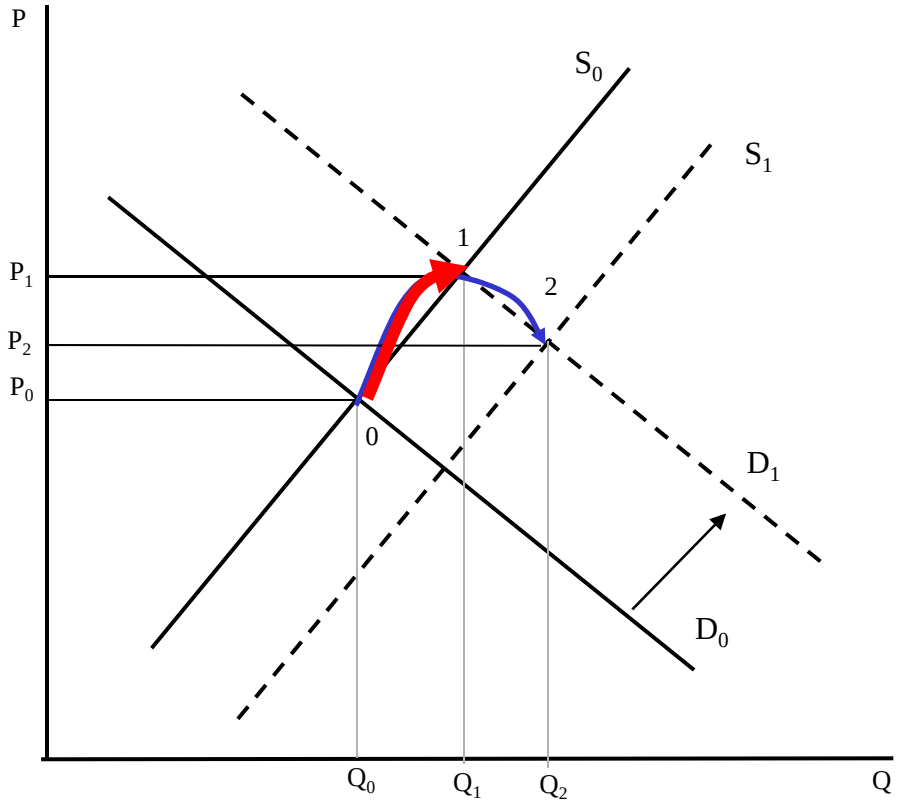
• Long run:

- New land is in remote parts of Brazil, Russia, Kazakhstan…It would require big investments in infrastructure. This could take a long time (and environmental damage?)

- GM foods could increase yields strong. Their introduction takes time too!

- High oil prices would reduce the use of oil-based fertilizers which have contributed to the sharply increase in yields.

7) Open questions:



- So, price will probably remain high until supply increases.

- In the meantime some people (and countries) suffer more than others.

- Asymmetric cost-benefits distribution because of **Consumption Basket Composition Effect:**

The higher the food share in consumption basket (relative to oil share),

the higher the transition cost.

8) Conclusions

• For us it is appealing to think financialization as an amplifier factor of commodity price cycles. In our framework speculative activity it is an **element that affects short run price dynamics, but not the long run equilibrium**.

• It is not necessary to have neither commodity derivative markets nor strong net long positions of financial participants to experience a commodity price boom or a bust.

• In the theoretical model, fundamentals continue to be the only real force that drives long run prices. However, heterogeneity in expectations among market participants is important in determining the adjustment properties to equilibrium.

• Regarding fundamentals we confirm roles for US real exchange rate, industrial production (world demand), and real interest rate. We verify a negative conditional correlation with the real return of stock markets.

8) Conclusions

• Our findings support the idea that commodity prices tend to **correct toward the equilibrium**, but this correction **takes place if past misalignment is high enough**. Thus, in the "low misalignment regime" correcting forces do not prevail and prices can move in any direction, depending on market sentiments.

• **Policy implications for emerging countries**

• For **commodity-dependent emerging countries:** Misalignment should be carefully monitored. Price reversions tend to be abrupt when misalignment surpasses 20-25%.

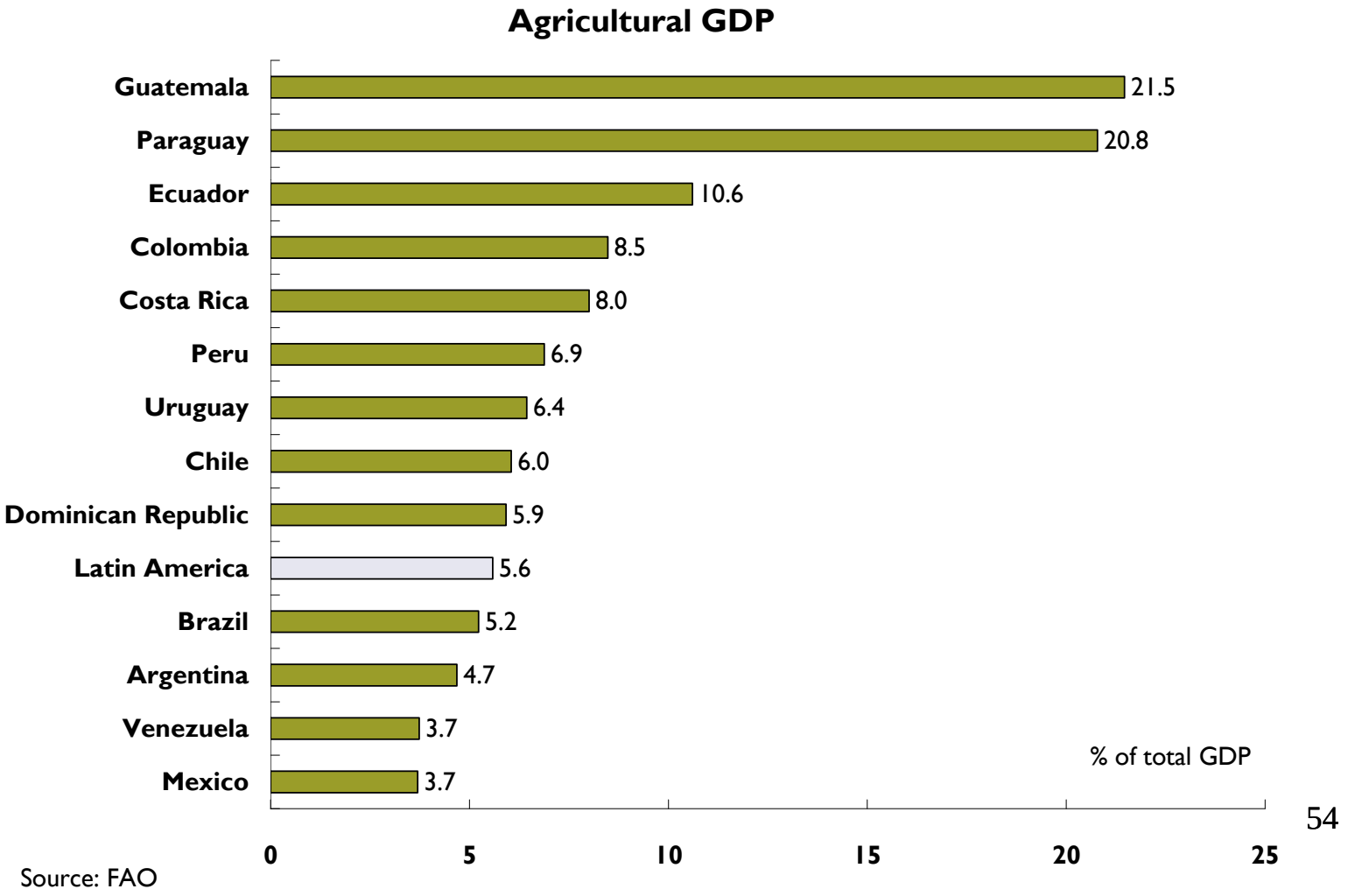
• Factors affecting commodity prices (real interest rates, real exchange rates, asset returns) are similar to those that influence capital flows. This explains why it is hard for developing countries to cushion terms of trade shocks with external finance. The same fundamentals that worsen terms of trade affect negatively the access to international credit market.

• Structural changes (Biofuels and demand pattern changes) should be taken into account when we configure future scenarios for commodity prices.

Thanks!

1) Motivation

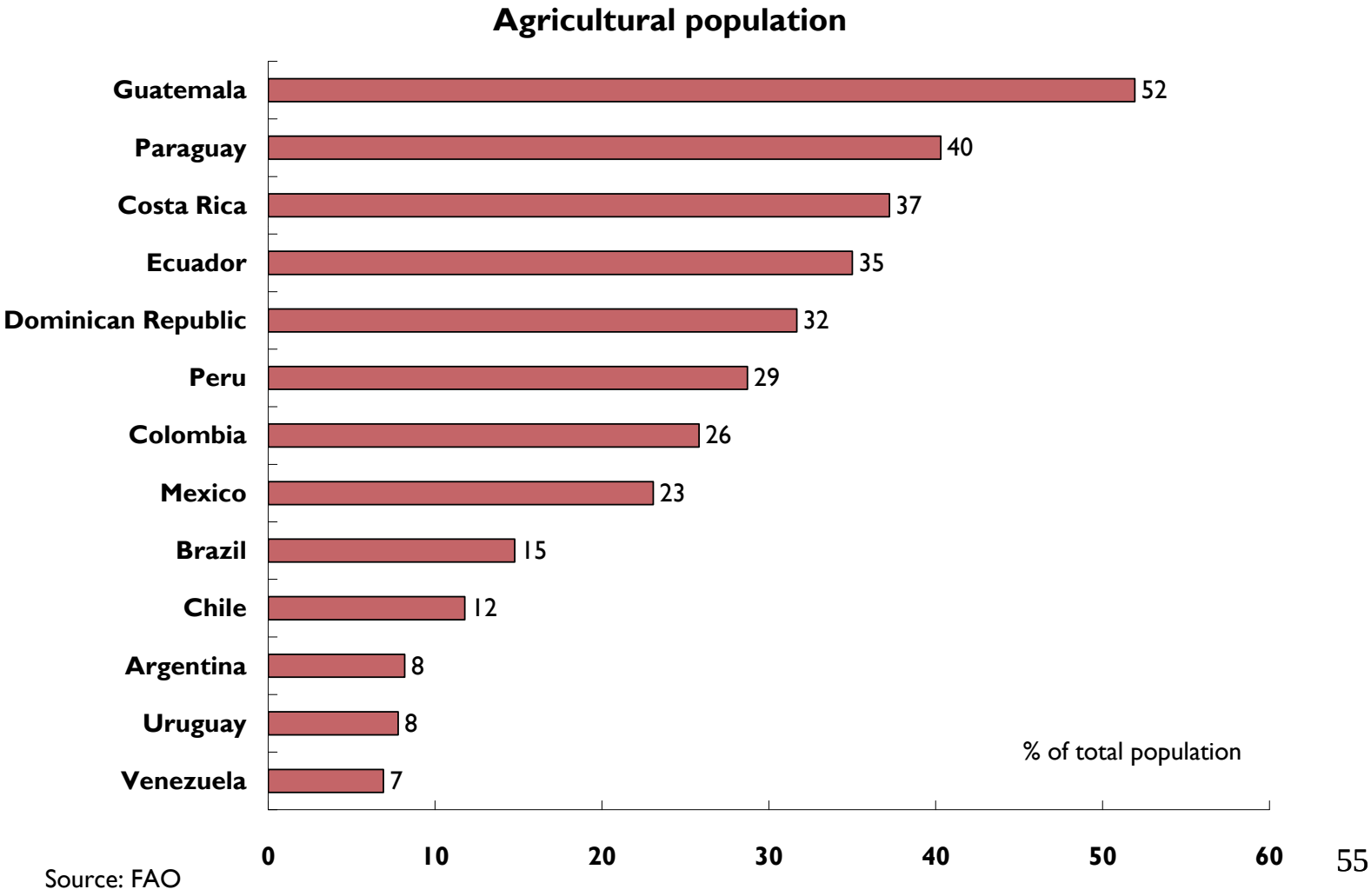
Agricultural production for some countries of Latin America has an important contribution to the GDP.



Source: FAO

1) Motivation

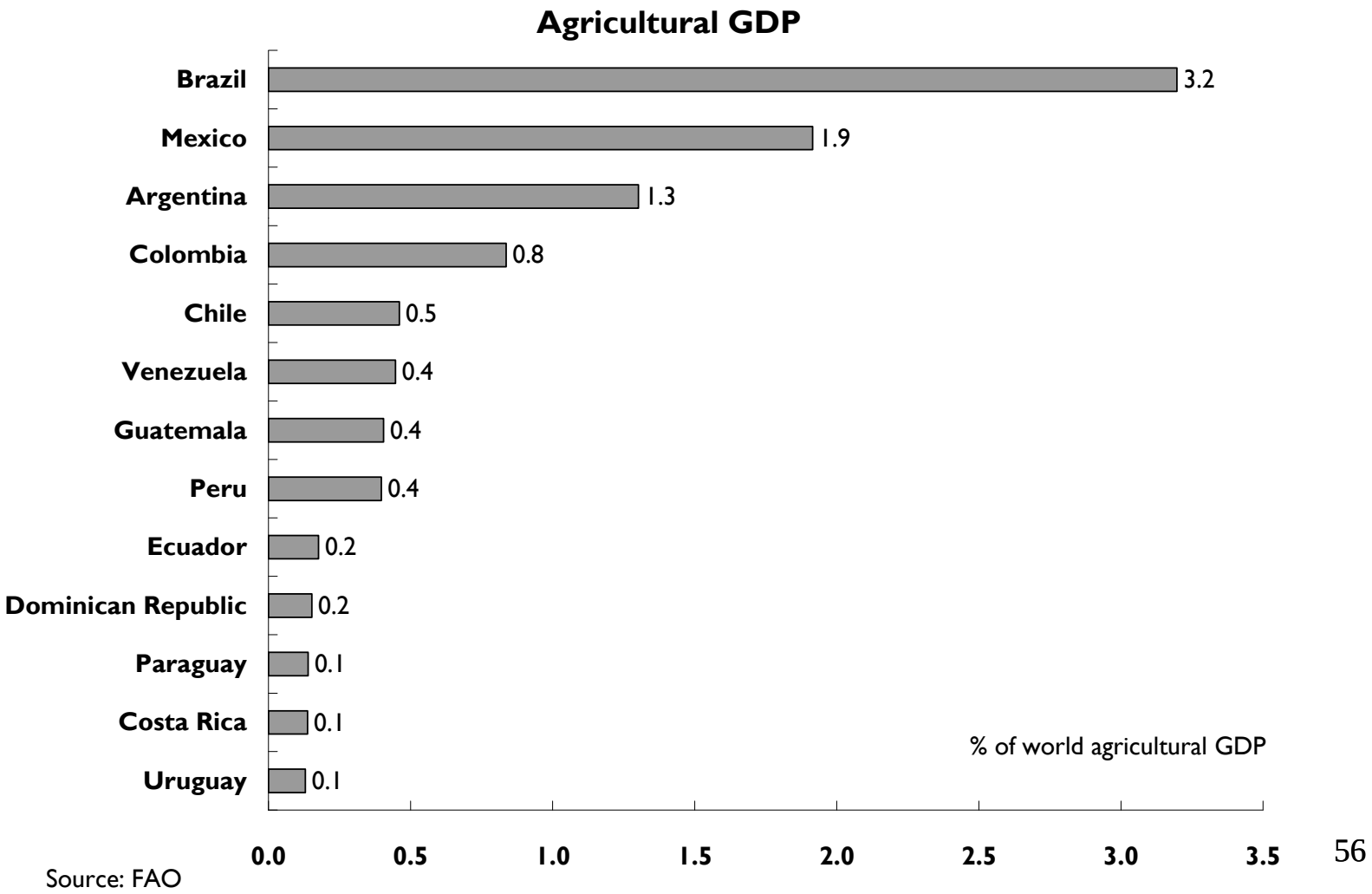
In addition, several countries have a high share of agricultural population.



Source: FAO

1) Motivation

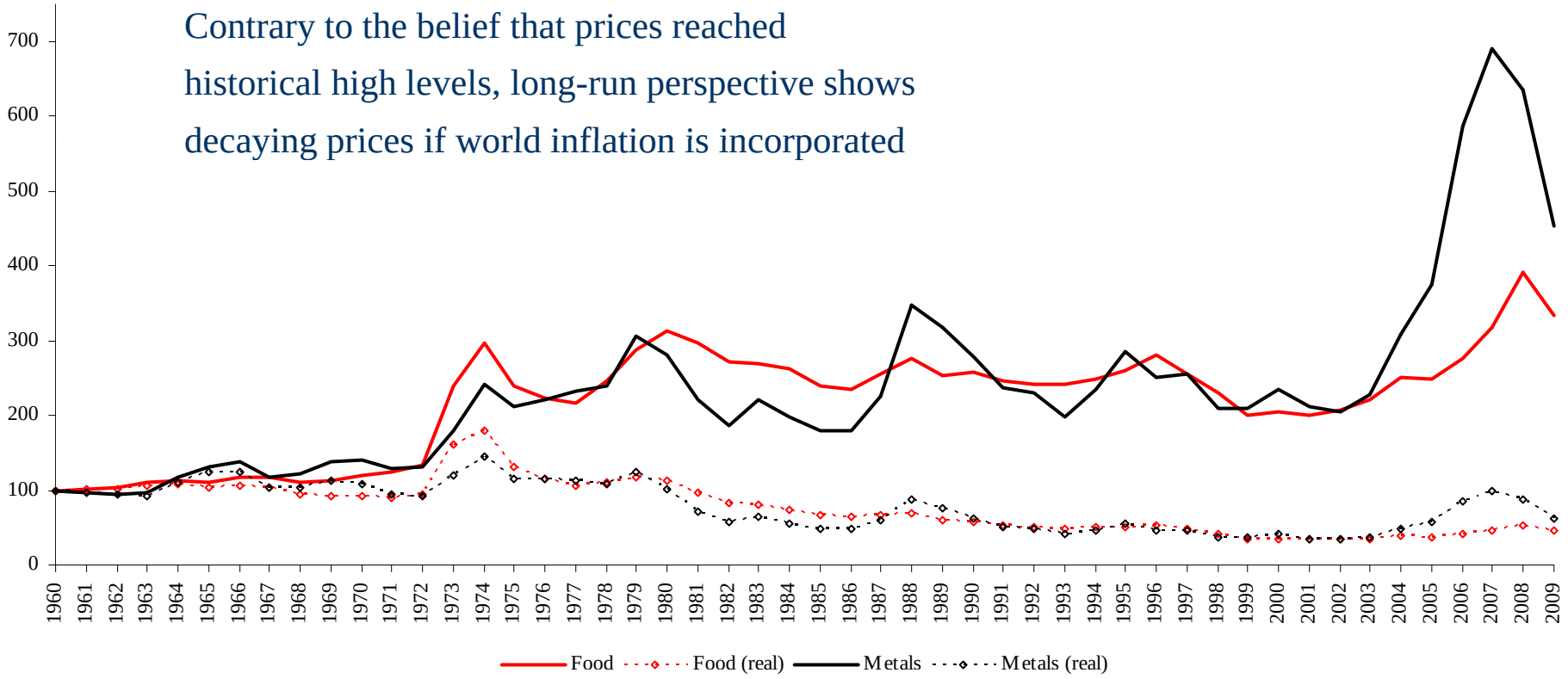
Finally, the Latin America's contribution to the world agricultural GDP is important



Source: FAO

Food and metal price IMF indexes (nominal and real, 1960=100)

Contrary to the belief that prices reached historical high levels, long-run perspective shows decaying prices if world inflation is incorporated



2) Long-run drivers of commodity prices

• Prebisch (1950) and Singer (1950) claimed that, contrary to the classical view, primary product prices would fall relatively to those of the industry. The influence of this hypothesis on empirical research has been significant.

• A different approach for studying commodity prices starts asking which **macroeconomic factors could act as determinants** of them.

• **US Real Exchange Rate:**

- Pioneering single-good model of Ridler and Yandle (1972) demonstrates that an increase a real exchange rate (appreciation) should result in a fall in dollar commodity prices.

-The implied elasticity is (Dornbusch, 1985):

$$\frac{\partial ln\left(\frac{P}{CPI}\right)}{\partial ln\left(\frac{CPI}{eCPI^*}\right)} = -\frac{\beta^*}{\left(\frac{\beta\eta}{\eta^*} + 58\beta^*\right)}$$

3) Financialization of commodities

The direction of causality…

Net financial positions and commodity prices, correlations and causality, 1986-2008

	COPPER	GOLD	SILVER	WTI	SUGAR	SOYA	MAIZE	WHEAT
T vs T-3	0.35	0.64	0.53	0.39	0.09	0.52	0.58	0.34
T vs T-2	0.37	0.59	0.50	0.39	0.07	0.51	0.56	0.37
T vs T-1	0.38	0.50	0.46	0.40	0.05	0.47	0.50	0.39
T vs T	0.39	0.42	0.44	0.41	0.02	0.40	0.42	0.37
T vs T+1	0.22	0.27	0.17	0.16	0.07	0.20	0.26	0.21
T vs T+2	0.19	0.29	0.13	0.11	0.15	0.15	0.24	0.20
T vs T+3	0.20	0.34	0.14	0.12	0.18	0.12	0.21	0.17

Granger Causality Test

Price Variantions do not Granger Cause Changes in Net Financial Positions	1.77820**	0.67559	0.86989	0.80581	0.30402	0.98956	1.57599*	0.82225
Changes in Net Financial Positions do not Granger Cause Price Variantions	0.76235	2.785***	1.05728	1.29875	0.80934	2.09115**	1.21476	1.56979*

5) Econometric results

- **Linearity F-test (Teräsvirta, 1994)**

1) Estimate the model under the assumption of linearity and compute the RSS_0 of the commodity price equation.

2) Estimate the auxiliary regression and calculate the RSS_1:

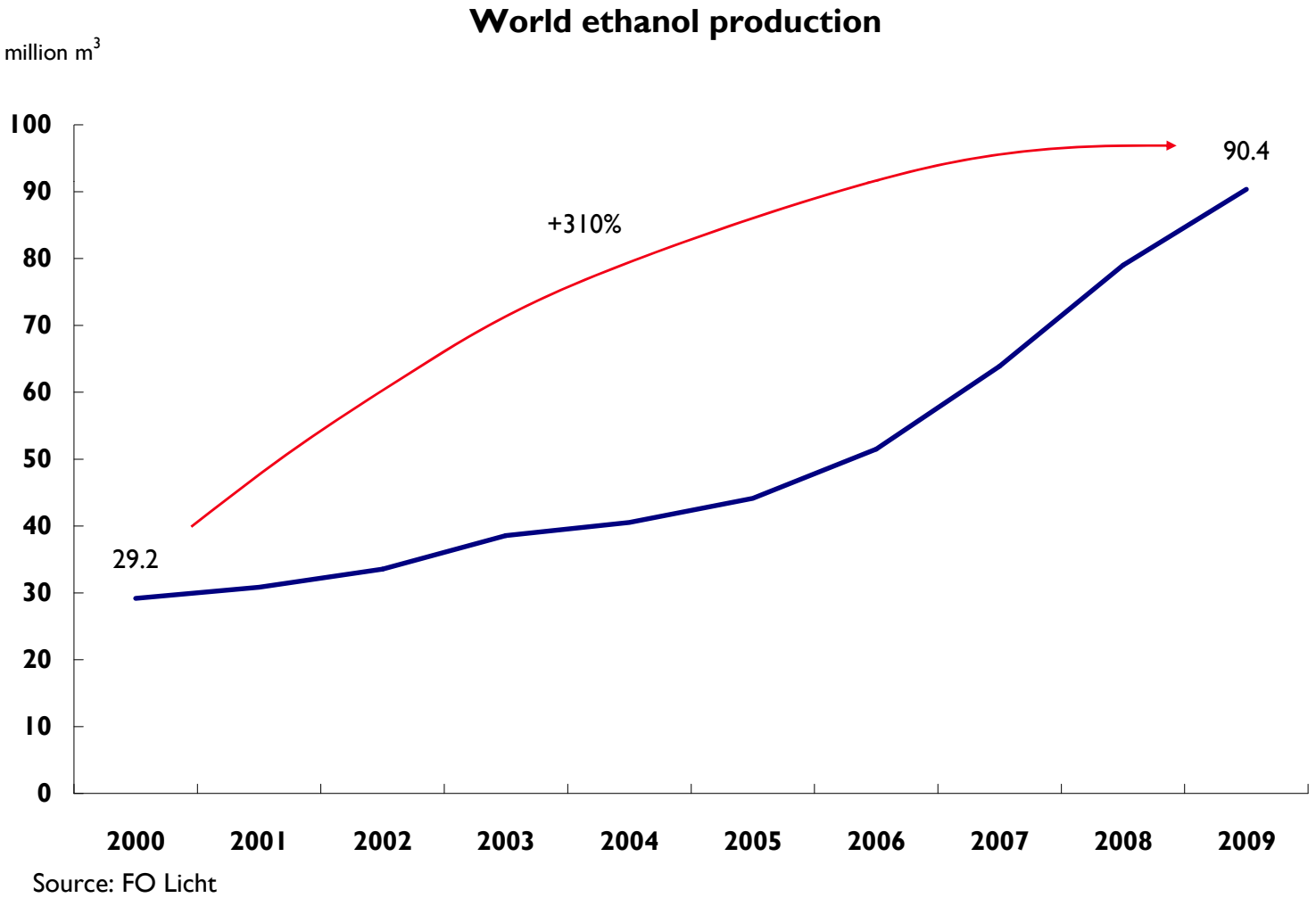
$$\Delta P_t = \beta'_{0,p}\Delta X_{t-p} + \nu_1 M_{t-1} + \beta'_{1,p}\Delta X_{t-p}TV_{t-d} + \nu_2 M_{t-1}TV_{t-d} + \beta'_{2,p}\Delta X_{t-p}TV_{t-d}^2 + \nu_3 M_{t-1}TV_{t-d}^2 + \omega_t$$

3) Compute the critical value of the F test

$$F = \frac{\left(RSS_0 - RSS_1\right)/l_1}{RSS_0/l_2}$$

7) Open questions: Biofuels

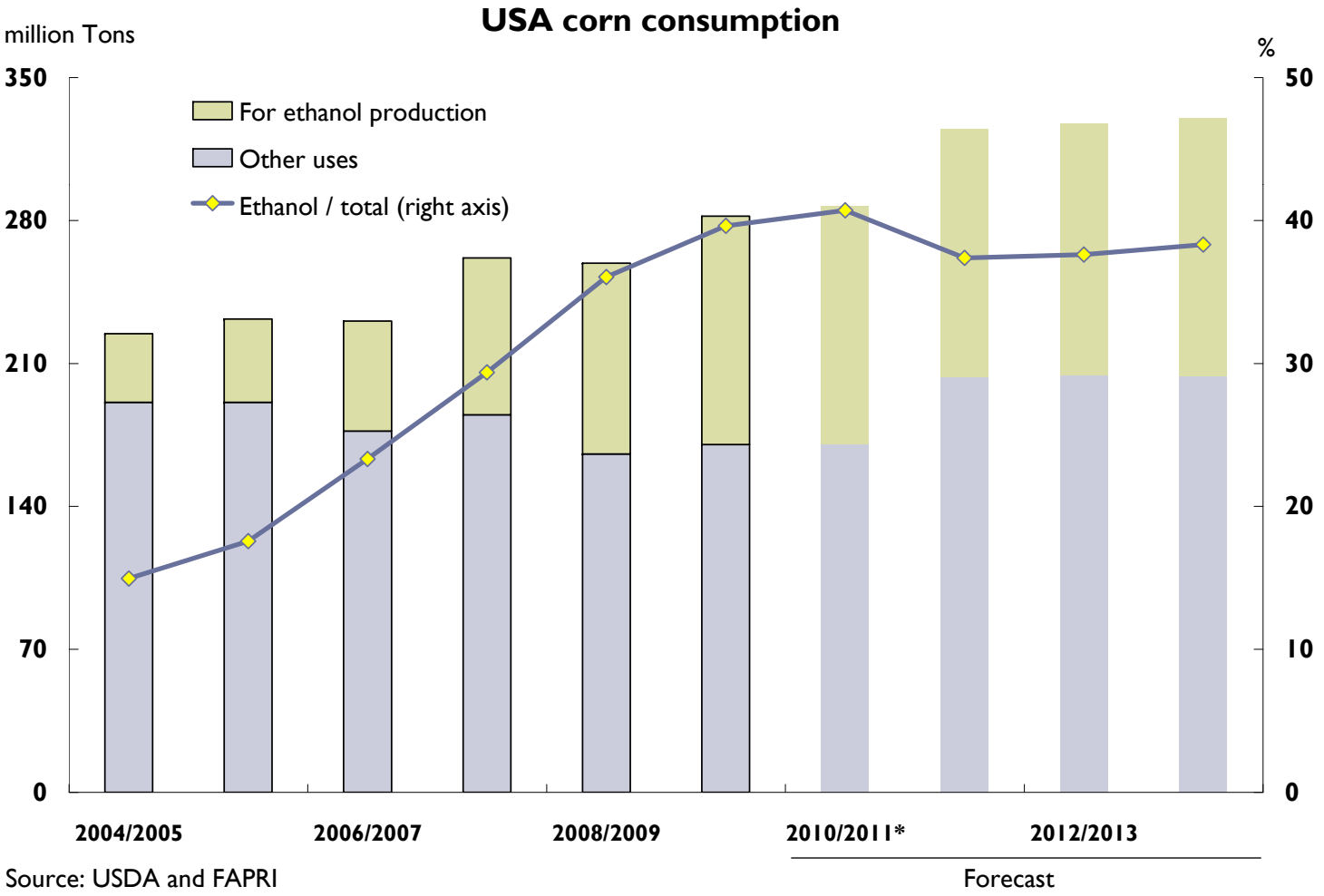
• The main liquid biofuel by volume is ethanol, which has quadrupled its production in the last decade.



Source: FO Licht

7) Open questions: Biofuels

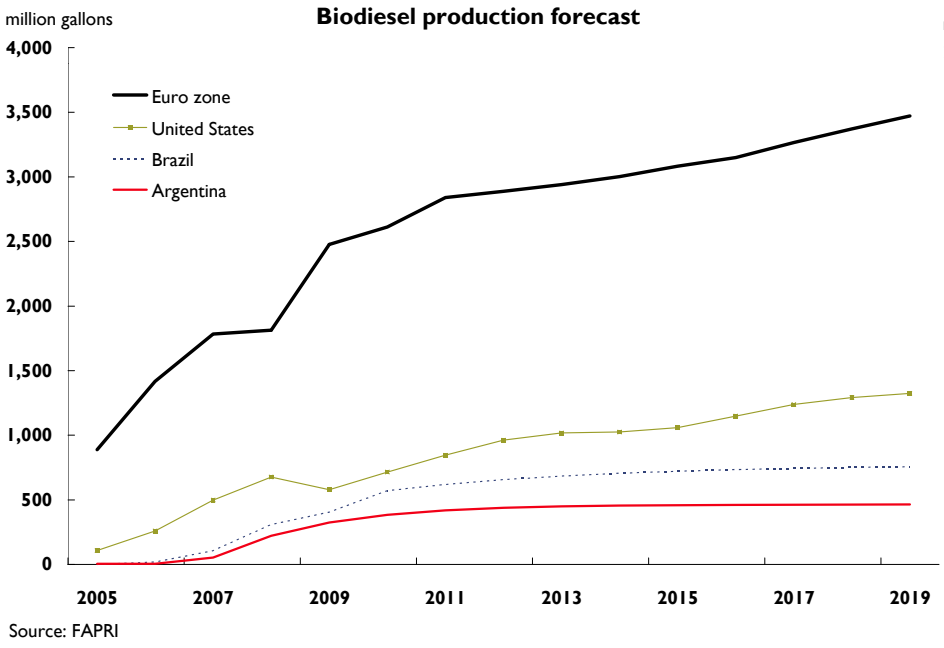
• Corn consumption for ethanol production accounts for almost 40% of corn demand in the USA.



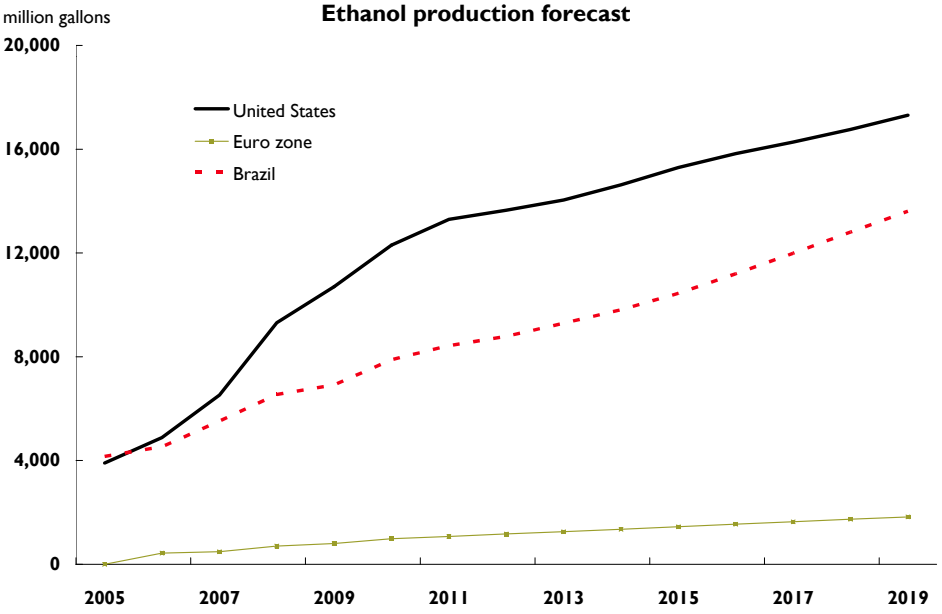
Source: USDA and FAPRI

7) Open questions: Biofuels

- Future targets and investment plans suggest strong gorwth will continue in the near future.



Source: FAPRI



Source: FAPRI

7) Open questions: Biofuels

• Several reports agree that biofuel production played a large role in the record increase in food commodity prices from 2005 to mid-2008.

Alternative estimates of the impact of biofuel production on market prices

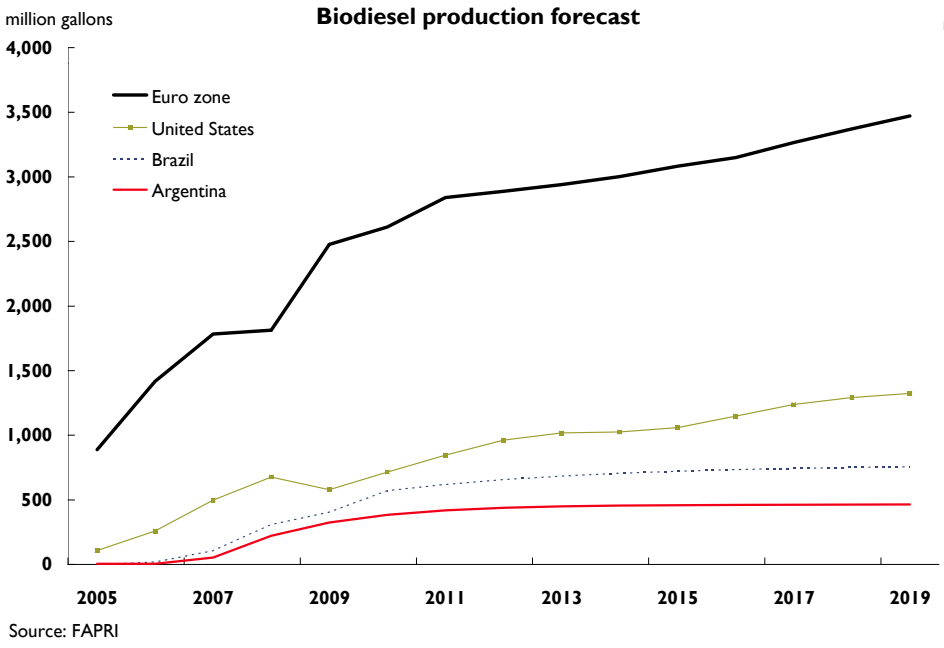
Source	Estimate	Commodity	Time period
World Bank (April 2008)	75%	global food index	January 2002–February 2008
IFPRI (May 2008)	39% 21-22%	corn rice & wheat	2000–2007 2000–2007
CEA (May 2008)	35% 3%	corn global food index	March 2007–March 2008 March 2007–March 2008
Collins (June 2008)	25-60% 19-26%	corn US retail food	2006–2008 2006–2008
Glauber (June 2008)	23-31% 10% 4-5%	commodities global food index US retail food	April 2007–April 2008 April 2007–April 2008 January–April 2008
OECD-FAO (May 2008)	42% 34% 24%	coarse grains vegetable oils wheat	2008–2017 2008–2017 2008–2017

Source: FAO Secretariat

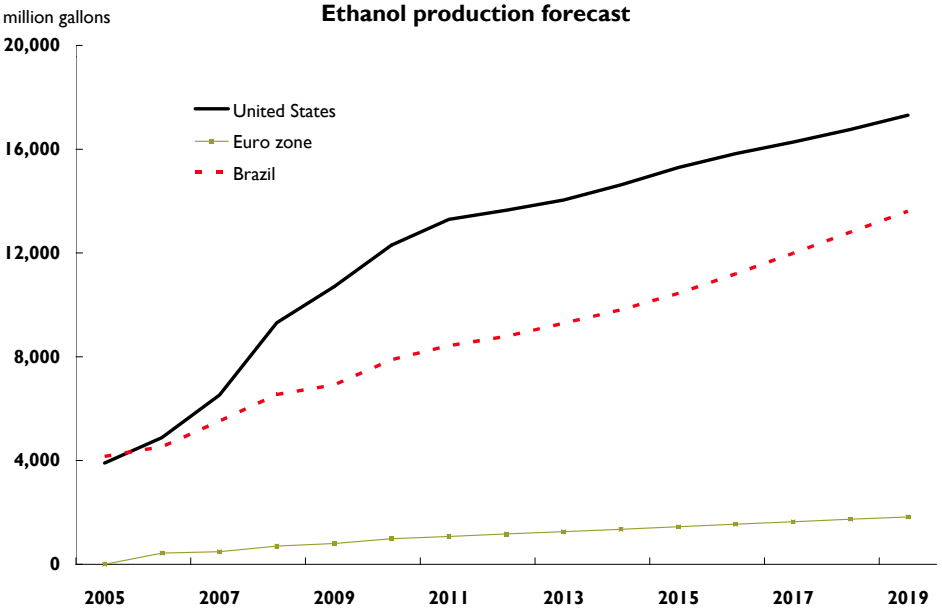
BANCO CENTRAL
DE LA REPÚBLICA ARGENTINA

7) Open questions: Biofuels

• Future targets and investment plans suggest strong gorwth will continue in the near future.



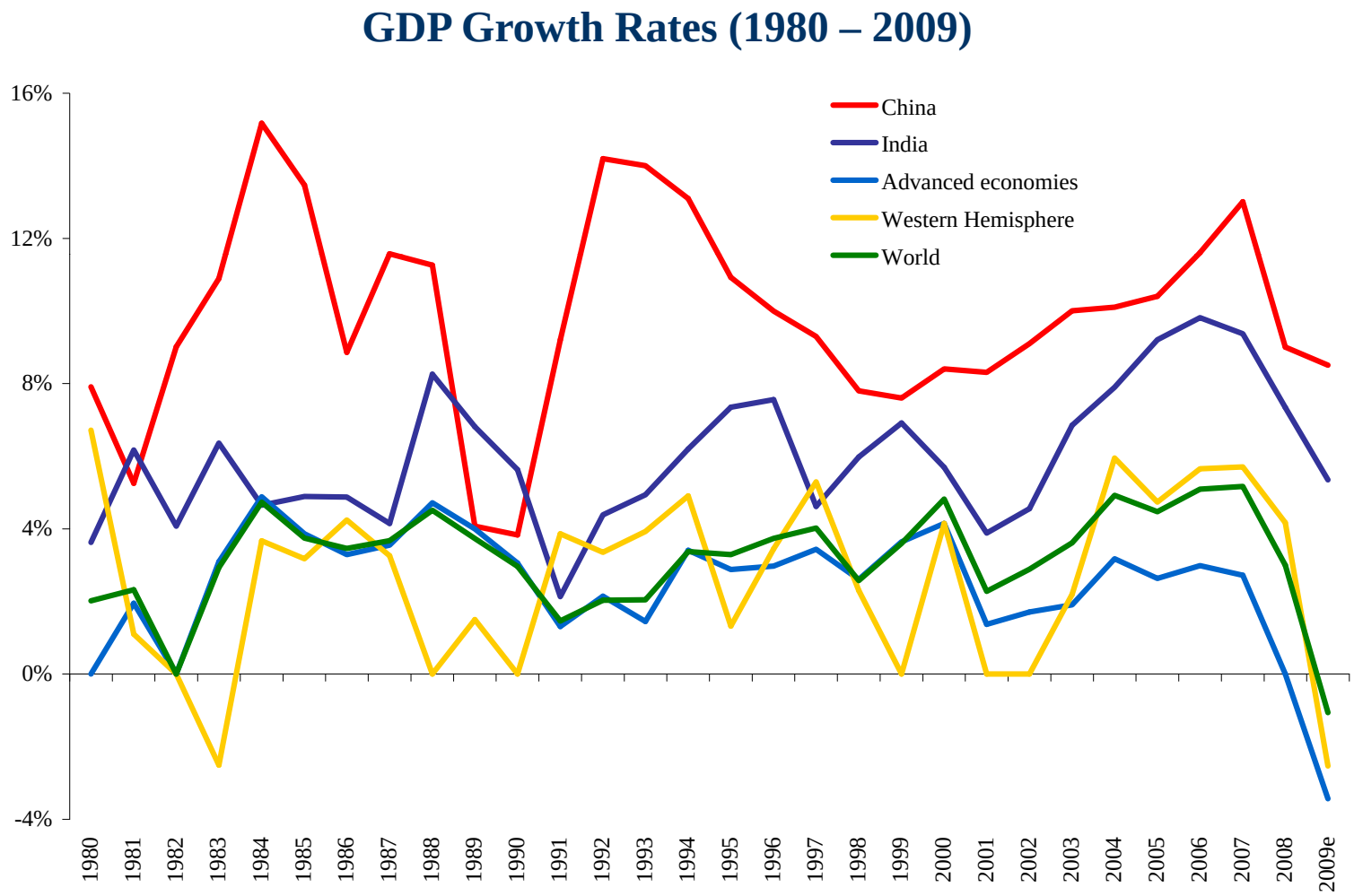
Source: FAPRI



Source: FAPRI

7) Open questions: Changes in demand patterns

- China and India have been experimented very high growth rates.



7) Open questions: Changes in demand patterns

• However, China and India are going thorough this process at a higher speed than other countries in the past. This has a big impact on commodity demand.

Diet composition of China and India (1990 – 2005)

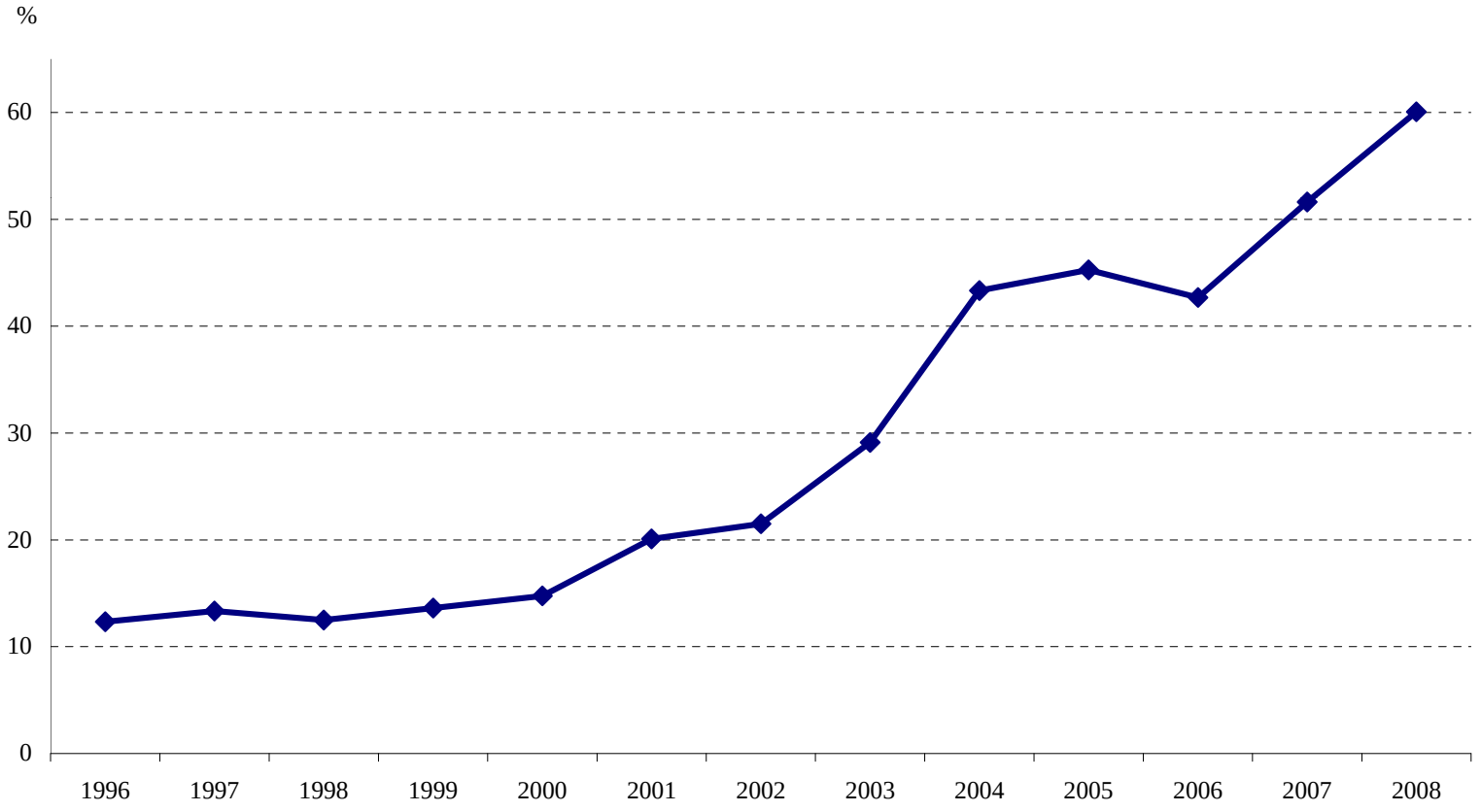
	China			*India*		
Producto	**1990-92**	**1995-97**	**2003-05**	**1990-92**	**1995-97**	**2003-05**
Alcoholic Beverages	**3,0**	**3,8**	**4,0**	**0,3**	**0,4**	**0,4**
Cereals	**42,7**	**32,8**	**21,2**	**42,6**	**40,2**	**36,6**
Eggs	**1,5**	**2,3**	**2,6**	**0,3**	**0,4**	**0,4**
Fish and seafood	**2,5**	**3,7**	**3,4**	**1,1**	**1,1**	**1,2**
Fruits	**3,9**	**5,9**	**7,2**	**7,4**	**8,5**	**7,9**
Meat	**5,9**	**6,8**	**7,6**	**1,2**	**1,2**	**1,3**
Milk	**1,3**	**1,3**	**2,7**	**13,9**	**14,8**	**15,5**
Oilcrops	**1,1**	**1,2**	**0,9**	**1,9**	**1,9**	**1,7**
Pulses	**0,4**	**0,2**	**0,1**	**3,4**	**3,2**	**2,8**
Starchy Roots	**12,1**	**10,5**	**9,8**	**5,2**	**5,5**	**5,2**
Sugar and Sweeteners	**1,7**	**1,4**	**1,0**	**5,9**	**5,7**	**5,8**
Vegetable Oils	**1,2**	**1,2**	**1,4**	**1,7**	**1,9**	**2,4**
Vegetables	**21,5**	**27,2**	**35,9**	**13,8**	**13,7**	**17,2**
Others	**1,3**	**1,6**	**2,2**	**1,4**	**1,5**	**1,7**
Total	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**

Source: Elaborated by the authors based on FAO data.

7) Open questions: Changes in demand patterns

Iron ore imports -China and India-

as % of world imports

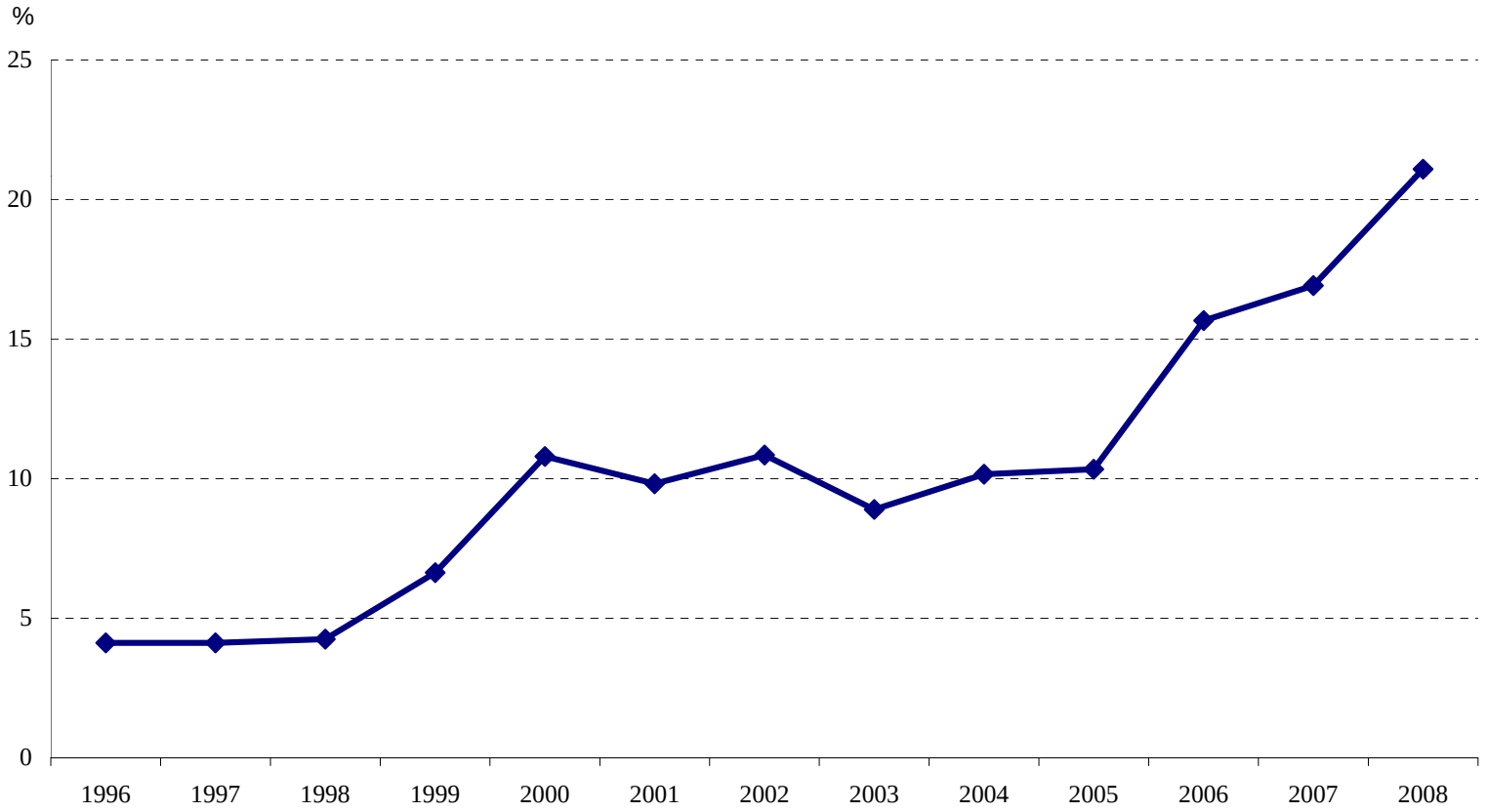


Source: Elaborated by the authors based on UN Comtrade

7) Open questions: Changes in demand patterns

Crude Oil Imports -China and India-

as % of world imports



Source: Elaborated by the authors based on UN Comtrade