VOLATILITY IN FOOD COMMODITIES AND CO-MOVEMENTS WITH CRUDE OIL PRICES

SEMINAR: Fondazione Eni Enrico Mattei

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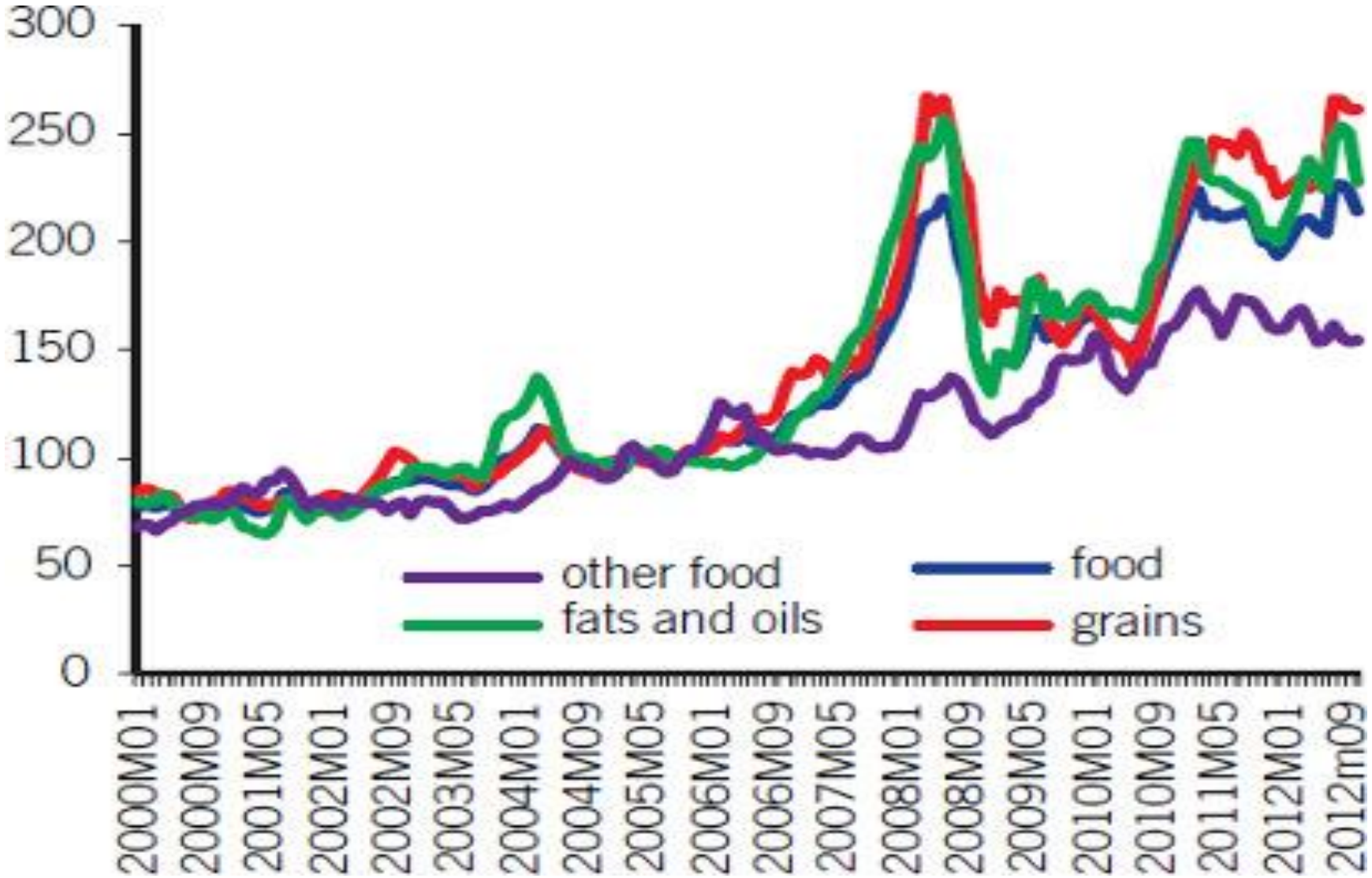
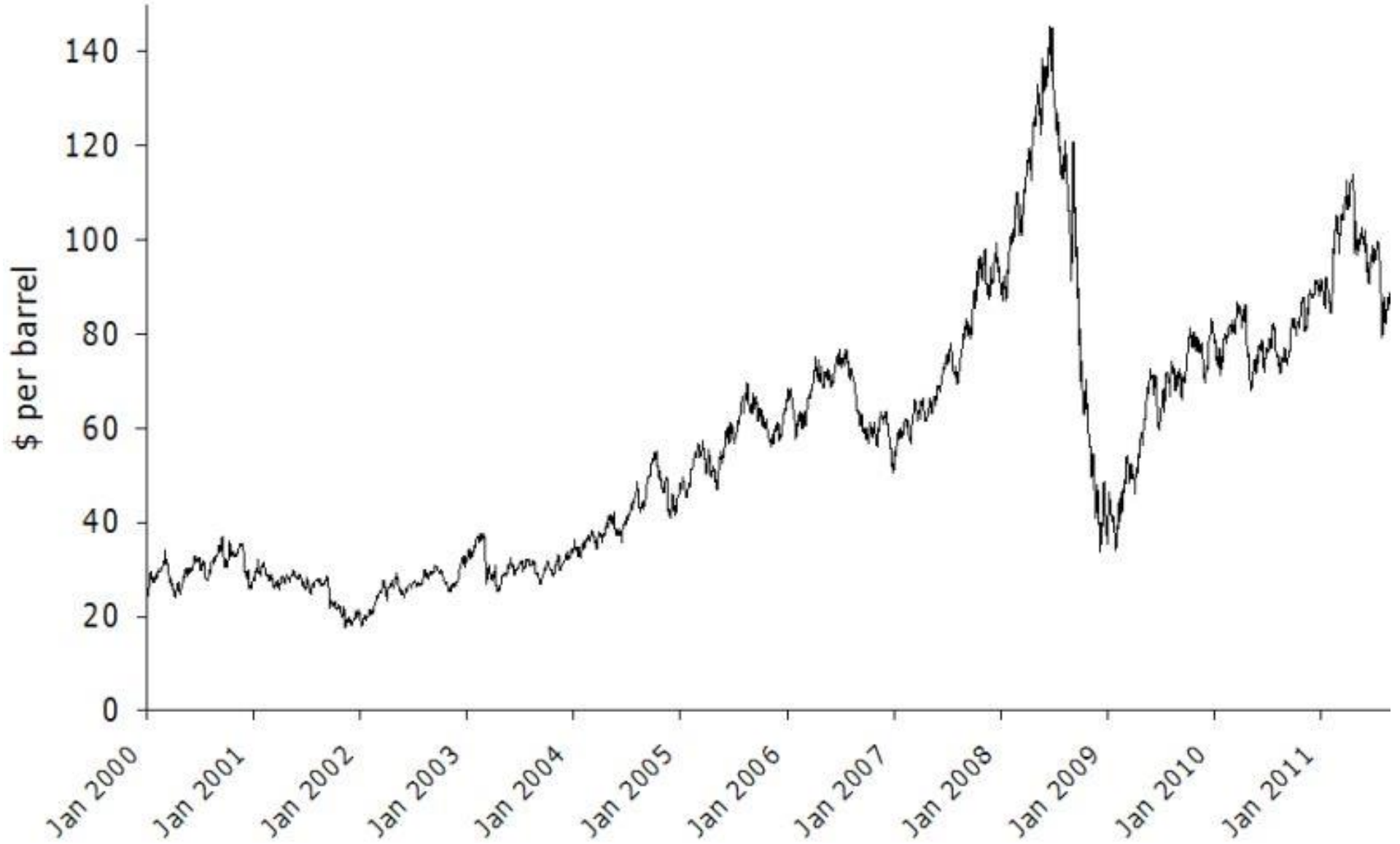
Food Commodity Prices – 2001-12



Source: FAO (2012)

WTI Crude Oil Prices since 2000



Introduction

- Multiple causes have been identified as drivers of the recent high food prices.

- Higher crude oil prices may affect agricultural markets in two main ways:
  - Through increased costs of inputs such as fertilizers, pesticides, heating and energy use.
  - By stimulating biofuel demand since the use of food commodities as biofuel feed-stocks becomes more attractive

- Increased co-movements between crude oil and agricultural commodity prices have been observed over the recent decade implying shock transmissions from crude oil to the grains markets.

Why is this relevant?

- High and volatile food commodity prices have resulted in:
  - Greater uncertainty in markets and may have serious implications for the poor globally.
  - Increased living costs throughout the world and, in poor food-importing developing countries, have threatened food security and increased vulnerability.
  - May have contributed to political unrest, for example in North Africa
  - Planning problems for governments and policy makers and is disruptive in the food supply chain.

This presentation

- Presents previous work and results
  - Empirically test whether increased correlation between crude oil and commodities is due to:
    - Increased biofuel production
    - Financialization in agricultural futures markets

- Presents new results on volatility decomposition
  - Decompose the volatility of grains.
    - Verify whether increased volatility in the grains was due to the transmission of shocks from crude oil.

- This research does not examine the direct impact of biofuels but for evidence of its effects on volatility
  - I look at this in other work

Linkages between commodity and crude oil markets

- *Increased prevalence of demand shocks:* demand-side shocks tend to be common across commodities whereas supply-side shocks are often commodity-specific.

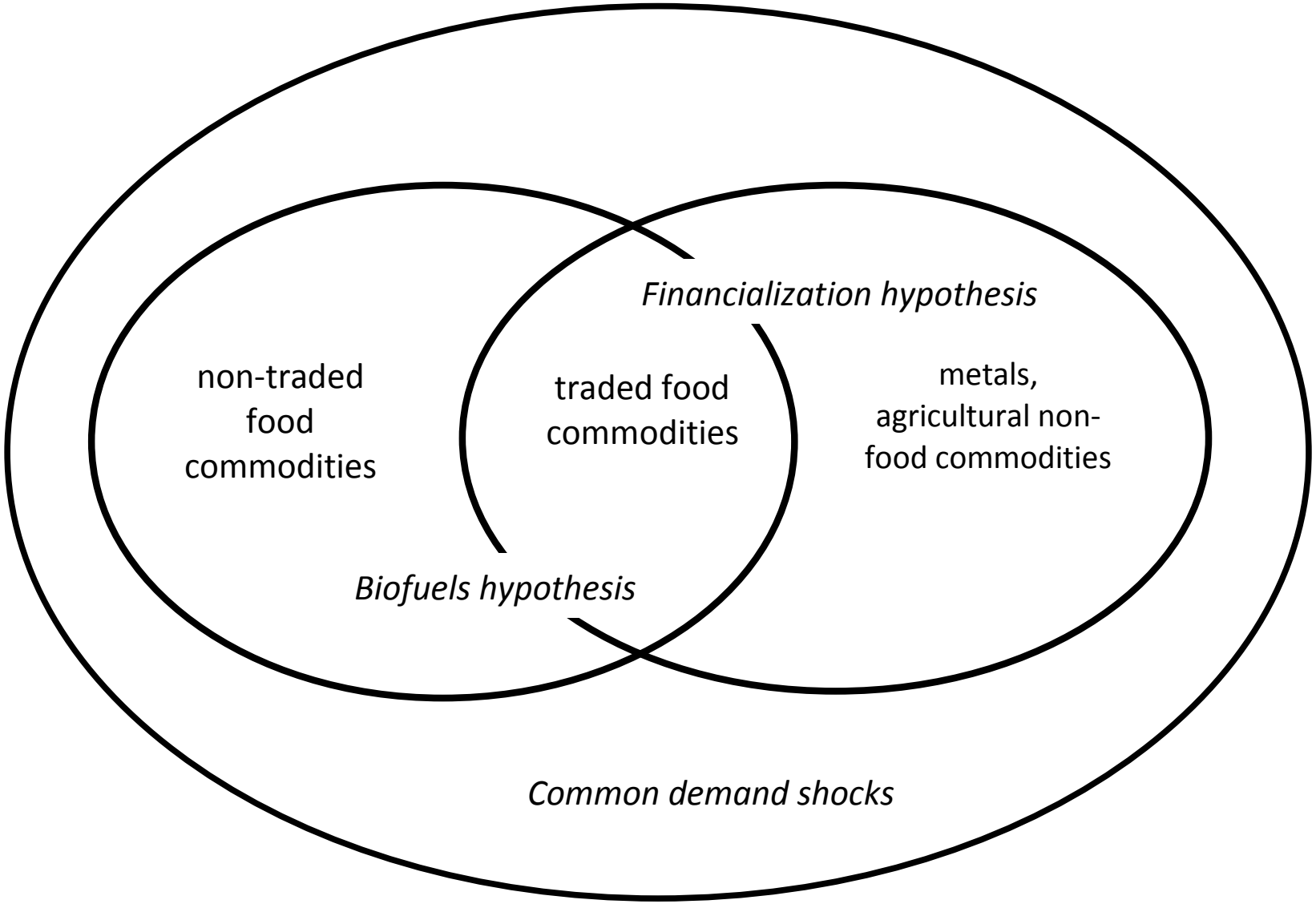
- *Financialization:* Food commodities are considered as part of the "commodity asset class" and are thus affected by financial market factors such as aggregate risk appetite for financial assets, and investment behaviour of diversified commodity index investors.
  - Investors in commodity futures aim to track indices (S&P GSCI, DJ-UBS) and therefore invest or disinvest across the entire "commodity asset class" increasing co-movement.

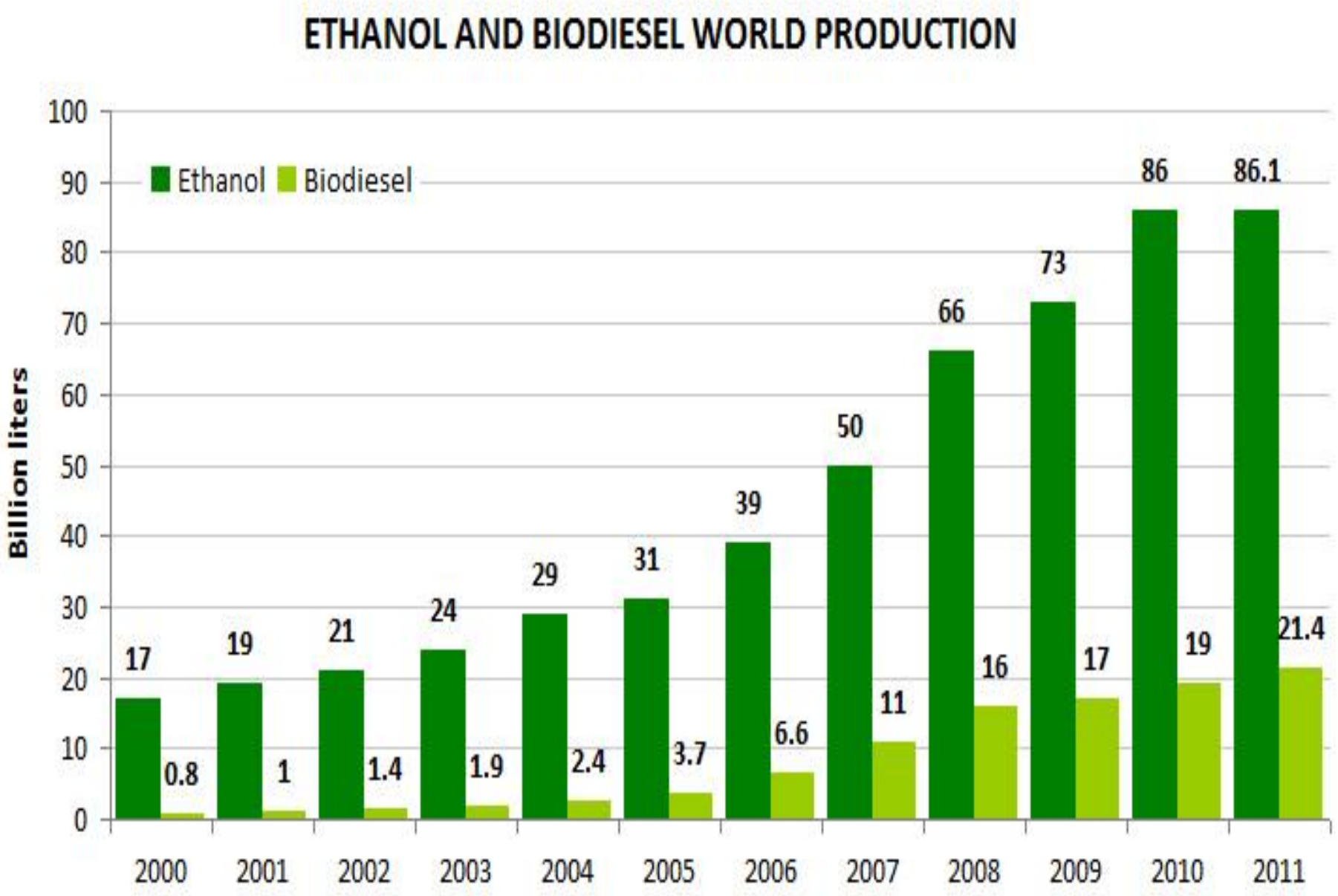
Linkages between commodity and crude oil markets

- *Biofuels hypothesis:* increased correlation between energy and agricultural markets due to biofuels boom peaking in mid-2008

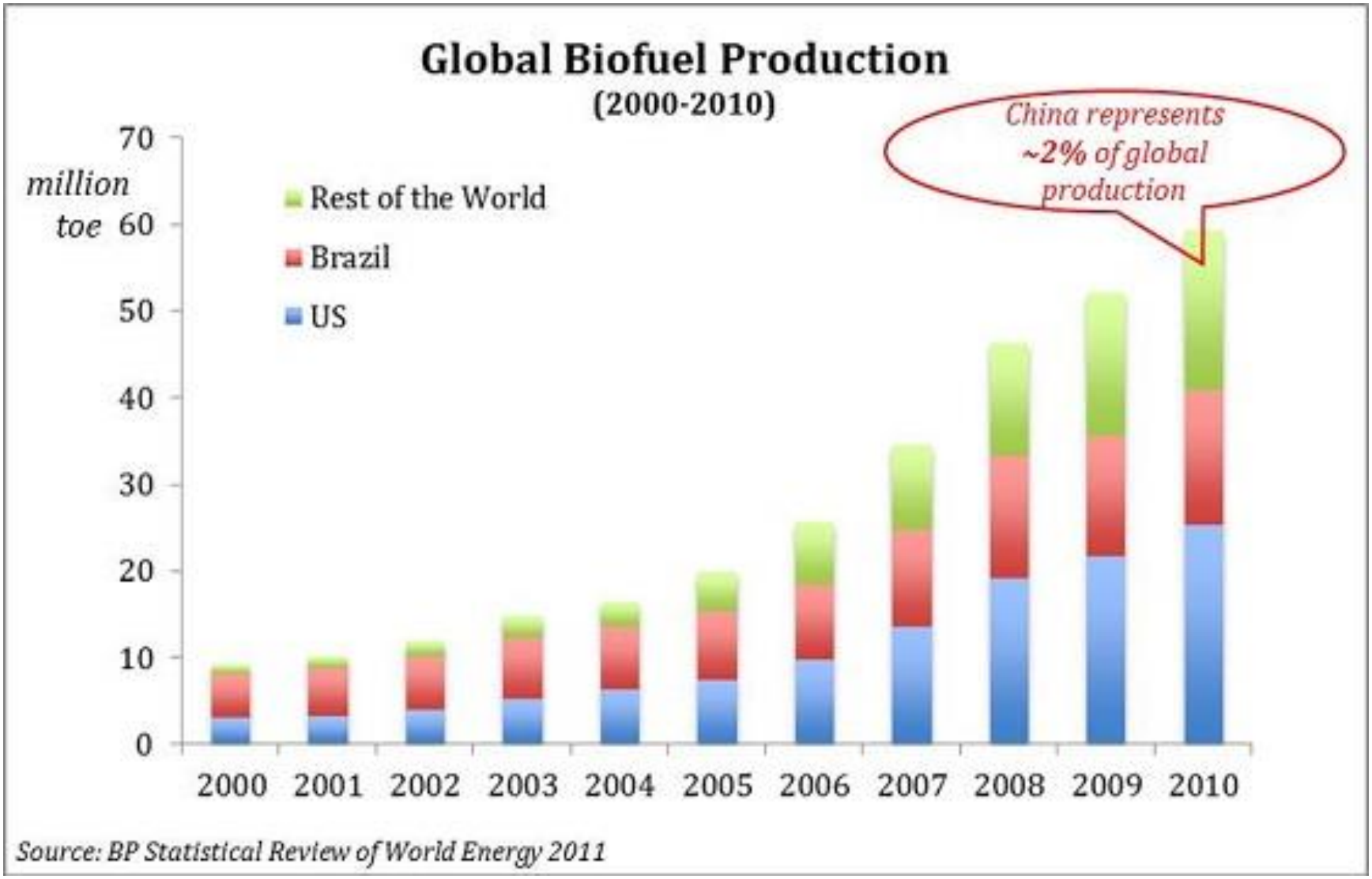
  - These correlations will be higher when crude oil prices are high since this is would increase the demand for biofuel feed-stocks.
  - This relationship may be affected by the presence or absence of policies as the mandates, tax credits and the blend wall. These policies affect demand and supply reactions of markets.
  - The relationship may also be affected by capcity constraints in production and consumption of biofuels.

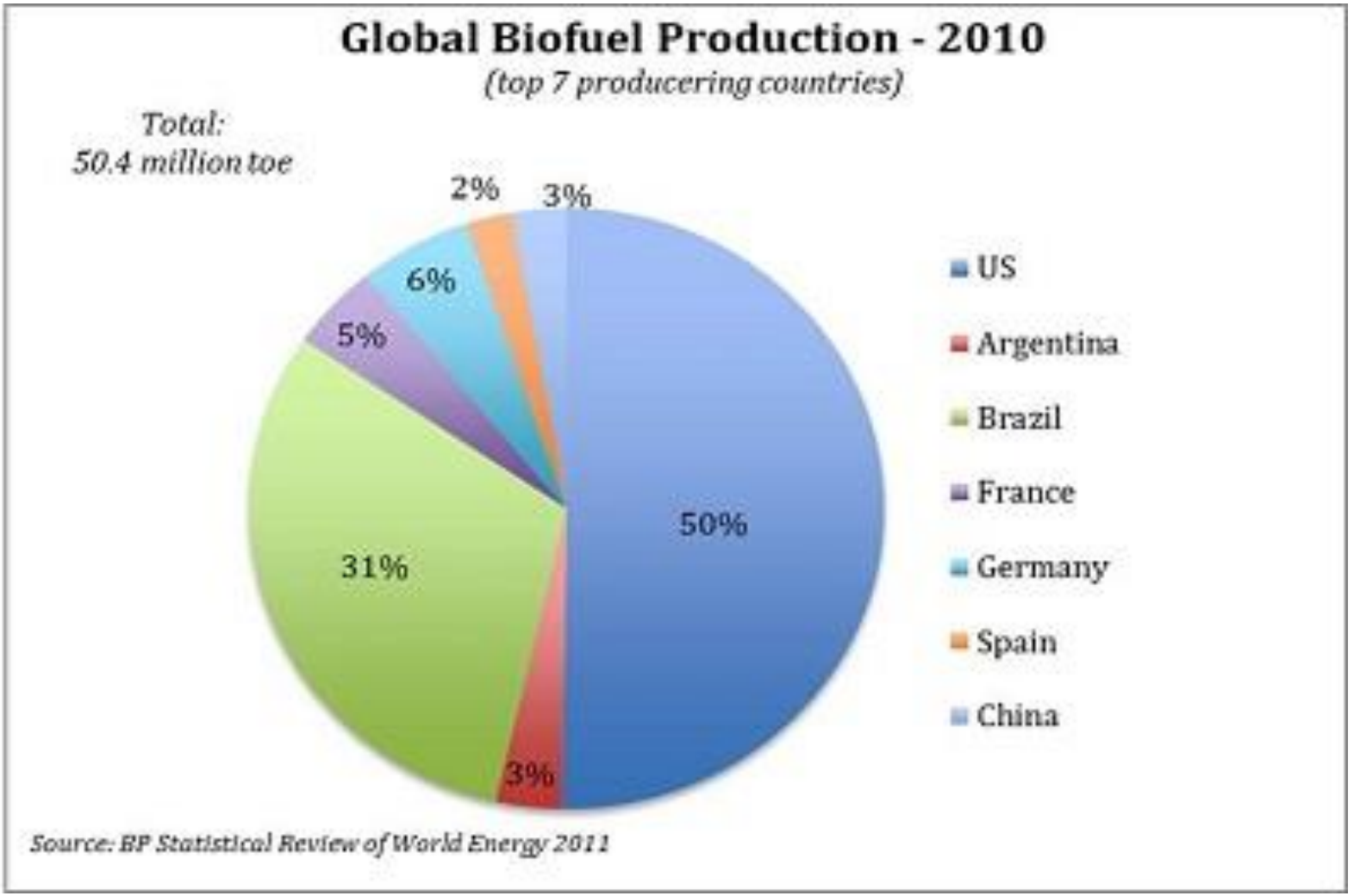
Linkages between commodity and crude oil markets





Source: Renewables 2012, Global Status Report


Global Biofuel Production
(2000-2010)
China represents ~2% of global production
million toe
70
60
50
40
30
20
10
0
Rest of the World
Brazil
US
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Source: BP Statistical Review of World Energy 2011



Source: Renewables 2012, Global Status Report

Effects of biofuels

- Three main effects:
  - Raise food price levels due to diversion of supplies from food and feed consumption. This can be directly or indirectly
  - May raise volatility in food prices as energy market shocks may be transmitted into food commodity markets
  - Increased demand may result in lower stock levels thereby further increasing volatility.

Debate on biofuels

- Food versus fuel debate:
  - Increased biofuel production has increased the demand for feedstocks. This demand is mainly satisfied by grains and vegetable oils and this in turn may have increased the prices of these food commodities.

- Drivers of biofuels:
  - Policy interventions versus market factors: some believe that the boom was mainly driven by the market and in particular by the increase in crude oil prices. Others sustain that the boom was mainly driven by government policies, such as mandates, tax credits and the blending wall in the US aimed at increasing energy self-sufficiency and, in Europe, at reducing emissions.

Data and Methodology

- ***Data*** front contracts for daily futures prices of corn, wheat, soybeans, rice, copper, crude oil (WTI)

- ***Data Sources:*** International Financial Statistics, Chicago Board of Trade (CBOT) for the grains and ICE-Brent and Nymex - WTI for crude oil.

- ***Co-movements:*** M-GARCH models were estimated on daily logarithmic prices over the twelve year sample 2000-2011.

GARCH Models

- GARCH process allows a more flexible and parsimonious representation of the variance (scedastic) process.
- Specifies an autoregressive Moving Average (ARMA) process for the scedastic process followed by a time series, providing an estimate of the conditional variance of the process at each date in the sample.
- The standard GARCH(1,1) specification includes a single lagged squared error (the ARCH term) and a single lag on the lagged conditional variance (the GARCH term).

$$r_t | r_{t-1}, r_{t-2}, \ldots \sim N(\mu, h_t)$$

$$h_t = \omega + \alpha(r_{t-1} - \mu)^2 + \beta h_{t-1}$$

where $\omega > 0 \; and \; \alpha, \beta \geq 0$

MGARCH Models

- The general MGARCH (1,1) model for an *m*-dimensional vector *r* of returns is

$$r_t \mid r_t, r_t, \ldots \sim N(\mu, H_t)$$

$$h_{jit} = \omega_{ji} + \sum_{k=1}^{m}\sum_{l=1}^{k} \alpha_{jik}\left(r_{k,t-1} - \mu_k\right)\left(r_{l,t-1} - \mu_l\right) + \sum_{k=1}^{m}\sum_{l=1}^{k} \beta_{jkl}\, h_{kl,t-1}$$

$$h_{ijt} = h_{jit} \qquad (j = 1, \ldots, m; i = 1, \ldots, j)$$

$$(j = 1, \ldots, m; i = 1, \ldots, j-1)$$

- This representation can be problematic:
  - High parameterization
  - Positive definiteness of conditional variance matrix.

CCC and DCC-MGARCH

- Two simplified versions of the MGARCH model :
  - *CCC (Constant Conditional Correlation)* MGARCH imposes a constant conditional correlation structure.
  - *DCC (Dynamic Conditional Correlation)* MGARCH model allows time - varying correlations but imposes a common structure on the variance process.

- *Trade-off*: the CCC imposes a constant correlation structure but leaves the variance dynamics unrestricted across the different returns while DCC allows a time-varying correlation structure but at the expense of imposing homogeneity of the variance dynamics.

Modified DCC- MGARCH

- The standard DCC model treats the *k* prices symmetrically. The variance-covariance matrix is given by:

$$h_{jj,t} = (1-\alpha-\beta)\bar{h}_{jj} + \beta h_{jj,t-1} + \alpha\left(r_{jt} - \mu_{jt}\right)^2 \qquad (j = 1,\ldots,k)$$

$$h_{ji,t} = h_{ij,t} = (1-\alpha-\beta)\bar{h}_{ji} + \beta h_{ji,t-1} + \alpha\left(r_{jt} - \mu_{jt}\right)\left(r_{it} - \mu_{it}\right) \quad (j = 1,\ldots,k; i = 1,\ldots,j-1)$$

- Modified DCC (MDCC) model which allows shocks in the crude oil market to be transmitted to the remaining *k*-1 markets

$$h_{11,t} = (1-\alpha-\beta)\bar{h}_{11} + \beta h_{11,t-1} + \alpha\left(r_{1t} - \mu_{1t}\right)^2$$

$$h_{ji,t} = h_{ij,t} = (1-\alpha-\beta)\bar{h}_{ji} + \beta h_{ji,t-1} + \alpha\left(r_{jt} - \mu_{1t}\right)\left(r_{it} - \mu_{2t}\right) \quad (j = 1,\ldots,k; i = 1,\ldots,j-1)$$

$$h_{jj,t} = (1-\alpha-\beta)\bar{h}_{jj} + \beta h_{jj,t-1} + \alpha\left[\lambda_{jt}^2\left(r_{1t} - \mu_{1t}\right)^2 + \left(r_{jt} - \mu_{jt}\right)^2\right] \quad (j = 2,\ldots,k)$$

$$\lambda_{jt} = \frac{h_{j1,t}}{h_{11,t}}$$

Previous work and results

- Estimated the univariate models, CCC, DCC MGARCH and the Modified DCC - MGARCH models on daily data from 2000 to 2011.
- Tested for the robustness of each of the models and compared the Log-likelihood estimates and the Akaike Information Criteria (AIC)
- Biofuels hypothesis: models for crude oil, corn, wheat and soybeans
- Financialization hypothesis: models for crude oil, corn, rice and copper
- Both biofuels and financialization explain increased correlation between crude oil and agricultural commodity prices.

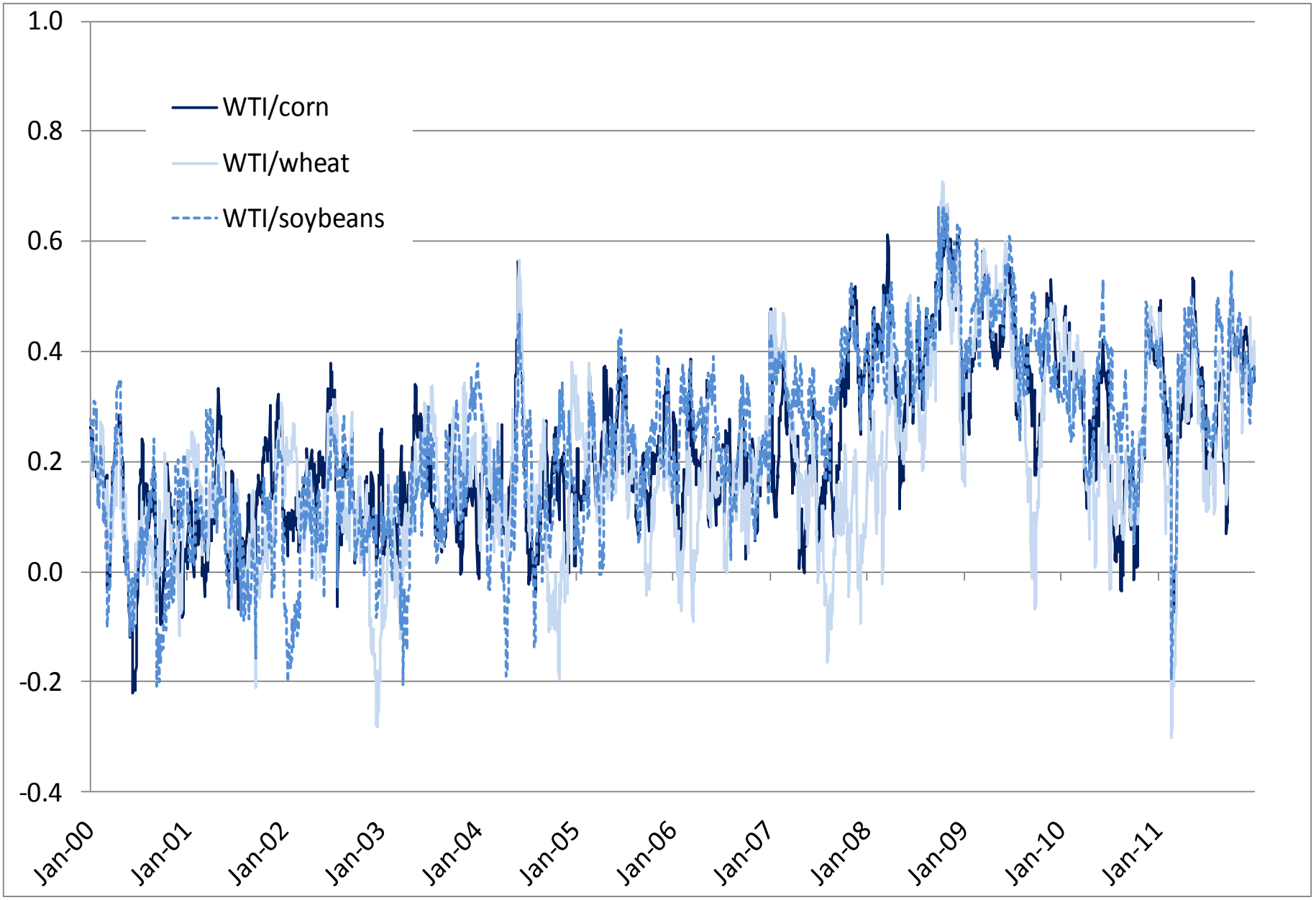
Results (1)

Multivariate CCC MGARCH estimates				
	WTI	Corn	Wheat	Soybeans
ARCH α	0.0530	0.0528	0.0466	0.0447
	(0.0282)	(0.0182)	(0.0186)	(0.0151)
GARCH β	0.9242	0.9298	0.9400	0.9407
	(0.0396)	(0.0224)	(0.0235)	(0.0197)
Correlations		0.2206	0.1798	0.2331
		(0.0171)	(0.0173)	(0.0170)
			0.6256	0.6232
			(0.0111)	(0.0112)
				0.4834
				(0.0140)
Log-likelihood	32729.17			
Test of univariate null	$X^2(6) = 3208.68$ [<0.0001]			
AIC	-65450.34			

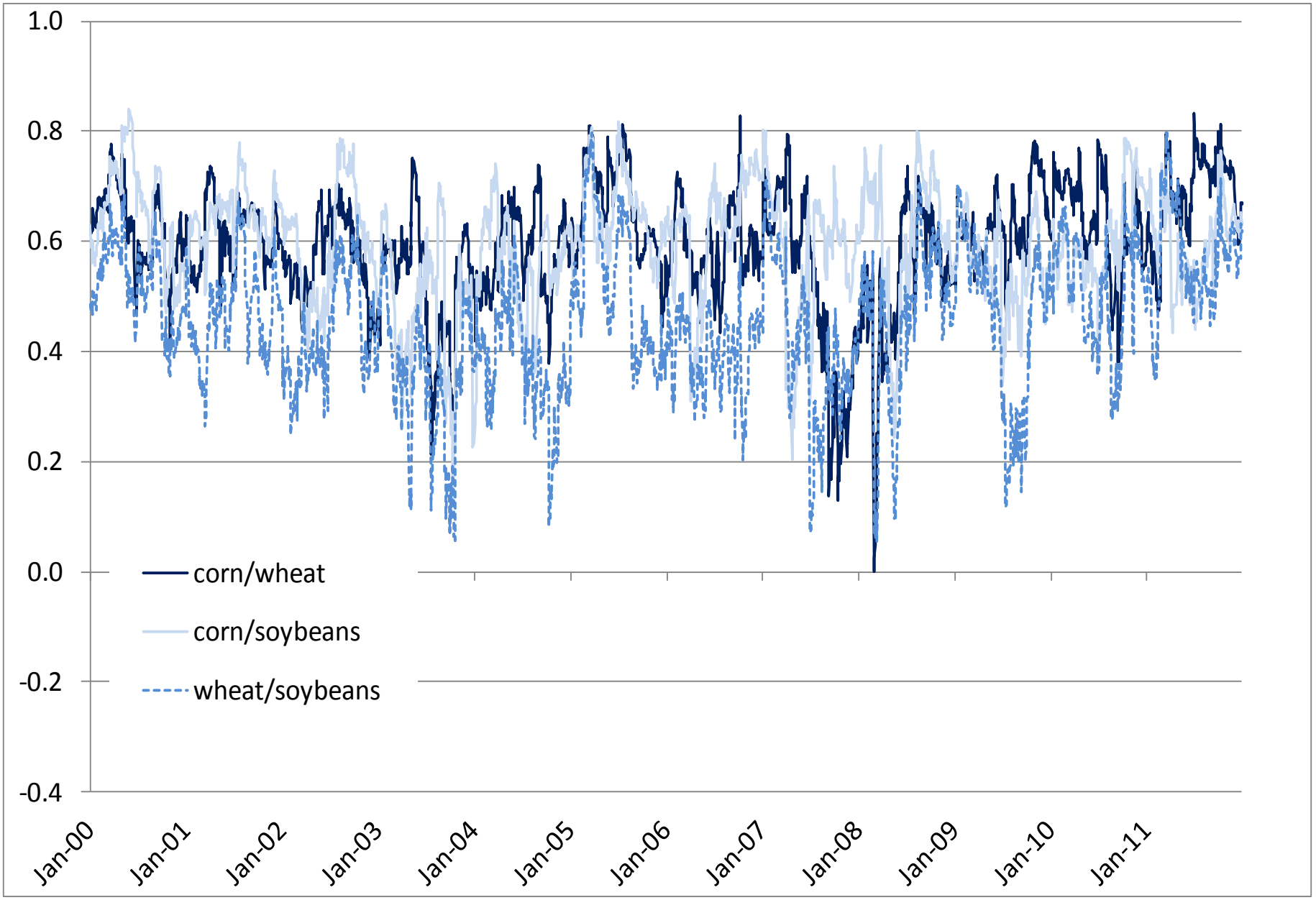
Sample: Daily, 5 January 2000 to 30 December 2011 (3001 observations)

Standard errors in round parentheses (robust for coefficients); tail probabilities in square parentheses.

Crude oil-grains correlations



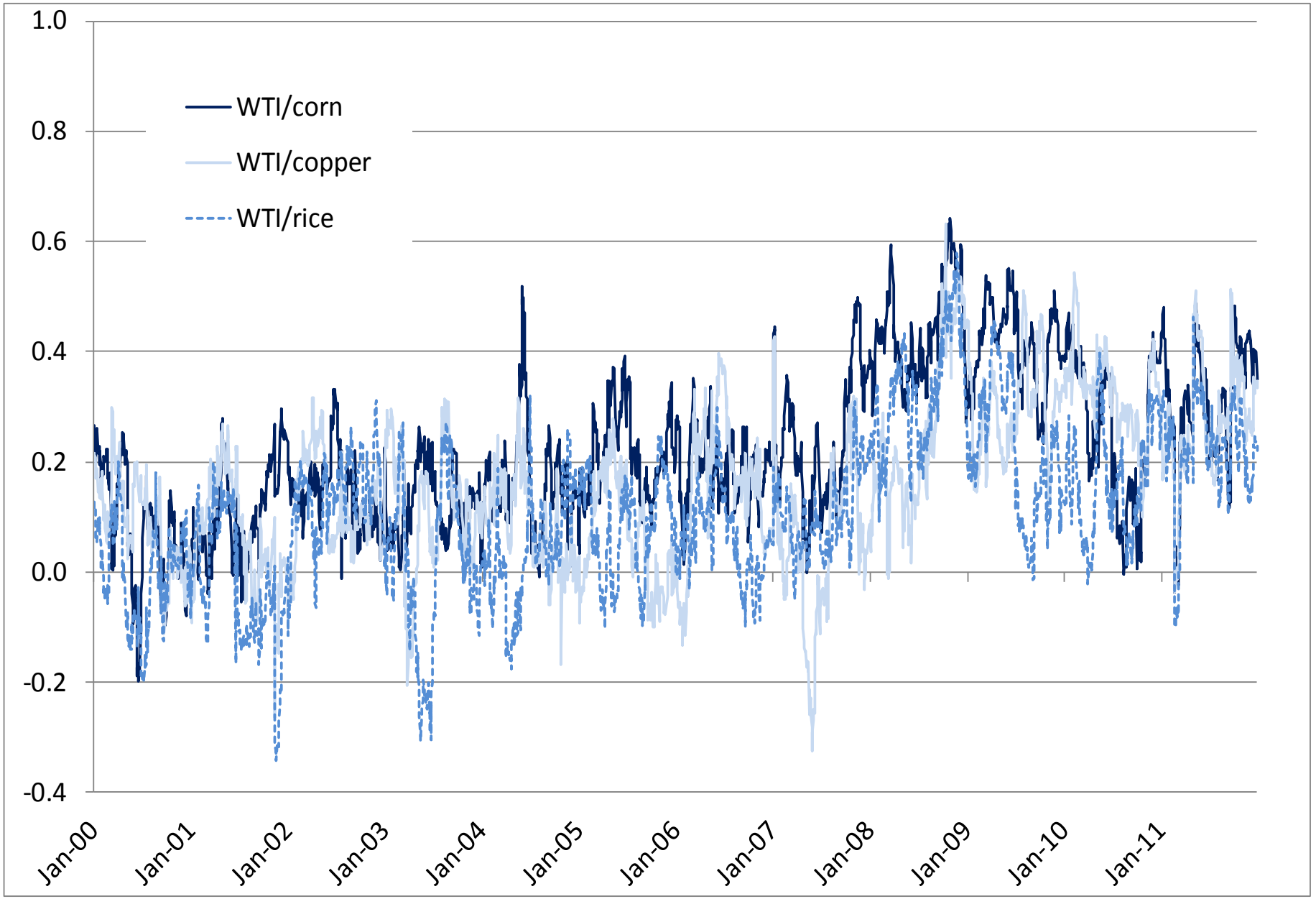
Inter-grains correlations



Results (2)

DCC and Modified DCC Multivariate GARCH estimates		
	DCC	Modified DCC
ARCH α	0.0304 (0.0020)	0.0352 (0.0024)
GARCH β	0.9611 (0.0029)	0.9546 (0.0034)
Log-likelihood	31080.80	31100.51
AIC	-62151.60	-62189.01

Sample: Daily, 5 January 2000 to 30 December 2011 (2943 observations)
Robust standard errors in parentheses.


1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
WTI/corn
WTI/copper
WTI/rice
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11

Volatility decomposition

- For each of the grains:

$$p_j = \alpha + \gamma_j q + \varepsilon_j$$

- Where:
  - p_j: logarithmic prices of corn, wheat and soybeans
  - q: logarithmic price of crude oil
  - γ_j: “pass-through” coefficient
  - ε_j: idiosyncratic error
- Decompose the conditional volatilities for corn, wheat and soybeans into three main components:
  - Commodity specific volatility
  - Crude oil volatility
  - Pass-through coefficient

Volatility decomposition

- The conditional volatility in the three grains can be affected by:

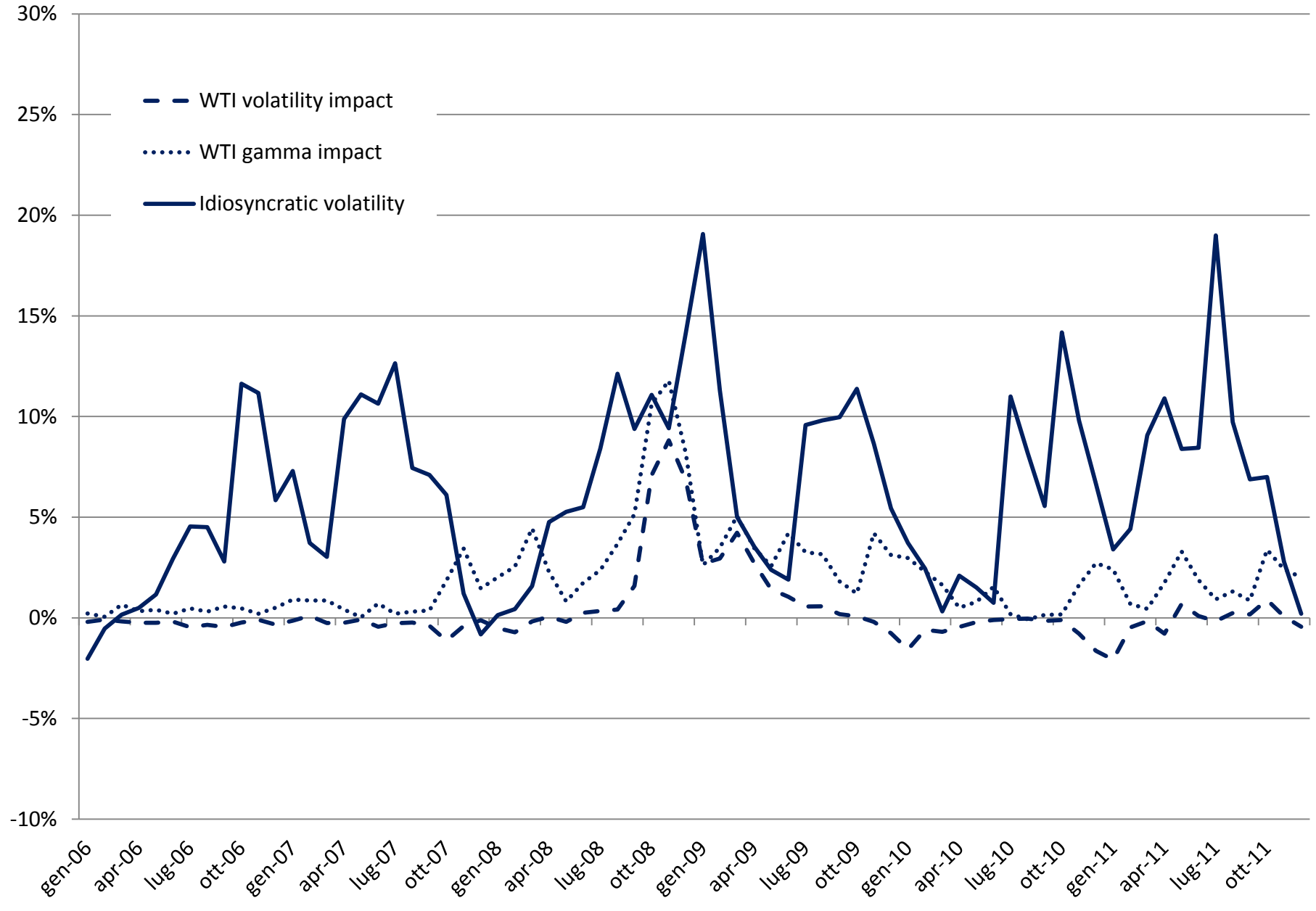
$$var(p_j) = \gamma_j^2 var(q) + var\varepsilon_j$$

  - Changes in the variance of crude oil prices var(q): this will be the case if crude oil prices become more volatile
  - Changes in the "pass-through" coefficient (γ_j): greater pass-through coefficient implies transmission of shocks from crude oil to the grains prices.
    - Biofuels hypothesis: high crude oil prices make biofuels more attractive thus increasing demand for grains (corn).
  - Changes in variance of commodity-specific factors $\mathrm{var}(\varepsilon_j)$: factors such as stocks, weather conditions could render the grains prices more volatile.

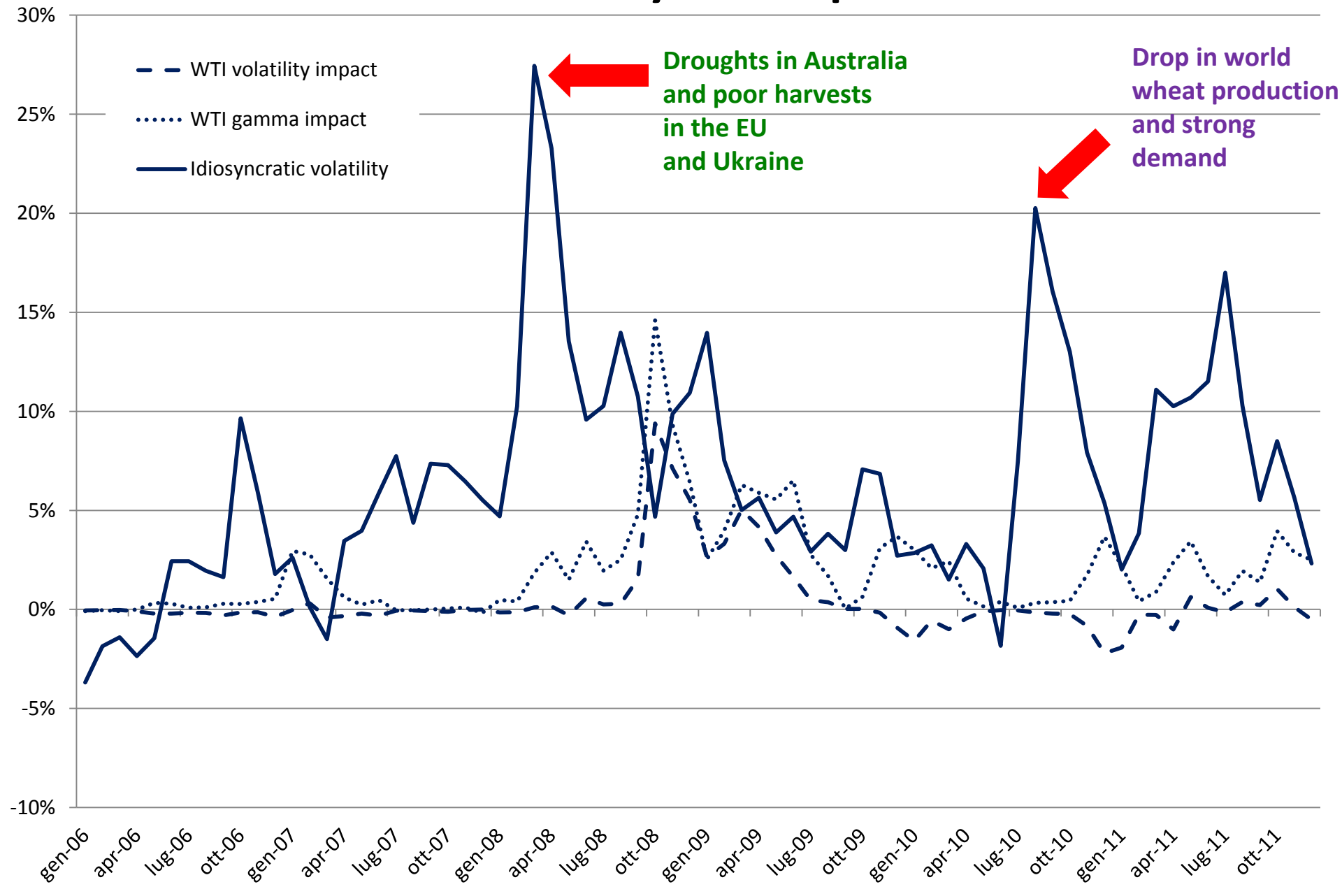
Volatility decomposition

- Using the estimated DCC-MGARCH we conduct a counterfactual decomposition.
  - From the estimates we are able to retrieve the three components.
- The DCC-MGARCH model gives continuous estimates which can be comparable to a recursive regression.
  - While the recursive regression estimates constant parameters over time
  - DCC-MGARCH model gives an estimate of evolving parameter over time (given that $\beta<1$).
- Estimate the average volatility values of 2000-05.
- Simulate the volatility of each of the grains, holding constant each of the three components
  - In this way, we are able to isolate the effects of each component.

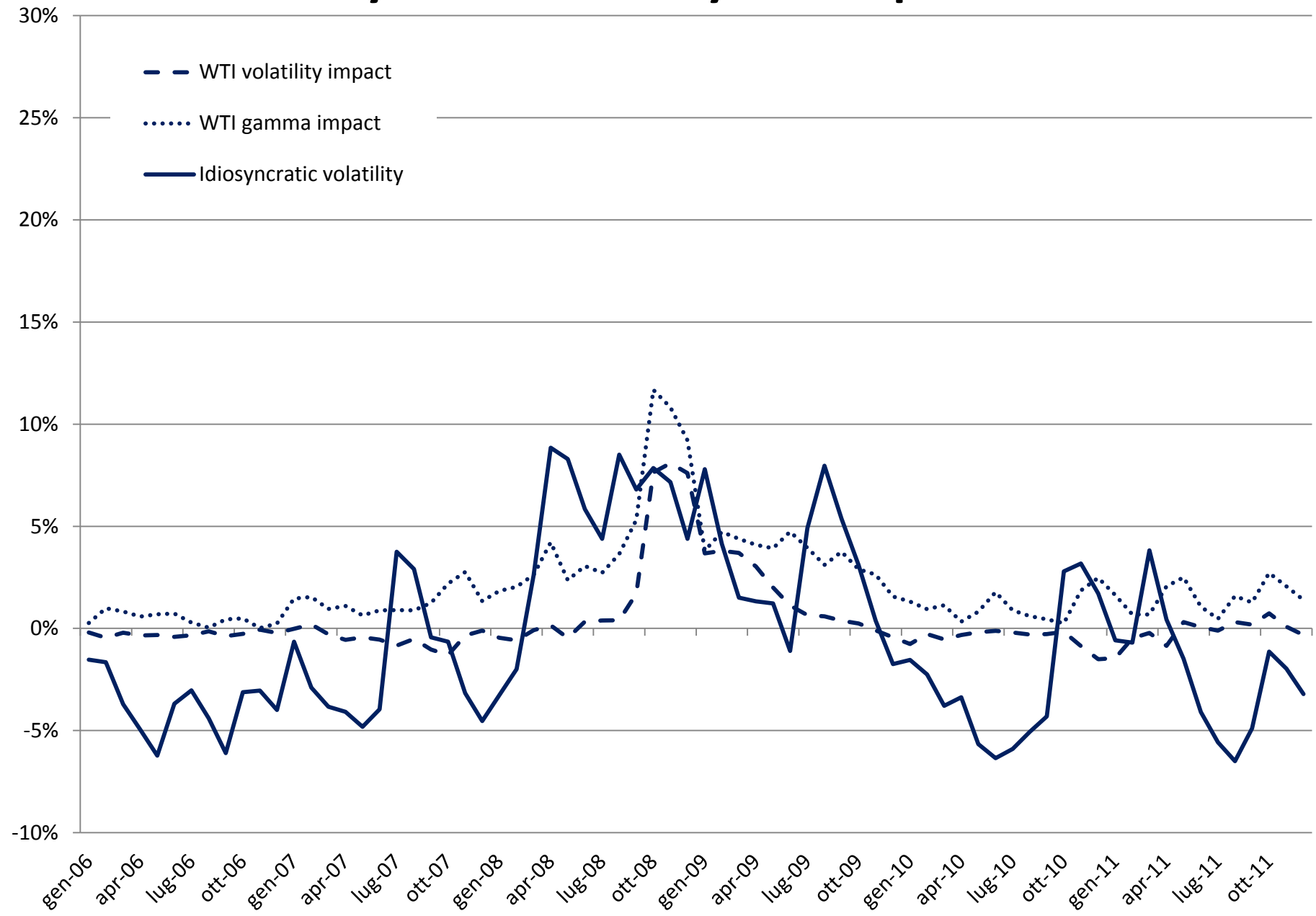
Corn volatility decomposition



Wheat volatility decomposition



Soybeans volatility decomposition



Concluding remarks

- The DCC model is preferred to the CCC model in this context as correlations appear to be highly variable over time. CCC-MGARCH models would not allow us to look at these changes.
- The DCC-MGARCH model provides a simple and parsimonious model as it successfully accounts for time-varying correlated schedastic processes.
- Evidence suggests both biofuels and financialization contributed to the increased correlations
- In 2007-08, crude oil prices changes were temporally prior to grains prices. Crude oil prices started to rise in 2007 and this could have prompted the need for alternative energy sources such as biofuels.

Concluding remarks

- Biofuels linked crude oil and grains prices over 2007-09.
  - Direct link: corn as a feed stock
  - Indirect links: wheat and soybeans- both substituted corn in animal feed and competed for land with corn.
- Biofuels production and consumption constraints in the United States became binding after 2008 de-linking crude oil prices with the grains.
  - Biofuels constraints may also have rendered grains more volatile through the idiosyncratic components such as stocks. To the extent that biofuels production have affected grains prices post-2009, this must be through the grains-specific volatility component and not via crude oil prices.
- Empirical evidence that increased volatility in grains during the 2008-09 spike was substantially due to shocks transmitted from crude oil to grains especially corn, wheat and soybean prices but contributed relatively less at other times.

Thank you for your attention