Price Volatility Co-movement among Major Crops

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Introduction

- Co-movement of commodity prices received substantial attention in economic literature.

- Pindyck and Rotemberg (1990, *Economic Journal)*
  - Seven (unrelated) commodities
  - Used macro-economic variables such as interest, inflation, and exchange rates.
  - Common macro-economic conditions (supply and demand) explain co-movement in commodity prices
  - After controlling, prices still showed **excess co-movement**.
  - Attributed to herd behaviour in financial markets

Introduction

- If there is indeed excess co-movement in commodity prices this is problematic
  - Casts doubt on efficiency of commodity markets
  - If true then problematic for portfolios of exporting countries and commodity traders.
  - Increases income fluctuations for farmers growing multiple crops (portfolio of crops does not work).

- However, subsequent literature challenged this **excess co-movement hypothesis (ECH)**

Introduction

- Deb, Trivedi, and Varangis (1996)
  - Most result of PR due to misspecification: neglected heteroscedasticity and structural break in 1973
  - Recommend further research using daily prices to analyse herd behaviour in commodity markets.
- Cashin, McDermott, and Scott (1999)
  - Non-parametric analysis of properties of price cycles
  - No co-movement for unrelated commodities, but strong evidence for co-movement of related commodities
- Ai, Chatrath, and Song (2006)
  - Fundamental factors (weather, stocks) are more important in explaining co-movement than macro-economic factors.

Problem Statement and Objective

- Focus in co-movement literature on price levels. What about co-movement in (conditional) **volatility**?
- Most studies use monthly or quarterly data. Using data with different frequencies gives better insight in nature and causes of co-movement.

Objective: Analyze co-movement in price levels and conditional volatility of US corn, soybean and wheat prices on a daily, weekly and monthly basis.

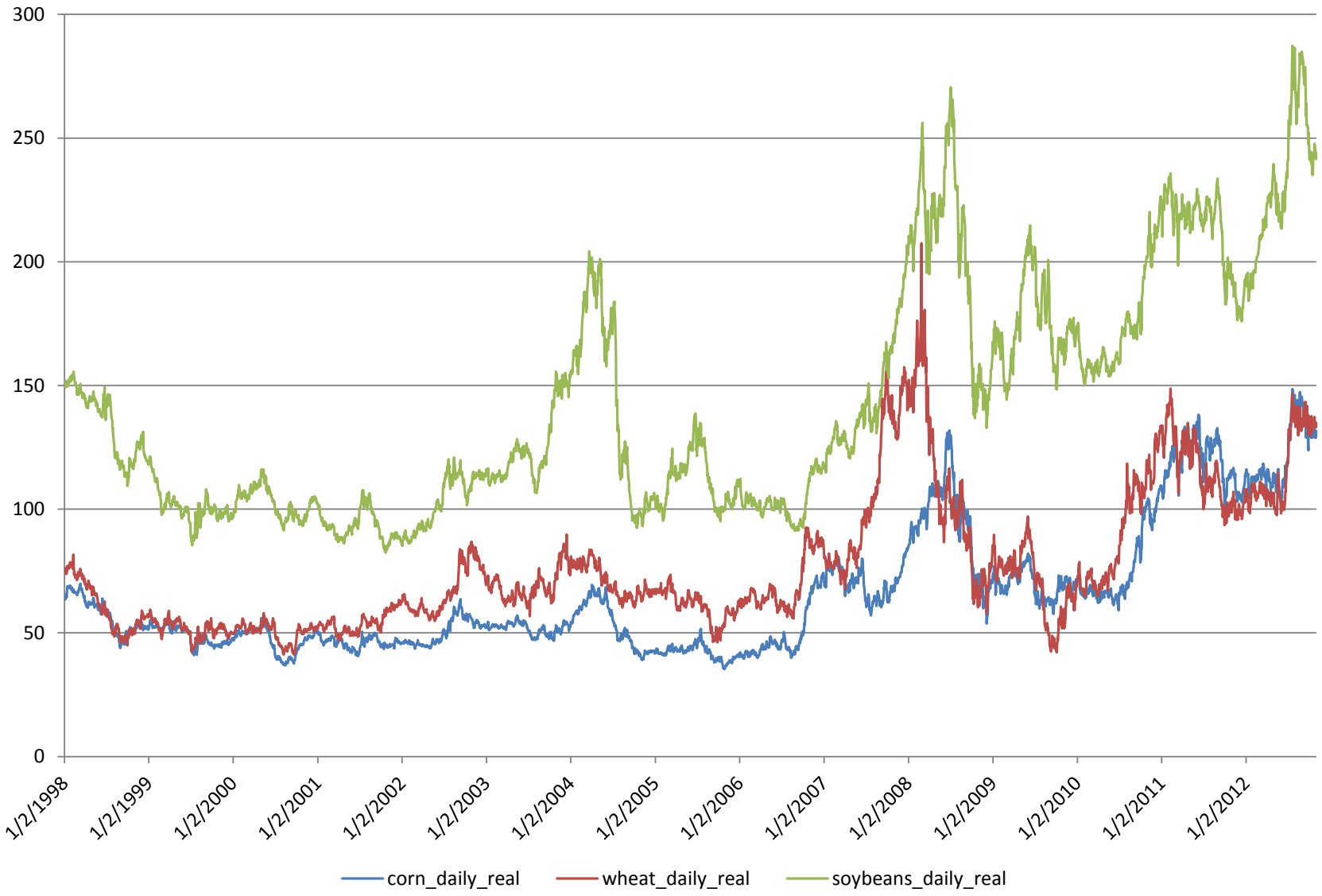
Reasons for co-movement

- Herding in trading (*daily or weekly price level*)
- Weather shocks (*weekly or monthly*)
- Macro-economic factors (*monthly*)
  - Interest and exchange rates
  - Crude oil prices
- Complementarity/substitution of crops (*monthly*)
  - Acreage
  - Substitution in demand (e.g. animal fodder)

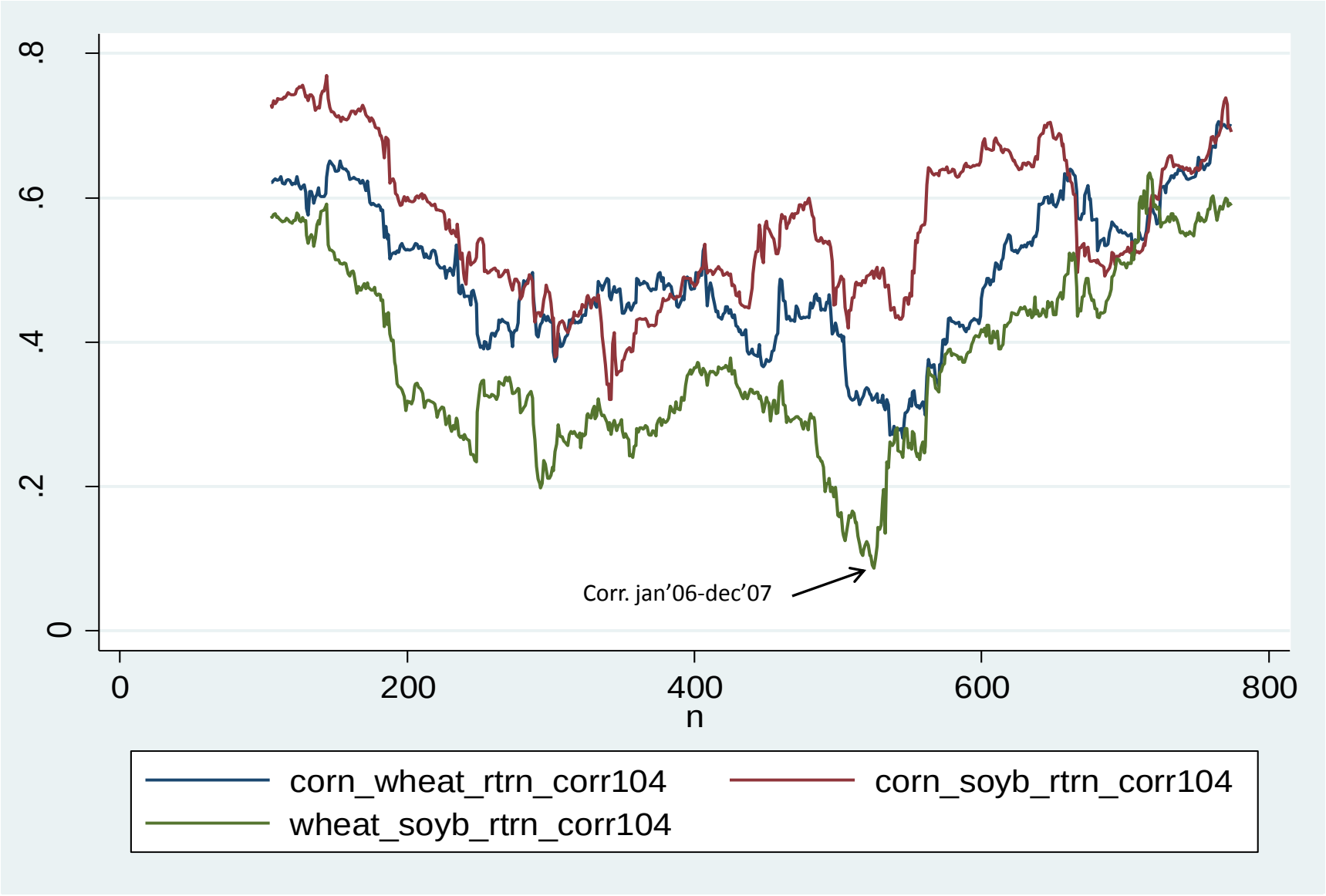
Data and Methodology

- Daily (3732 obs.), weekly (772 obs.) and monthly (177 obs.) cash prices data for corn, wheat and soybeans from CBOT, Jan 1998-October 2012.
- Analysis on basis of returns: $y_t = \ln(P_{it}/P_{it-1})$
- Basic statistics
  - rolling Pearson correlation coefficients
  - rolling standard deviations
- MGARCH models
  - T-BEKK model
  - DCC model

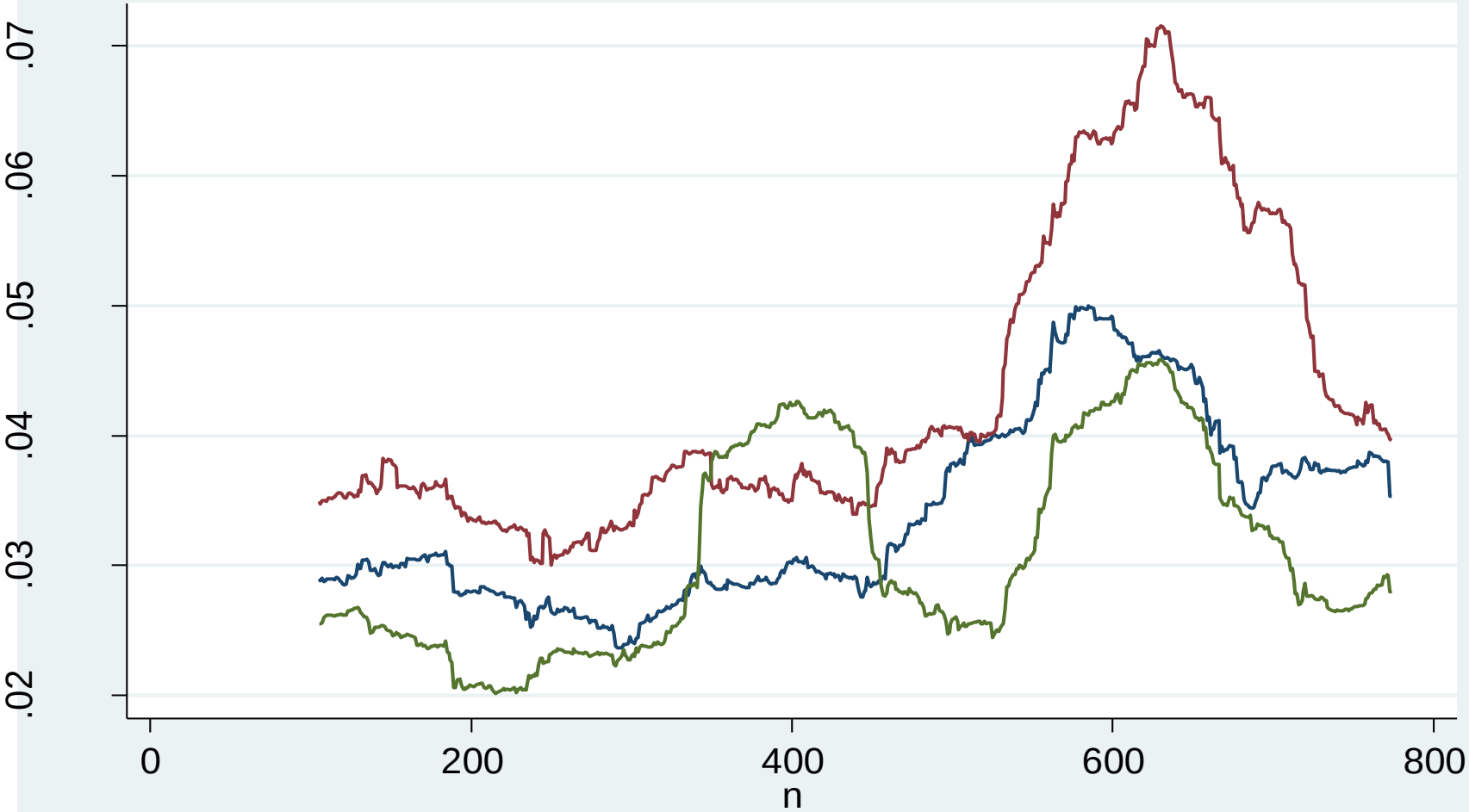
Evolution real daily prices Jan ’98 - Oct ‘12



2-year moving correlations of weekly returns



2-year moving standard deviations returns



Methodology: Multivariate GARCH models

- Multivariate system of equations for conditional means y_i (**price levels**) and conditional (co)variances h_{ijt} (**conditional price volatility**).
- Allows for **volatility spillovers**: shocks to one variable may affect volatility of related variables.

  E.g. shock in corn prices may affect soybean or wheat price volatility

$$y_t = \gamma_0 + \sum_{j=1}^{p} \gamma_j y_{t-j} + \varepsilon_t,$$

$$\varepsilon_t \mid I_{t-1} \sim (0, H_t)$$

- Various MGARCH models deal with H_t differently

Conditional variance: BEKK model

+ Ensures positive variances via quadratic forms
+ Own and cross-volatility spillovers and persistence
- Many parameters to be estimated

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B$$

E.g., Conditional variance equation for Market 1:

Own spillovers | Cross spillovers 2 to 1 | Cross spillovers 3 to 1

$$h_{11,t} = c_{11}^2 + a_{11}^2\varepsilon_{1,t-1}^2 + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^2\varepsilon_{2,t-1}^2 + 2a_{11}a_{31}\varepsilon_{1,t-1}\varepsilon_{3,t-1} + a_{31}^2\varepsilon_{3,t-1}^2$$
$$+ 2a_{21}a_{31}\varepsilon_{2,t-1}\varepsilon_{3,t-1} + b_{22}^2h_{11,t-1} + 2b_{11}b_{21}h_{12,t-1} + b_{21}^2h_{22,t-1} + 2b_{11}b_{31}h_{13,t-1} + b_{31}^2h_{33,t-1}$$
$$+ 2b_{21}b_{31}h_{23,t-1}$$

Own persistence | Cross persistence 1 & 2 | Cross persistence 1 & 3

Conditional variance: DCC model

+ Allows for changes in degree of interdependence between markets over time.

Estimation proceeds in two steps:

1. Estimate univ. GARCH models to obtain stdzd. res:

$$u_{it} = \hat{\varepsilon}_{it} \Big/ \sqrt{\hat{h}_{iit}}$$

2. By smoothing these standardized residuals via

$$q_{ijt} = (1-\alpha-\beta)\overline{u}_{ij} + \alpha u_{it}u_{jt} + \beta q_{ijt-1}$$

where $\overline{u}_{ij}$ is the unconditional cov. between u_{it} and u_{jt} and $0 \le \alpha + \beta < 1$

the dynamic correlations are obtained by:

$$\rho_{ijt} = q_{ijt} \Big/ \sqrt{q_{iit}q_{jjt}}$$

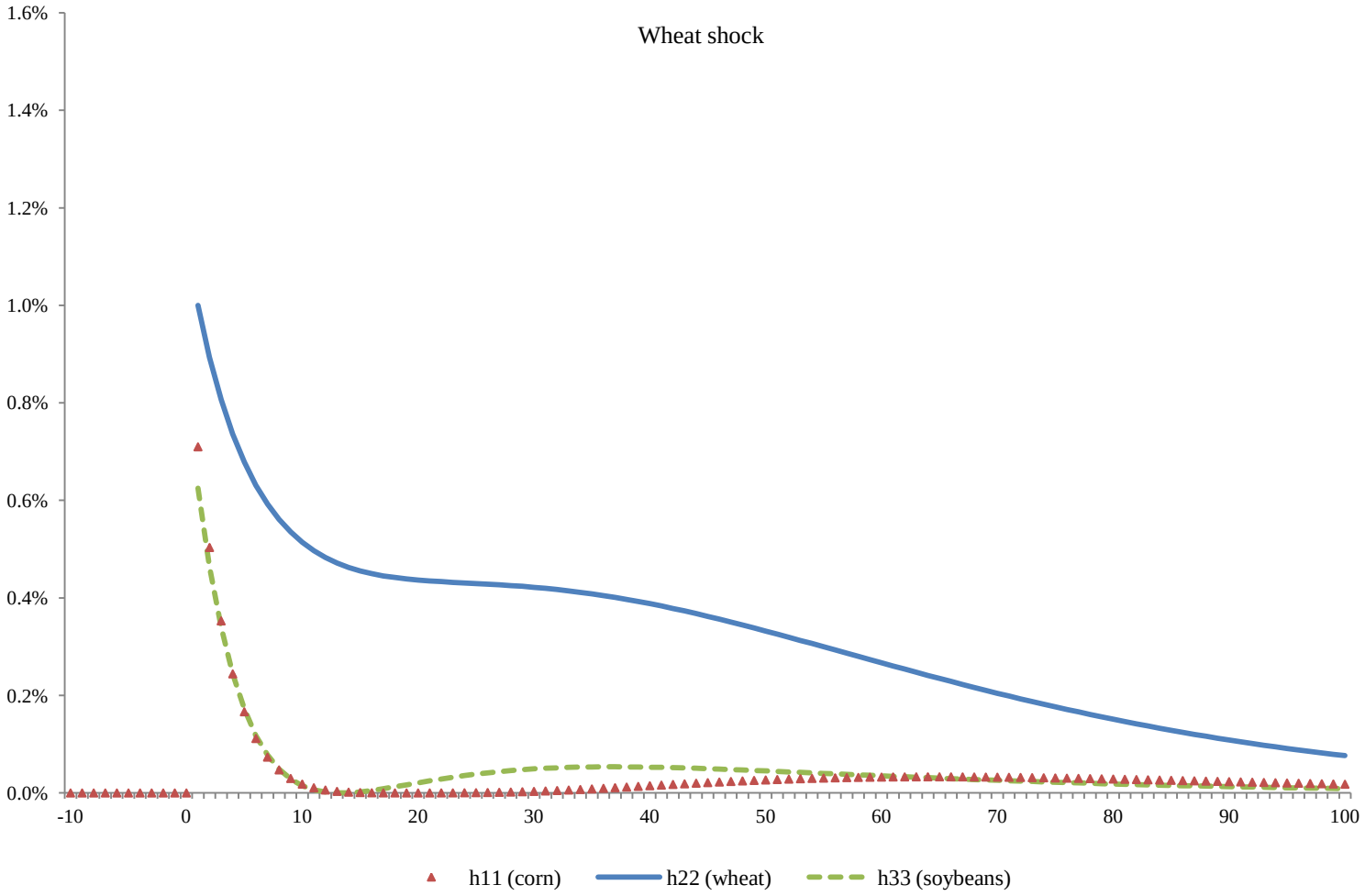
Pretesting

- Three series of returns are stationary at all frequency levels
- VAR to check relations among levels of returns. Only daily wheat returns depend (negatively) on one-period lagged own values and soybean prices.
- Ljung-Box tests indicate serial correlation in squared residuals → GARCH effects.

Main results T-BEKK models

- Volatility interactions across markets at the weekly level (especially between corn and wheat), and to lower extent at monthly level.
- Shocks in conditional volatility of corn or wheat prices have effect on other volatilities, not for soybeans.
- No volatility interaction at the daily level.
- Residual diagnostic tests point that T-BEKK models are not necessarily the most appropriate for daily and monthly data.
- Persistence in the conditional variance/covariances decreases as frequency of data decreases.

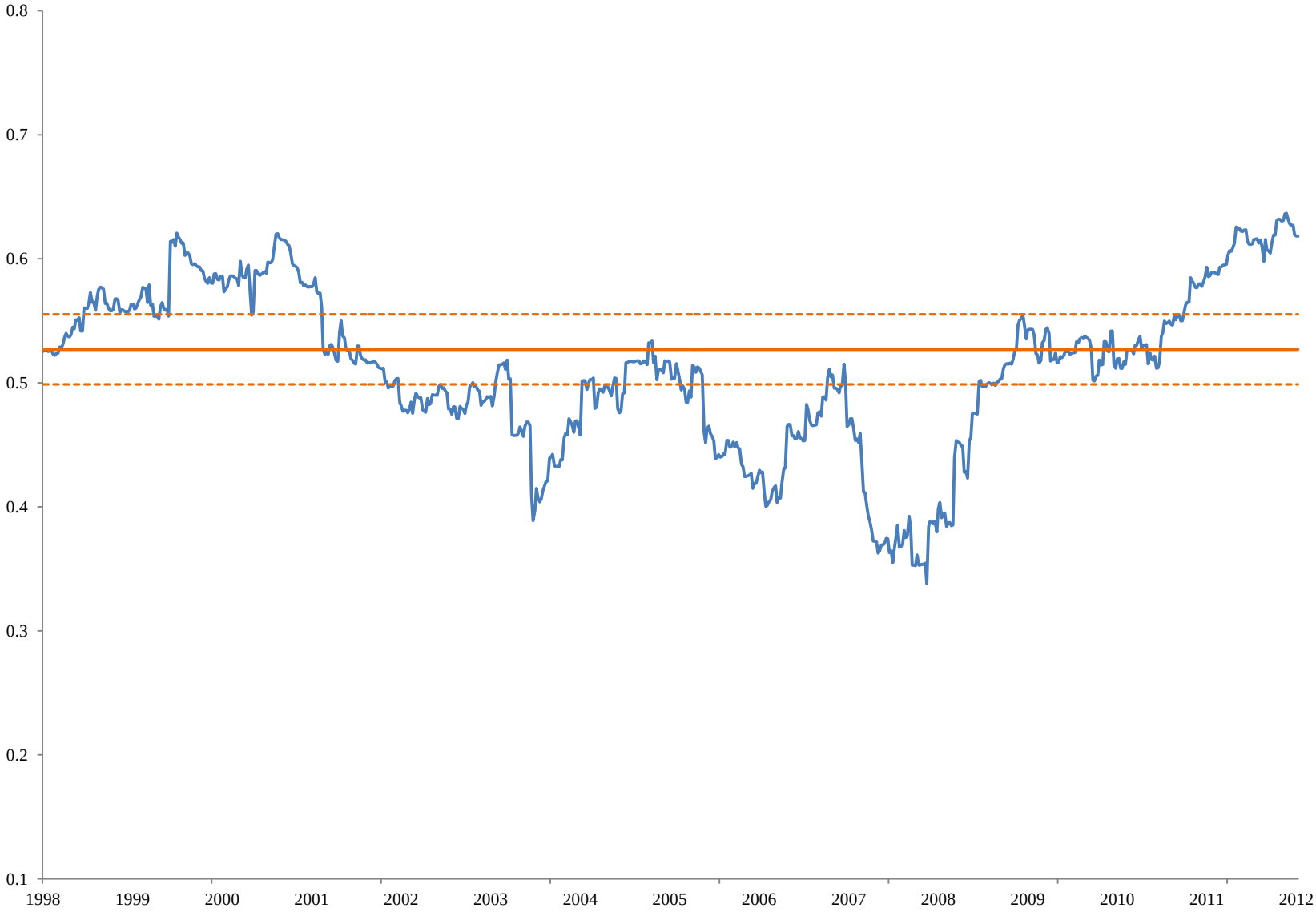
Example IRF T-BEKK model for wheat shock



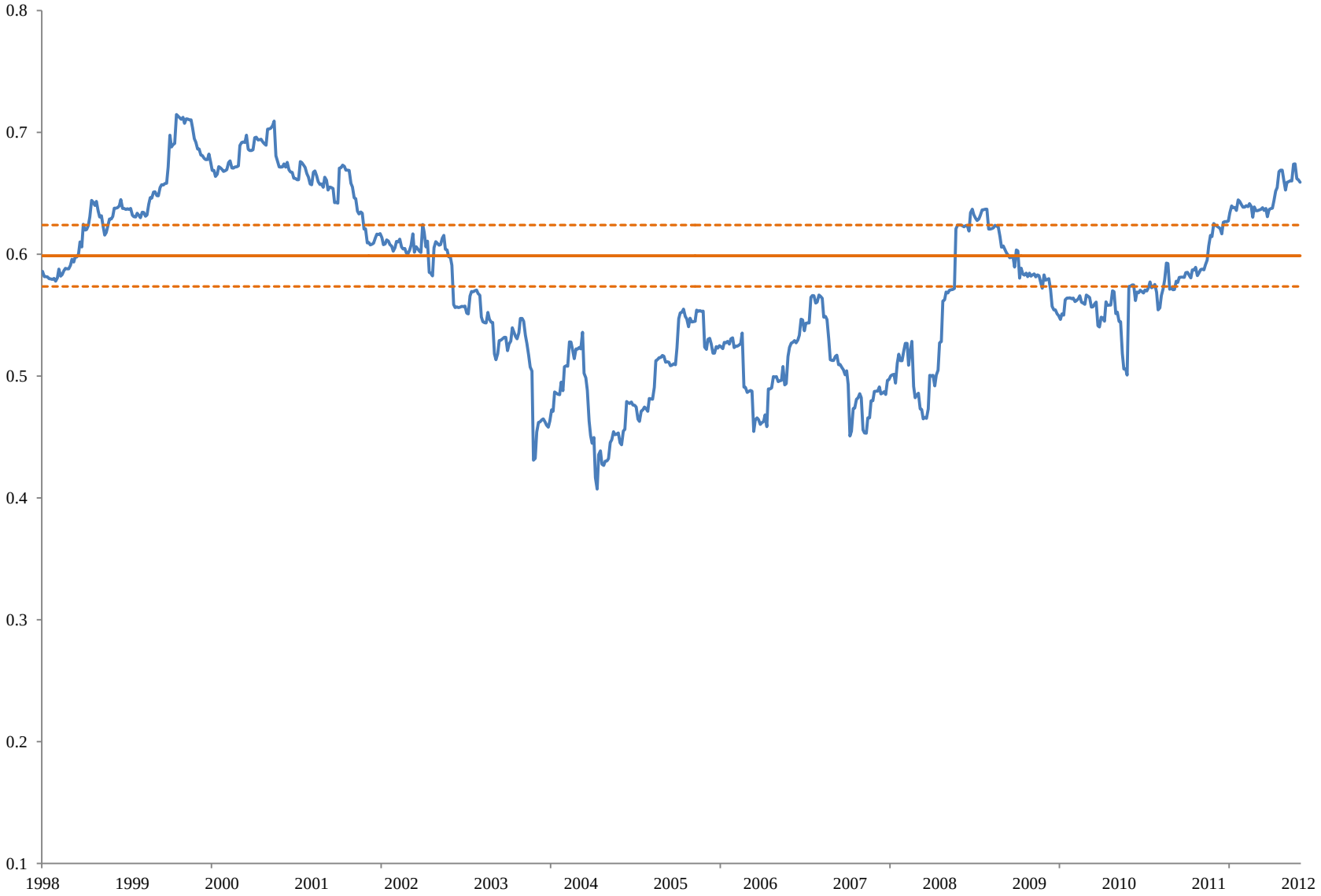
Main results DCC models

- Tests (Ljung-Box; LM test for ARCH residuals and Portmanteau test for cross-correlation) indicate that DCC model is appropriate for weekly returns (but less for daily and monthly returns).

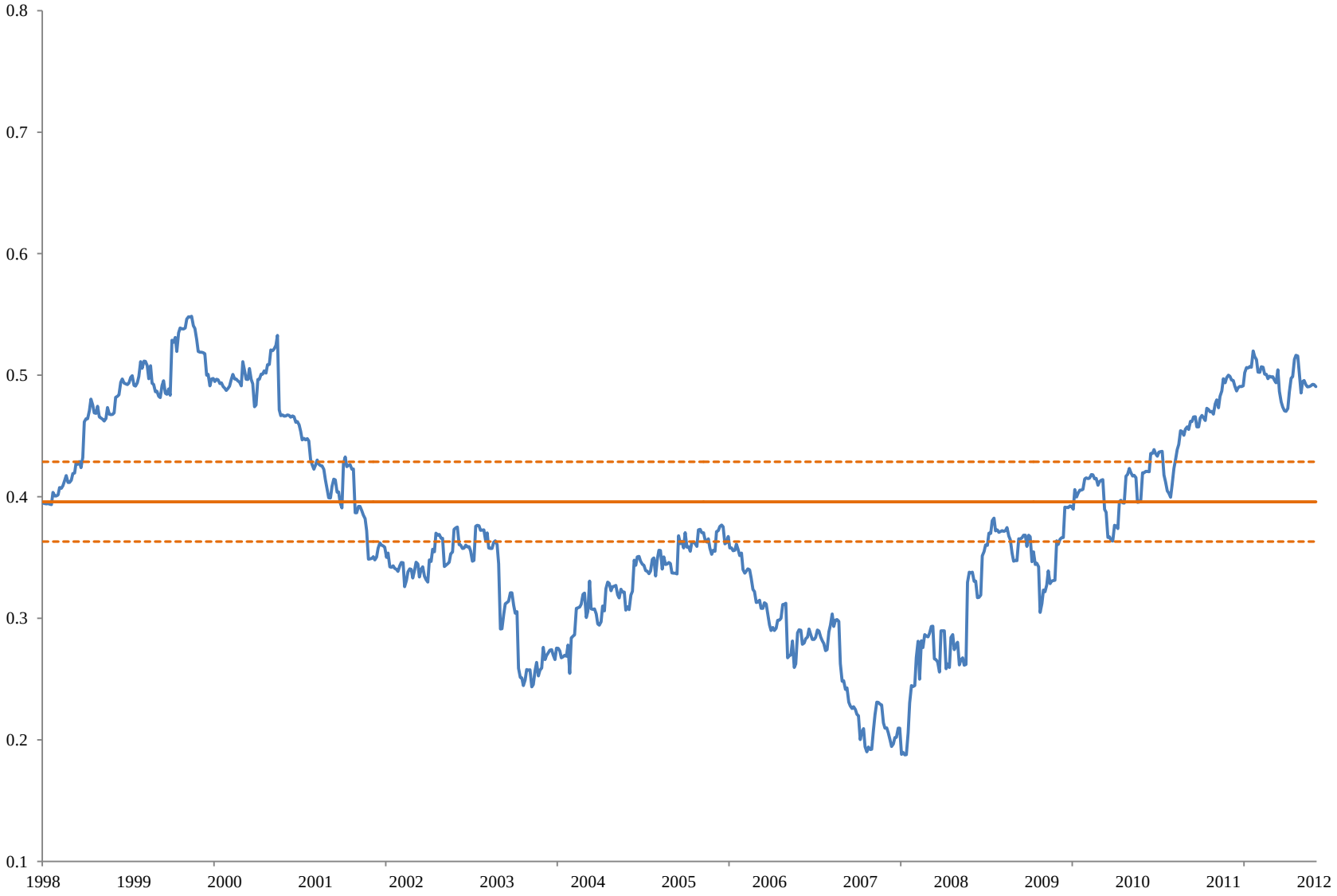
DCC model: correlation corn-wheat



DCC model: correlation corn-soybeans



DCC model: correlation wheat-soybeans



Conclusions

- Overall, it is not found that markets have become more interdependent in recent years. Similar interdependencies than in the late 90s (after a decrease in the early-mid 2000s).
- Most evidence for volatility interdependencies\ co-movement at weekly level.
- Lack of evidence at daily level suggests absence of herding behavior in trading. However, models can be improved in a number of ways.

Extensions

- Inclusion of explanatory variables in MGARCH
  - Acreages
  - Stock levels
  - Supply
  - Crude oil prices (transportation and input costs)
  - Macro-economic variables
- Other MGARCH specifications since T-BEKK does not perform well for daily and monthly prices.