Modeling the Global Wheat Market Using a GVAR Model

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Background

- Global agricultural markets rather volatile in last decade

- Foreign shocks and international spill-overs play an important role
    - Australian drought 2007
    - Russian wheat export bans 2010
    - USA drought 2012

→ Analyse commodity markets from global perspective

Common modelling approaches

Time-series econometric models

- Based on time-series observations
- Parameters are estimated
- Higher frequency data
- Theoretical basis often weak
- Curse of dimensionality

Simulation models

- Based on economic theory
- Parameters are calibrated
- Yearly data
- Complex; often considered as black box

The GVAR model

- Long-run relationships can be included
- As many countries and variables as desired
- Results relatively easy to interpret

Global Vector Autoregression (GVAR)

- Macroeconometric model
- Estimated subject to long-run relationships
- Able to take into account international linkages among a large number of countries
- Analysing shocks with impulse response functions
- Mostly used in financial markets, rather new for analysing agricultural markets
    - Gutierrez et al. (forthcoming)

GVAR: Two steps involved

1. Estimating country-specific VAR models
   - Domestic variables
   - Foreign variables; constructed using weights and assumed to be weakly exogenous

   → Co-integrating relationships

2. Country-specific models stacked together and solved for GVAR

Objective of the study

- Investigate the advantages and disadvantages of the GVAR modelling approach in analysing global agricultural markets

- To this purpose we developed a small GVAR model

Application: GVAR model for wheat market

- Wheat one of the most traded agricultural commodities
- Analyse interdependencies in wheat price movements
- Relatively small model
    - Countries: Argentina, Australia, Canada, Europe, US
    - Variables:
        - Domestic export prices → Endogenous
        - Country-specific foreign prices → Weakly endogenous
        - Exchange rates and oil price → Exogenous

Country-specific ADL equations

$$P_{i,t} = \beta_{i1} + \beta_{i2}t + \sum_{k=1}^{p_i} a_{ik} P_{i,t-k} + \sum_{l=0}^{q_i} \gamma_{il} P^*_{i,t-l}$$

$$+ \sum_{l=0}^{q_1} \delta_{il} ER_{i,t-l} + \sum_{l=0}^{q_i} \theta_{il} PO_{t-l} + \varepsilon_{i,t}$$

$P_{i,t}$ = Wheat export price

$ER_{i,t}$ = Nominal exchange rate

$P^*_{i,t} = \sum_{j=0}^{N} w_{ij} P_{j,t}$

PO_t = Nominal crude oil price

Data

- Monthly data, covering July 2001 until April 2012

Variable	Definition	Source
$P_{i,t}$	Wheat export price in US dollars per ton	International Grains Council (2012)
PO_t	Nominal crude oil price in US dollars per barrel obtained as an equally weighted average of the spot price of Brent, Dubai and West Texas Intermediate	World Bank Commodity Price Data (Pink Sheet) (2014)
$ER_{i,t}$	National currency per SDR, end of period	International Financial Statistics (2014)

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Data: missing observations

- Single missing observations
    - Solved by interpolation
- Longer periods of missing observations
    - Australia: 14 months of missing observations
    - Combination of forecasting and backcasting
    - Using Australian barley prices

Construction of the weights

$$P_{i,t}^{*} = \sum_{j=0}^{N} w_{ij} P_{j,t}$$

- Weights (w_{ij}) are constructed by export shares
- w_{ij} is the average share of the export volume of country j over 2009-2011 in total exports of all the countries in the model (excluding country i)

Weights

Variables	Argentina	Australia	Canada	EU	US
Argentina	0.000	0.198	0.220	0.246	0.336
Australia	0.082	0.00	0.252	0.281	0.384
Canada	0.084	0.233	0.000	0.289	0.394
EU	0.087	0.240	0.267	0.000	0.407
USA	0.097	0.269	0.299	0.334	0.000

Country-specific models

- Order of integration
    - All time-series integrated of order 1

- Lag orders VARX(p_i, q_i)
    - Distinction between the domestic prices (p_i) and the other variables (q_i)
    - Maximum lag order of 3
    - Initial lag order determined by comparing BIC values

    → VARX(3,0)

Country-specific models

Co-integrating relationships

Country	Co-integrating variables
Argentina	$P_{ar,t}, P^*_{ar,t}$
Australia	$P_{au,t}, P^*_{au,t}$
Canada	$P_{ca,t}, P^*_{ca,t}, PO_t, ER_t$
Europe	$P_{eu,t}, P^*_{eu,t}$
US	$P_{us,t}, P^*_{us,t}, PO_t$

Estimation of country-specific equations

$$\Delta P_{ar,t} = \boxed{-0.186\left(P_{ar,t-1} - 0.890 P^{*}_{ar,t-1}\right)} + \boxed{0.265\Delta P_{ar,t-1}} + \boxed{0.593\Delta P^{*}_{ar,t}} + \varepsilon_{ar,t}$$

$$\Delta P_{au,t} = 18.834 - 0.180\left(P_{au,t-1} - 0.501 P^{*}_{au,t-1}\right) + 0.237\Delta P_{au,t-1} + 0.450\Delta P^{*}_{au,t} + 0.530\Delta PO_{t} + \varepsilon_{ar,t}$$

$$\Delta P_{ca,t} = -0.225(P_{ca,t-1} - 1.730 P^{*}_{ca,t-1} + 32.125 ER_{ca,t-1} + 0.547 PO_{t-1}) - 0.128\Delta P_{ca,t-1} + 0.171\Delta P_{ca,t-2} + 1.142\Delta P^{*}_{ca,t} - 99.203\Delta ER_{ca,t} - 0.970\Delta PO_{t} + \varepsilon_{ca,t}$$

$$\Delta P_{eu,t} = -0.146\left(P_{eu,t-1} - 0.855 P^{*}_{eu,t-1}\right) + 0.227\Delta P_{eu,t-1} + 0.752\Delta P^{*}_{eu,t} + \varepsilon_{eu,t}$$

$$\Delta P_{us,t} = -0.297\left(P_{us,t-1} - 0.967 P^{*}_{us,t-1} - 0.033 PO_{t-1}\right) - 0.024\Delta P_{us,t-1} - 0.113\Delta P_{us,t-2} + 0.978\Delta P^{*}_{us,t} + \varepsilon_{us,t}$$

Testing weak exogeneity

T Statistics of weakly exogeneity test for $P_{i,t}^{*}$

Country	
Argentina	0.17
Australia	0.78
Canada	-1.36
Europe	2.1**
US	-2.8 ***

** Significant at a 5% significance level
*** Significant at a 1% significance level

Testing weak exogeneity

- Possible solutions:
  - Using an instrumental variable for $P^*_{us,t}$
  - Estimating $P^*_{us,t}$ endogenous
  - Removing $P^*_{us,t}$ (Chudik and Smith, 2013)
    - $P^*_{us,t}$ is the only foreign variable in equation US

      → No effect of foreign prices on US domestic price

Country-specific equations

$$\Delta P_{ar,t} = -0.186\left(P_{ar,t-1} - 0.890P^{*}_{ar,t-1}\right) + 0.265\Delta P_{ar,t-1} + 0.593\Delta P^{*}_{ar,t} + \varepsilon_{ar,t}$$

$$\begin{aligned}\Delta P_{au,t} = {} & 18.834 - 0.180\left(P_{au,t-1} - 0.501P^{*}_{au,t-1}\right) + 0.237\Delta P_{au,t-1} + 0.450\Delta P^{*}_{au,t} \\ & + 0.530\Delta PO_{t} + \varepsilon_{ar,t}\end{aligned}$$

$$\begin{aligned}\Delta P_{ca,t} = {} & -0.225(P_{ca,t-1} - 1.730P^{*}_{ca,t-1} + 32.125ER_{ca,t-1} + 0.547PO_{t-1}) \\ & - 0.128\Delta P_{ca,t-1} + 0.171\Delta P_{ca,t-2} + 1.142\Delta P^{*}_{ca,t} - 99.203\Delta ER_{ca,t} \\ & - 0.970\Delta PO_{t} + \varepsilon_{ca,t}\end{aligned}$$

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Solving the GVAR

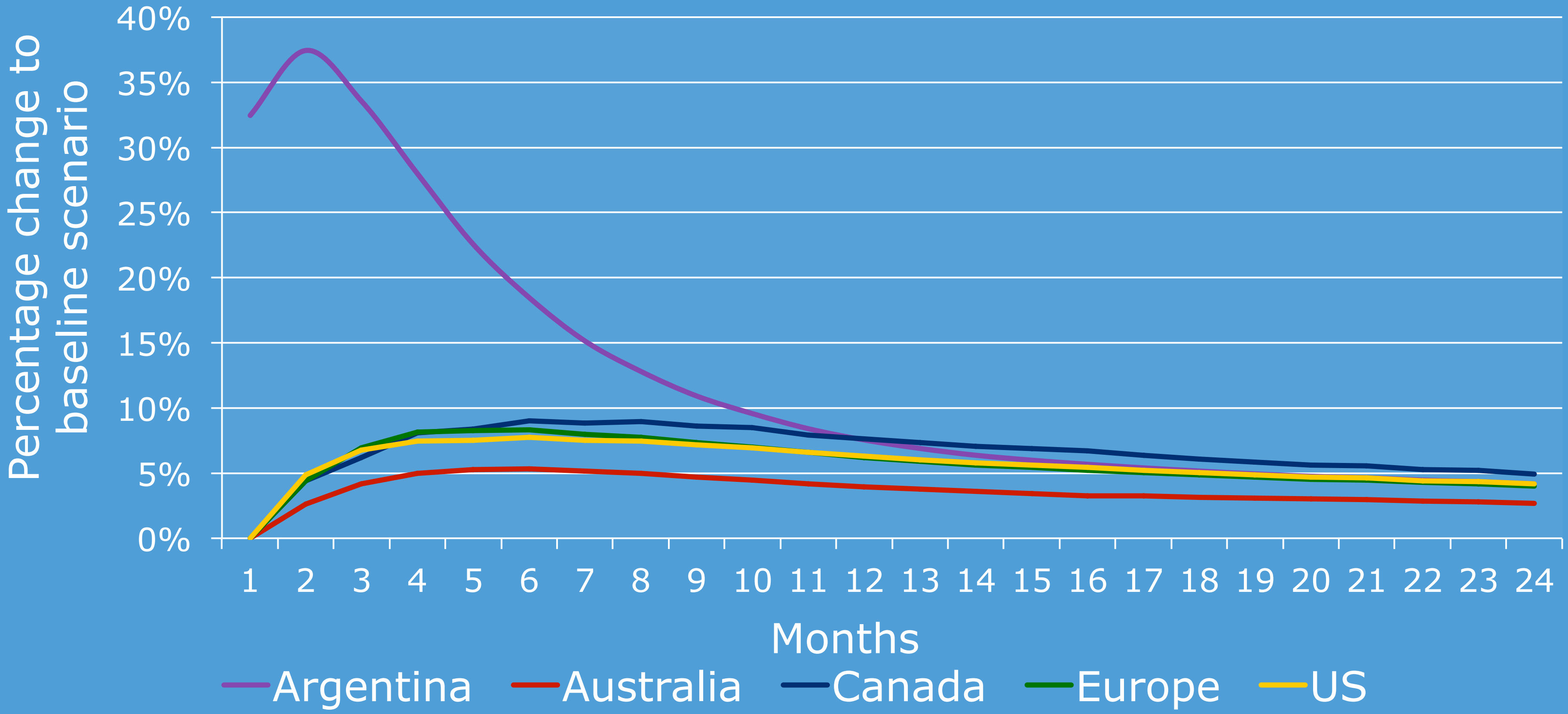
$$\begin{pmatrix} P_{i,t} \\ P_{i,t}^{*} \end{pmatrix} = W_i X_t = W_i \begin{pmatrix} P_{ar,t} \\ P_{au,t} \\ P_{ca,t} \\ P_{eu,t} \\ P_{ar,t} \end{pmatrix}$$

$$X_t = G^{-1}a_1 + G^{-1}H_1X_{t-1} + G^{-1}H_2X_{t-2} + G^{-1}H_3X_{t-3} + G^{-1}a_2ER_t$$

$$+G^{-1}a_3ER_{t-1} + G^{-1}a_4PO_t + G^{-1}a_5PO_{t-1} + G^{-1}\varepsilon_t$$

Impulse response functions

Impulse response of wheat export prices to a positive standard error shock (32,4%) to the Argentinian wheat price



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Reliability of weights

- Weight are a key element in the model
    - Restrict the model
    - Influences small economy assumption
- Comparison with un unrestricted model
    - Individual $P_{i,t}$'s not all significant
    - $P_{eu,t}$ underestimated for all domestic prices

Conclusion

Advantages of GVAR approach:

- ability to include as many countries and variables as desirable
- the possibility to include both short-run as well as long-run relationships
- the compactness and flexibility of the model

Conclusion

Disadvantages:

- The lack of a proper solution to the rejection of the weakly exogeneity assumption
- Questionable reliability of the constructed weights

Thank you