Impacts of Export Restrictions on Food Price Volatility

Evidence from VAR-X and EGARCH-X Models

Bernhard Dalheimer, Bernhard Brümmer, Tinoush Jamali Jaghdani

Department of Agricultural Economics and Rural Development

University of Göttingen

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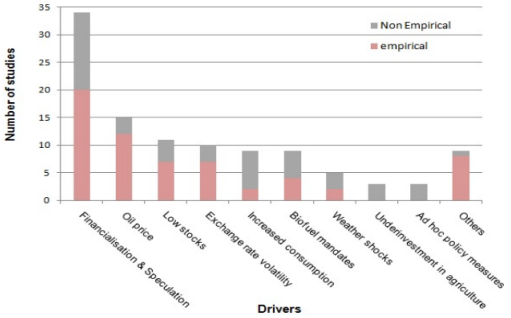
Outline

- Food price volatility has been increasingly studied in the aftermath of food price spikes 2007/09
- Food Price Volatility is a threat to food security
- Lack of empirical attention towards policy
- Policy one of the few manageable drivers
- Notorious reaction of countries to high prices: Export Restrictions
- Currently, no *binding* WTO regulation

Figure 1: Drivers of Food Price Volatility in the Literature



Source: Brümmer et al. (2013)

How do export restrictions affect price volatility?

- Price Level effects are well studied: Restrictions increase prices
- Trade as market stabilization mechanism distorted through policy intervention
- Frequent policy changes over time $\rightarrow$ frequent price changes over time $\rightarrow$ volatility
- Collective action problem in policies: Countries outbalance each other's responses to international market turmoil (Anderson and Martin, 2011)

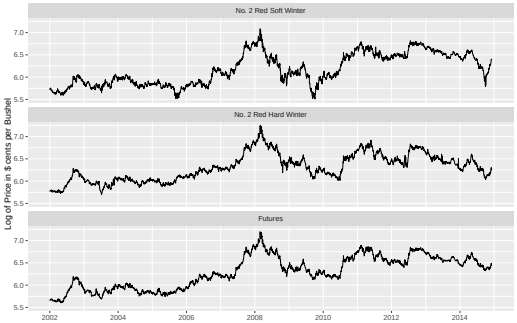
1. Are export restrictive policies associated with increased food price volatility?
2. Are there different impacts among the array of export restrictive measures?
3. Have some country policies particularly impacted food price volatility?
4. Does the timing of such policies matter?

Along the time, country and policy dimensions...

1. Measure export restrictive policy (Policy Indicators)
2. Estimate Volatility (parametric: *GARCH*, and non-parametric: *realized volatility* (σ^2)) of international prices (Soft and Hard Winter varieties, spot and futures markets)
3. Test exogenous effects of policy on volatility over time (*VAR-X*: long(er) term strategies, country policies
4. Estimate parameters for different time periods (*EGARCH-X*: short term strategies)

One market, three prices:

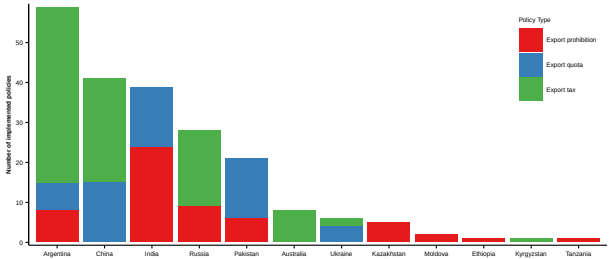
Figure 2: Daily wheat spot and futures prices, 2002-2015



Source:

- CBOT prices obtained from Datastream, daily and weekly

Figure 3: Number of export restrictive policies by country and type, 2012-2015



Sources:

- AMIS (2016)
- OECD (2016)
- Sharma (2011)

Table 1: World Wheat Export Shares by Country

Rank	Country	Wheat Export Share
1	United States	21.39%
2	European Union	15.35%
3	Canada	13.45%
4	**Australia**	**11.56%**
5	**Russia**	**10.16%**
6	**Argentina**	**6.38%**
7	**Ukraine**	**4.97%**
8	**Kazakhstan**	**4.91%**
9	Turkey	2.13%
10	**India**	**1.75%**
11	**China**	**1.16%**
12	**Pakistan**	**0.73%**
13	Brazil	0.71%
14	Mexico	0.63%
15	Uruguay	0.48%
...	...	...
60	**Kyrgyzstan**	**0.01%**
...	...	...
76	**Tanzania**	**0.00%**

Rows highlighted in bold are countries which have been operating export restrictive measures on wheat during the target period Shares are calculated as 2002-2015 averages Export data have been retrieved from USDA (2016)

Indicator of Export restrictiveness

- Idea: Describe exposure of world market to export restrictive policy over time
- Problem: How to quantify and aggregate different export measures? (taxes, quotas, bans, Licenses, etc)
- Solution: Treat each measure separately and construct weighted counts

$$ERI_{j,t} = \sum_{i \in c} \left(\frac{P_{j,c,t}}{P_{j,w,t}} * x_{c,t-1} \right) \tag{1}$$

P: Number of policies, x: Trade weight

Features: Policy based measure, *severity* of restriction, relative country size, reflected, Global policy environment, Timing of implementationl policy environment reflected, Decomposability to country indicators

Table 2: Monthly realized volatilities

	Soft Red Winter	Hard Red Winter	Futures Contracts
SRW_{t-1}	0.18	−0.11	−0.10
	(0.12)	(0.09)	(0.09)
HRW_{t-1}	0.41	0.38	0.30**
	(0.20)	(0.16)	(0.15)
$Futures_{t-1}$	−0.29	−0.14	−0.13
	(0.21)	(0.16)	(0.15)
SRW_{t-2}	0.27**	0.22**	0.24***
	(0.12)	(0.10)	(0.09)
HRW_{t-2}	−0.14	0.03	−0.14
	(0.20)	(0.16)	(0.14)
$Futures_{t-2}$	0.21	−0.06	0.16
	(0.20)	(0.16)	(0.15)
SRW_{t-3}	−0.01	−0.13	−0.08
	(0.12)	(0.10)	(0.09)
HRW_{t-3}	−0.33	−0.35**	−0.35**
	(0.20)	(0.16)	(0.14)
$Futures_{t-3}$	0.23	0.33**	0.41***
	(0.21)	(0.16)	0.15
constant	0.07***	0.09***	0.07***
	(0.02)	(0.02)	(0.01)
Export Quotas	0.01	0.03***	0.02**
	(0.01)	(0.01)	(0.01)

Standard errors in parenthesis. Significance levels are '∗ ∗ ∗', '∗∗' and '∗' for < 0.1, < 0.05 and < 0.01 respectively Seasonality is addressed through the inclusion of seasonal dummies which are not reported

Table 3: Weekly GARCH volatilities

	Soft Red Winter	Hard Red Winter	Futures Contracts
SRW_{t-1}	0.9713***	0.0005	−0.0077
	(0.0469)	(0.0456)	(0.0212)
HRW_{t-1}	0.0202	0.9187***	0.0190
	(0.0604)	(0.0586)	(0.0273)
$Futures_{t-1}$	−0.0567	−0.2020	0.9353***
	(0.1354)	(0.1314)	(0.0613)
SRW_{t-2}	−0.0144	−0.0027	0.0095
	(0.0472)	(0.0458)	(0.0214)
HRW_{t-2}	−0.0215	−0.1360***	−0.0109
	(0.0567)	(0.0551)	(0.0257)
$Futures_{t-2}$	0.0273	0.2054	−0.0044
	(0.1337)	(0.1298)	(0.0605)
constant	0.0237***	0.0679***	0.0155***
	(0.0097)	(0.0095)	(0.0044)
Export Quotas	0.0029	0.0052*	0.0018**
	(0.0021)	(0.0020)	(0.0009)

Standard errors in parenthesis. Significance levels are '∗ ∗ ∗', '∗∗' and '∗' for < 0.1, < 0.05 and < 0.01 respectively

Table 4: VAR-X summary: Weekly GARCH volatilities and Country Indicators

	Soft Red Winter	Hard Red Winter	Futures Contracts
SRW_{t-1}	0.9448^{***}	–	-0.0112
	(0.0150)	–	(0.0074)
HRW_{t-1}	–	0.9189^{***}	0.0296^{**}
	–	(0.0581)	(0.0149)
$Futures_{t-1}$	–	-0.2126^{*}	0.8792^{***}
	–	(0.1249)	(0.0228)
HRW_{t-2}	–	-0.1420^{***}	–
	–	(0.0545)	–
$Futures_{t-2}$	-0.0510	0.2090^{*}	–
	(0.0351)	(0.1220)	–
const	0.0323^{***}	0.0608^{***}	0.0170^{***}
	(0.0096)	(0.0091)	(0.0046)
EP India	0.0013^{**}	–	–
	(0.0005)	–	–
EP Pakistan	–	0.0042^{**}	0.0027^{**}
	–	(0.0020)	(0.0012)
EQ Argentina	-0.0001	0.0025^{*}	0.0013^{***}
	(0.0006)	(0.0009)	(0.0005)
EQ KKRU[1]	–	–	0.0043^{**}
	–	–	(0.0019)
ET Australia	–	–	0.0012^{**}
	–	–	(0.0005)
ET China	–	–	0.0003
	–	–	(0.0002)

Standard errors in parenthesis. Significance levels are '***', '**' and '*' for < 0.1, < 0.05 and < 0.01 respectively EP, EQ and ET stand for export prohibitions, export quotas and export taxes respectively [1]Kazachstan, Kyrgyzstan, Russia, Ukraine

Table 5: EGARCH-X results for multiple periods

Parameter	Pre-Crisis	07/08 Crisis	Between Crisis	10/11 Crisis	Post-Crisis
ω	-0.8934^{***}	-0.3605^{***}	-1.007	-0.2448^{***}	-0.1898^{***}
α	0.0751^{***}	0.1094	0.1189	0.0828^{***}	0.011
β	0.8945^{***}	0.9671^{***}	0.8743^{***}	0.9754^{***}	0.9777^{***}
γ	0.1123^{***}	-0.1271^{***}	0.0859	-0.1767^{***}	0.1116^{***}
Export Prohibitions	0.0023	-0.015^{***}	-0.0079	0.0004^{***}	-0.0002
Export Quotas	0.0029	0.0686^{***}	0.0396	0.031	-0.0141
Export Taxes	0.0031	0.0222^{***}	0.0113	0.0125^{***}	0.006^{**}

Significance levels are '$***$', '$**$' and '$*$' for < 0.1, < 0.05 and < 0.01 respectively

Table 6: EGARCH-X results 2002-2014

Parameter	Estimate	Std. Error
ω	-0.1522^{***}	0.0030
α	0.0413^{***}	0.0097
β	0.9818^{***}	0.0002
γ	0.0915^{***}	0.0040
Export Bans	0.0011	0.0007
Export Quotas	0.0073^{*}	0.0022
Export Taxes	0.0222	0.4164

Significance levels are '$***$', '$**$' and '$*$' for < 0.1, < 0.05 and < 0.01 respectively

Lessons learned

1. Export restrictive policies have significantly increased wheat price volatility
2. Long term tax policies have not been the main problem $\rightarrow$ should be considered more in relation to the import tariff discussion
3. Uncoordinated export measures imposed in times of market turmoil exacerbate the volatility problem
4. Yet *real* emergency measures are not to blame
5. The most pronounced distorters are longer term quota policies (Argentina, KKRU) which are introduced as emergency measures, but keept in place for extended periods

- AoA, Article XII, in referece to GATT Article XI allows
  "export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other products essential to the exporting contracting party"
- more binding regulation suggested
- no apparent need to ban tariffs (from a volatility perspective)

- Extend analysis to more grain and oilseed markets
- Explore/improve policy measure
- Examine import measures as well as other policies
- Explore more econometric techniques: Multivariate GARCH and Markov-Switching volatility models
- Combine volatility and level analysis to provide more nuanced insights on whole market effects

Thanks for your attention

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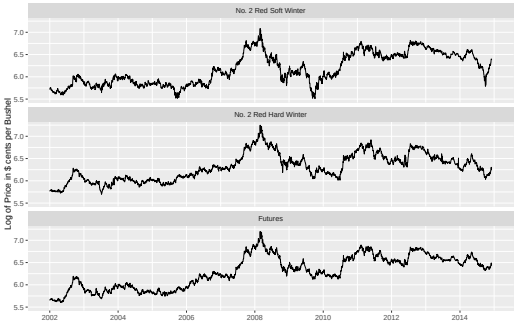
Wheat Price Data

Figure 4: Daily wheat spot and futures prices, 2002-2015



Source:

- CBOT prices obtained from Datastream, daily and weekly

Policy Indicator and Volatility Estimates

Figure 5: Export restrictions indicators 2002-2015

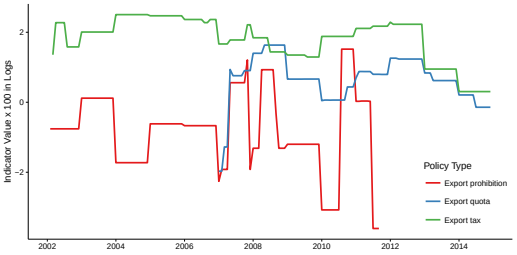
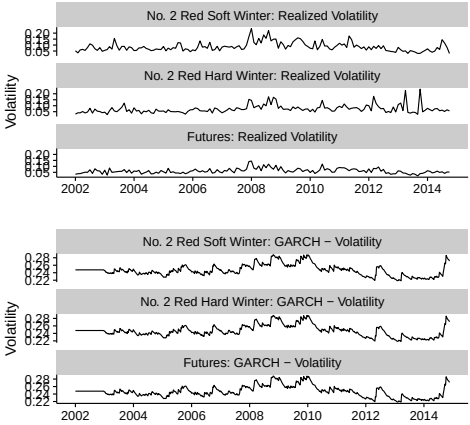


Figure 6: Volatility series



1. Realized Volatility:

$$\hat{\sigma} = \sqrt{\frac{1}{N-1}\sum_{t=1}^{N}(r_t - \bar{r})^2} \tag{2}$$

where

$$r_t = ln(p_t) - ln(p_{t-1}) \tag{3}$$

2. General Autoregressive Conditional Heteroskedasticity (GARCH) model:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p}\alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{q}\beta_j \sigma_{t-j}^2 \tag{4}$$

where

$$y_t = \mu_t + \epsilon_t \quad \epsilon_t|\omega_{t-1} \sim N(0, \sigma_t^2) \tag{5}$$

and

$$\alpha_0 > 0, \alpha_i > 0, \beta_j > 0, \sum_{i=1}^{p}\alpha_i + \sum_{j=1}^{q}\beta_j < 1 \tag{6}$$

1. VAR-X model (Volatilities are stationary time series)

$$y_t = v_0 + v_1 t + A_1 y_{t-1} + ... + A_p y_{t-p} + B_1 x_{t-1} + ... + B_q x_{t-q} + u_t \tag{7}$$

2. EGARCH-X model (asymmetric volatility model)

$$ln(\sigma_t^2) = \omega + \beta ln(\sigma_{t-1}^2) + \gamma \frac{\epsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|\epsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \delta x_{t-1} \tag{8}$$