The effects of maritime shipping disruptions on fertilizer prices

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October 2026

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Introduction

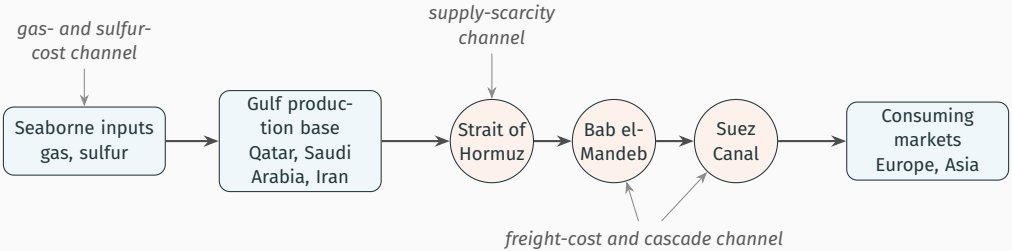
Fertilizer prices rose 40 to 100 percent in 2020–22 as a key corridor was disrupted

- Fertilizer prices are a primary determinant of global food costs, and traded fertilizer comes from **a few places**
- The **Persian Gulf** is the dominant one: about 41% of global urea exports come from producers whose shipments must transit the Strait of Hormuz; Saudi Arabia alone is 23% of global DAP exports (The Fertilizer Institute 2026)
- One third of seaborne fertilizer trade, close to 16 million tonnes, passes through Hormuz (UNCTAD 2026)
- COVID-19 and the Russia–Ukraine war disrupted this corridor in 2020–22 (Njoroge et al. 2023; Beghin and Nogueira 2021)
- **Freight, production and energy costs all moved together**, so the price record alone cannot say how much shipping caused

Question

How much do disruptions to maritime shipping raise fertilizer prices, and through which channels does a chokepoint disruption reach the farm gate?

A chokepoint disruption is not just a freight shock



- **Freight** is only one channel: a Hormuz closure also **traps Gulf production** at the terminal, and restricting LNG transit raises the feedstock cost of nitrogen fertilizer
- Gulf producers have **no bypass route** around Hormuz; westbound cargo then crosses the Bab el-Mandeb and Suez
- Identification needs **exogenous, supply-side** shipping shocks, separated from demand-driven freight movements

Preview of results

- A one-standard-deviation shipping disruption, which raises bulk freight about **12%** on impact, raises **all five** fertilizer prices persistently over 36 months
- Responses are **hump-shaped**, peaking 8 to 33 months out; potash and urea have the largest peaks, near 4%
- The ranking **inverts** between impact and peak: urea and DAP lead on impact (about 2.2% and 1.5%); potash starts near zero and builds to about 4.1%
- The shock explains about **27 to 29%** of urea and potash forecast error variance at 36 months
- It accounts for **at most 19 to 24%** of the 2020–22 DAP and urea price increases, an upper bound because the 2022 war confounds shipping with a direct gas-cost channel

The timing and ranking are consistent with a sequence of channels; the design supports this reading but does not identify them separately.

Contributions and related literature

1. **Causal estimate** of the effect of maritime shipping disruptions on fertilizer prices, using two independently constructed shipping shocks (Känzig and Raghavan 2025; Bini 2025)
2. **Transmission**: from chokepoint to farm gate it runs through more than freight
3. **Magnitude**: how much of observed fertilizer price movements shipping explains

- **Freight and commodity markets**: freight transmits to equities, futures and bulk routes (Andrikopoulos et al. 2025; Prokopczuk 2011; Kamrud et al. 2023); chokepoint disruptions raise shipping costs persistently (Merendino and Monacelli 2025; De Santis 2024). They take freight as given; here the upstream shock is identified
- **Gas-to-fertilizer pass-through**: asymmetric, lagged, regime-dependent (Kontsevaya 2025; Galbraith 2010)
- **Food security**: the 2021–22 shock cut profitability and adoption (Vos et al. 2025; Amankwah et al. 2025); here, a magnitude for the shipping channel
- **Closest**: Morão (2025a) (fertilizer supply shocks); here, one step upstream

Framework and Method

A simple framework: two exposures, different speeds

Under spatial arbitrage, the delivered price of fertilizer j is the export price plus the cost of moving it:

$$p_{j,t}^{\text{land}} = \underbrace{\gamma_j s_t}_{\text{supply scarcity}} + \underbrace{\tau_j f_t}_{\text{freight}} + \tilde{\zeta}_{j,t}$$

- γ_j: production concentration at the disrupted chokepoints; τ_j: freight intensity (higher for low value-to-weight, long-haul products)
- **Prediction 1**: both channels raise prices, so a shipping shock raises fertilizer prices
- **Prediction 2**: the cross-section follows γ_j (DAP, urea) and τ_j (potash: $\gamma_j \approx 0$, long routes, low value-to-weight)
- **Prediction 3**: s_t acts on impact, f_t builds, so the ranking **inverts** between impact and peak
- Predictions 4–5: a lagged gas-to-urea channel; phosphate rock leads finished phosphates (derived demand)

The mechanism most consistent with the estimated responses, not separately identified effects.

Value-to-weight

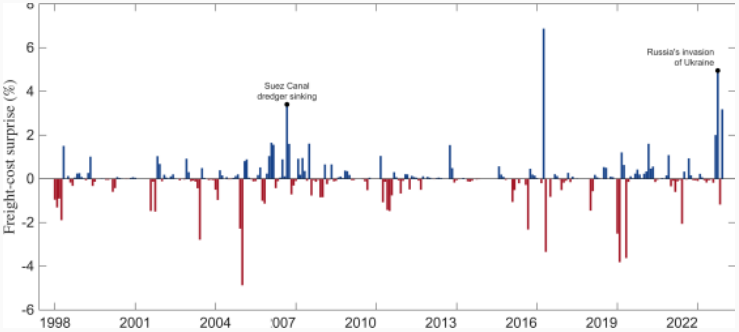
Data: monthly, January 1998 to December 2022 (300 observations)

Block	Variable	Source
Baseline instrument	Dry-bulk freight-cost surprise m_t	Känzig and Raghavan (2025)
Complementary	Carrier price-surcharge series z_t	Bini (2025)
Shipping, activity	Supply chain pressure (GSCPI); bulk shipping (Baltic Dry Index); global activity	Benigno et al. (2022); Baumeister et al. (2022)
Fertilizer prices	Phosphate rock, DAP, TSP, urea, potash (nominal USD)	World Bank Pink Sheet

- $n = 8$ endogenous variables; fertilizer and bulk shipping prices enter as $100 \times \log$ levels; a crisis dummy (COVID-19, Russia–Ukraine) is exogenous
- Start: earliest date with the supply-chain index; end: where m_t is defined. z_t runs February 2014 to December 2024
- Prices are **FOB export benchmarks**, not delivered (CIF) quotes: any freight absorbed in FOB prices would attenuate the measured response, not reverse it

Full table Series

The baseline instrument: a dry-bulk freight-cost surprise



Notes: Monthly surprise, in percent. Blue: adverse (cost-raising); red: improvement.

Ends December 2022.

- Fertilizers move as **dry bulk**: the shock is native to the freight market that carries them
- Exogenous, supply-side component of dry-bulk freight costs; orthogonal to global demand and geopolitical risk by construction
- First-stage F of about 24 (Känzig and Raghavan 2025)
- Largest late-sample surprises: autumn 2022 (Black Sea)

Identification: sign restrictions plus a correlation with the instrument

	gscpi	*bulk*	*gecon*	p^{ph}	p^{dap}	p^{tsp}	p^{u}	p^{k}
Shipping shock	+	+	−	+	+	+	+	**free**

- Signs imposed on impact, following Arias et al. (2018) and Ludvigson et al. (2021)
- **Correlation restriction**: $\rho_1 = \text{corr}(m_t, \eta_{1,t}) \geq \bar{c}$, with m_t the Känzig and Raghavan surprise; operationalised as three joint conditions on each draw
  - highest absolute correlation with m_t among all n shocks
  - highest squared correlation
  - p-value of the correlation test below 10%
- m_t is a **soft instrument** (Ludvigson et al. 2021; Georgiadis et al. 2024): it identifies through comovement, not a recursive ordering
- **Potash is left unrestricted**: it has no Gulf production exposure, so a positive response comes from the data, not the assumption

Complementary instrument

Estimation: Bayesian VAR with a Minnesota prior

- Reduced form, with a crisis indicator $\mathbf{x}_t$ as exogenous regressor:

$$\mathbf{y}_t = \mathbf{c} + \mathbf{A}(L)\mathbf{y}_{t-1} + \mathbf{D}\mathbf{x}_t + \varepsilon_t, \qquad \varepsilon_t = \mathbf{S}\eta_t, \qquad \Sigma = \mathbf{S}\mathbf{S}'$$

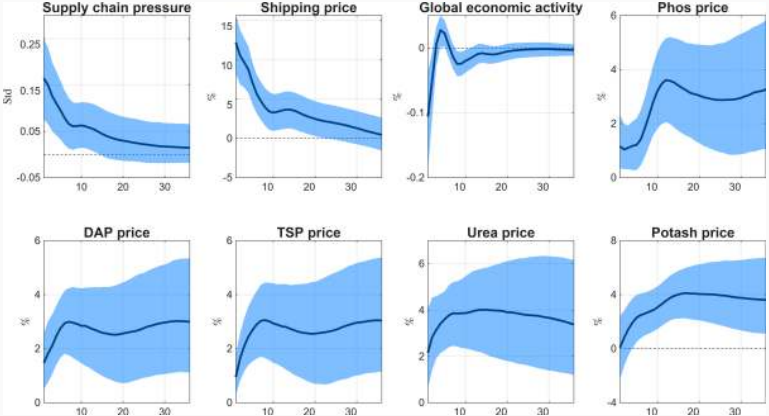
$$\mathbf{y}_t = (gscpi_t,\ bulk_t,\ gecon_t,\ p_t^{ph},\ p_t^{dap},\ p_t^{tsp},\ p_t^{u},\ p_t^{k})'$$

- Lag order $p = 12$ months; Minnesota prior (Litterman 1986), BEAR toolbox (Dieppe et al. 2016); 3,000 draws, 500 burn-in
- Impulse responses: one-standard-deviation shock; line is the posterior median, shaded areas are **68% credible bands**
- **Complementary specification**: the surcharge z_t ordered first as an internal instrument (Plagborg-Møller and Wolf 2021) in a nine-variable VAR

Prior and crisis dummy | Internal instrument

Results

Shipping disruptions raise all five fertilizer prices, with a hump



Notes: One-standard-deviation shock (bulk shipping price up about 12% on impact); posterior median and 68% credible bands; 36-month horizon.

- **Bulk shipping**: about 12% on impact, then eases; stays modestly positive
- **Supply chain pressure**: up on impact, decays over about two years
- **Global activity**: dips about 0.1 on impact, back to baseline within about half a year
- **Fertilizers**: hump-shaped, elevated at month 36; potash band includes zero at the shortest horizons

The cross-fertilizer ranking inverts between impact and peak

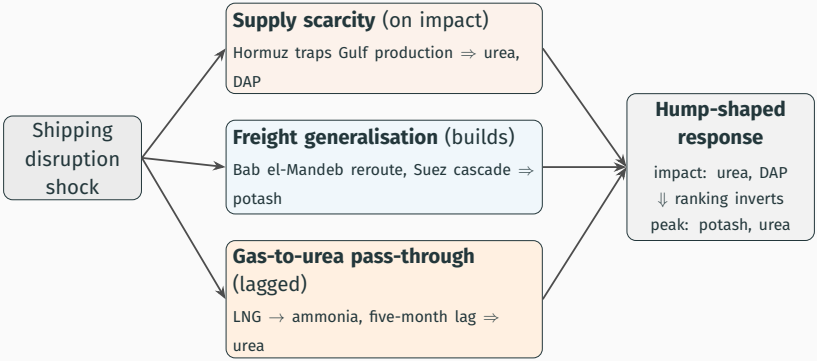
	Impact (%)	Peak (%)	Month of peak
Urea	2.2	4.0	15
DAP	1.5	3.0	broad
Phosphate rock	1.2	3.6	12
TSP	1.0	3.1	8
Potash	≈ 0	4.1	17

Notes: Posterior medians read from the baseline impulse responses. DAP builds slowly to a broad, imprecisely timed peak.

- **Impact**: urea and DAP lead. Gulf production is trapped behind Hormuz, with no bypass
- **Peak**: potash and urea lead. Potash has **no Gulf production exposure**, so its large response points to system-wide freight pass-through
- The inversion rests on these robust features, **not on DAP's own peak timing**, which is imprecise and varies across specifications

Bulk freight peaks on impact, yet fertilizer prices keep building for another 8 to 33 months

Reading the timing: three channels with different speeds



- An **interpretation**, grounded in the event composition of the surcharge catalogue, the response timing and the ranking
- The design identifies the **aggregate response**, not the individual channels

Fertilizer by fertilizer

The shock's share of price variance grows with the horizon

h	GSCPI	Bulk	GECON	Phos. rock	DAP	TSP	Urea	Potash
1	34.19	50.80	15.85	4.81	13.42	9.75	9.10	8.03
12	27.52	35.01	13.67	15.31	23.14	22.15	29.43	22.48
24	22.87	28.68	13.01	18.63	20.94	19.31	30.14	27.85
36	21.15	25.89	12.73	19.34	22.81	21.11	29.27	26.80

Notes: Posterior median share of forecast error variance (%) explained by the shipping disruption shock, baseline identification.

- Freight and supply chains: 51% of bulk shipping price variance on impact (26% at three years); 34% to 21% for supply chain pressure; 13 to 16% for global activity, so a **shipping and supply-chain disturbance**, not a broad demand factor
- At $h = 1$, DAP has the largest fertilizer share (about 13%); by $h = 36$ **urea and potash lead at about 27 to 29%**, with DAP, TSP and phosphate rock near 19 to 23%

Shipping explains at most 19 to 24 percent of the 2020–22 DAP and urea surge

	Contribution (log pts)	Share of increase
Phosphate rock	29.8	20.1%
DAP	25.0	18.7%
TSP	24.2	18.4%
Urea	38.5	24.1%
Potash	30.1	18.0%

Notes: Historical decomposition, baseline identification: cumulative contribution of the shock from 2020 to the price peak, in $100 \times \log$ points; share divides it by the observed increase.

- **2014–19**: the shock contributes negatively to DAP and urea (about -16 to -23 log points by 2015–16), when dry-bulk freight was exceptionally weak
- **2020–22**: the contribution turns positive and builds through 2022, adding 24 to 39 log points; 18 to 24% of the increases across the five fertilizers
- **Upper bound**: the 2022 war raised prices through shipping and, at once, through a direct natural-gas channel; the decomposition cannot separate them

Log-change specification

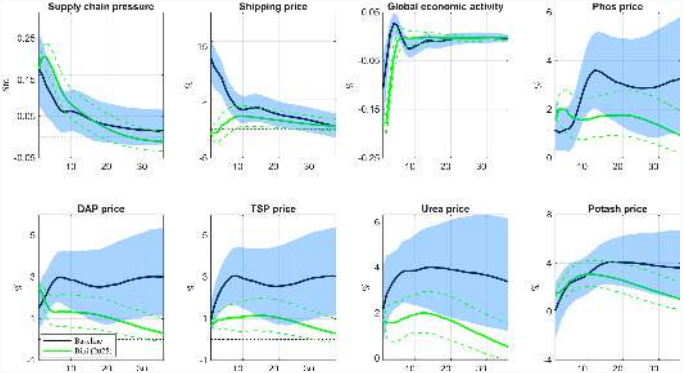
Freight pass-through can rationalise the size, but not the timing or ranking

- Transport costs add 12 to 39% to delivered fertilizer prices (Tonelli et al. 2024)
- With freight up about 12% on impact and about 2% once eased:

$$0.12 \times 2 \approx 0.2\% \qquad \text{to} \qquad 0.39 \times 12 \approx 4.7\%$$

- The estimated peaks of **3.0 to 4.1%** sit inside this wide range, so pass-through can rationalise their size at the upper end of the transport-share estimates
- **Magnitude alone does not establish a role for other channels**; that case rests on timing and ranking
  - bulk freight peaks on impact, yet fertilizer prices build for another 8 to 33 months
  - potash has the largest peak despite no Gulf production exposure
- Persistence at 36 months is consistent with new capacity taking 5 to 10 years to come online (Ott 2012)

A second, independent identification: carrier surcharges



Notes: Baseline (black, 68% band) vs. Bini (2025) surcharge internal-instruments recursive ordering (green); both normalised to a common supply-chain-pressure impact.

- Different instrument, different method: Cholesky ordering with the surcharge first
- Fertilizer prices rise and are hump-shaped under both
- Under the surcharge identification the responses are **smaller** and, in the figure, leave the baseline band in places (DAP, TSP, urea)
- The shipping-price response is far smaller, because ordering the surcharge ahead of freight absorbs the contemporaneous freight movement

Instrument details

Robustness summary

Check	Result
Identification	Surcharge instrument gives hump-shaped fertilizer responses of the same sign; smaller than baseline
Sample, 2008–22	Sign and hump shape kept; somewhat smaller peaks; DAP is the most timing-sensitive (peaks on impact)
Levels vs. changes	Historical decomposition keeps its sign; shares are about 40% (DAP) and 38% (urea), not directly comparable
Confounding uncertainty	Adding the energy transportation uncertainty index or geopolitical risk: responses lie almost exactly on the baseline
Lag length (4, 6, 9)	6 and 9 closely track the baseline; hump shape, peak ranking and the unrestricted potash response preserved at all three
Priors	Bayesian variants track the baseline; OLS gives wider bands and larger potash and urea responses
Deterministic terms	No dummy-initial-observation prior, linear trend, no constant: results not driven by these choices

2008–22 Uncertainty 4 lags OLS Trend

Conclusion

Policy discussion in the paper

- **No quick supply response**: persistence beyond 20 months reflects the multi-year delay before new capacity enters (Ott 2012), so market supply cannot stabilise prices in the short run after a major chokepoint disruption
- **Reserves**: the paper argues that strategic reserves of finished fertilizers, in particular DAP and MAP, are the most effective operational buffer; phosphate rock reserves give only partial protection, since conversion needs sulfur and ammonia with Gulf exposure
- **Potash**: its response means disruptions at any of the three chokepoints affect all fertilizer markets, so import policy should account for **system-wide shipping stress**, not corridor-specific risk alone
- Coordinate reserve design and route resilience across the **full fertilizer basket**

Conclusion

- Sign and correlation restrictions anchored to a dry-bulk freight-cost surprise identify a shipping disruption shock in a structural VAR; the surcharge internal-instrument specification is a complement
- A shock raising bulk freight about 12% on impact raises **all five** fertilizer prices persistently, with hump-shaped responses peaking between months 8 and 33
- The **ranking inverts**: urea and DAP lead on impact; potash, left unrestricted, builds from near zero to the largest peak
- The variance share grows with the horizon; **at most 19 to 24%** of the 2020–22 DAP and urea increases

Caveats stated in the paper

The channel reading is an interpretation, not separately identified; DAP's peak timing is imprecise; the 19 to 24% share is an upper bound because the 2022 war confounds the shipping and gas-cost channels.

Thank you! hmorao@phd.iseg.ulisboa.pt

Backup

Data description and sources

Label	Description	Source
m_t	Dry-bulk freight-cost surprise (baseline instrument)	Känzig and Raghavan (2025)
z_t	Price surcharge series (complementary instrument)	Bini (2025)
$gscpi_t$	Global Supply Chain Pressure Index	Benigno et al. (2022)
$bulk_t$	Bulk shipping price	Baltic Dry Index (BDIY:IND)
$gecon_t$	Global economic activity	Baumeister et al. (2022)
$p_t^{ph}, p_t^{dap}, p_t^{tsp}, p_t^{u}, p_t^{k}$	Nominal phosphate rock, DAP, TSP, urea, potash prices	World Bank Pink Sheet
$crisis_t$	Crisis indicator (COVID-19 and Russia–Ukraine war)	Author
etu_t	Energy Transportation Uncertainty index (robustness)	Morão (2025b)
gpr_t	Geopolitical Risk index (robustness)	Caldara and Iacoviello (2022)

Notes: All series monthly. Baseline: January 1998 to December 2022. Fertilizer and bulk shipping prices enter as $100 \times \log$; the supply-chain and global-activity indices enter in native units.

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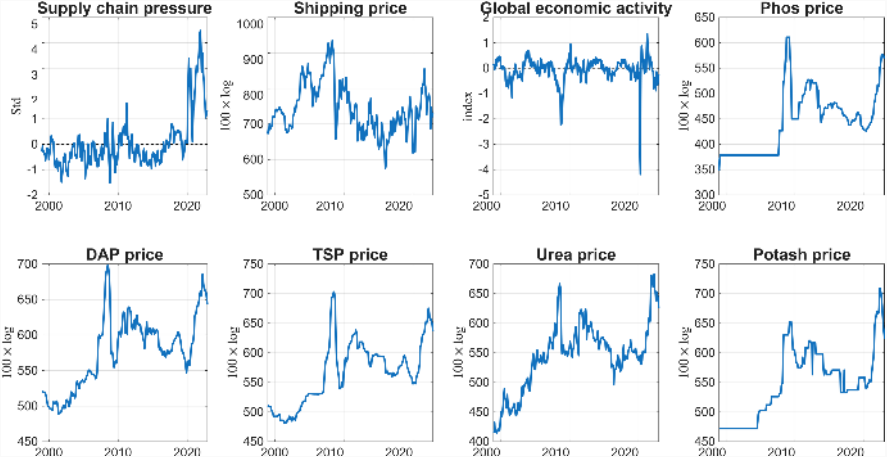
The data series in the baseline model



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Complementary instrument: carrier price surcharges

- Container carriers are an oligopoly: in 2014–2024 three alliances held 80 to 90% of global capacity (UNCTAD 2022)
- After an exogenous cost increase they impose **lane-wide surcharges**, encoding the scale and reach of the supply-side event
- z_t (Bini 2025): narrative series built from announcements of the three largest carriers; 62 events, February 2014 to December 2024
- z_t ordered first in the nine-variable VAR; impact vector from the Cholesky factor:

$$\mathbf{s}_1 = [\text{chol}(\boldsymbol{\Sigma})]_{\cdot,1} \,/\, [\text{chol}(\boldsymbol{\Sigma})]_{1,1}$$

- Requires relevance, contemporaneous orthogonality to other shocks and lead-lag exogeneity; the narrative construction restricts surcharges to validated supply-side disruptions
- The events mostly lie on the Gulf route (Hormuz, Bab el-Mandeb, Suez); two categories are route-independent (St. Lawrence low water, Panama Canal drought)

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Prior specification and crisis indicator

- **Minnesota prior** with full VAR residual variance (Litterman 1986); BEAR toolbox (Dieppe et al. 2016)
- AR(1) prior means: 0.95 fertilizer prices; 0.9 supply-chain pressure and bulk freight; 0.8 global activity; 0 for the shipping instruments
- Tightness: $\lambda_1 = 0.2$, $\lambda_2 = 0.5$, $\lambda_3 = 1$, $\lambda_4 = 10^5$; sum-of-coefficients $\lambda_6 = 10$; dummy-initial-observation $\lambda_7 = 1$ (Doan et al. 1984; Sims 1993)
- Prior on Σ: inverse-Wishart, scale from the full OLS residual covariance
- 3,000 draws, 500 burn-in; all bands are 68% credible intervals
- **Crisis indicator**: one in April to July 2020 and from March 2022 onward (in the baseline window, 2020m4–2020m7 and 2022m3–2022m12); exogenous, so the two episodes do not drive the estimated shipping-shock dynamics

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Value-to-weight and freight exposure

Fertilizer	Mean price (USD/tonne)	Freight share at $80/t
Phosphate rock	153	34%
Urea	341	19%
Potash (MOP)	381	17%
TSP	432	16%
DAP	471	15%

- Mean nominal price over 2008–2024 (World Bank Pink Sheet), a proxy for inverse freight intensity (Hummels 2007)
- Freight share $= f/(\bar{p}_j + f)$ with a common dry-bulk freight $f = \$80$ per tonne; illustrative, used only to rank freight intensities
- The other loading, Gulf export concentration γ_j: largest for DAP (about 23% of world exports through Jubail) and urea (about 41% Hormuz-exposed), near zero for potash

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Fertilizer by fertilizer: the paper's interpretation

Price	Impact → peak	Interpretation
Urea	2.2 → 4.0% (month 15)	Hormuz trapping (about 41% of global urea exports; Iran and Qatar 11% each, Saudi Arabia 8%), then gas-cost pass-through with a documented five-month lag (Kontsevaya 2025) and Bab el-Mandeb freight
DAP	1.5 → 3.0% (broad)	Hormuz traps Saudi Arabia's Jubail program (23% of global DAP exports); builds slowly via freight and cascade channels; Moroccan producers buffer, keeping the peak among the lowest, though cost-constrained by Gulf sulfur imports
Phosphate rock	1.2 → 3.6% (month 12)	Direct freight-intensity effect (largest freight share of the five), amplified by derived demand from non-Gulf processors; the series is a merchant benchmark
TSP	1.0 → 3.1% (month 8)	Lower direct Gulf exposure than DAP; costs rise with phosphate rock, with the same timing
Potash	≈ 0 → 4.1% (month 17)	Freight generalisation: spot freight shocks feed into pre-contracted routes progressively, annual contract renewals lock in higher prices, and substitution toward potassium raises demand

The paper offers these as interpretations grounded in timing and ranking, not as separately identified effects.

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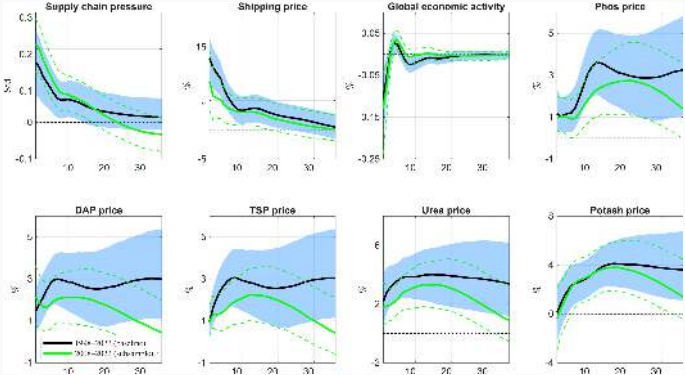
Subsample: 2008–2022 versus the baseline



- Black: baseline 1998–2022 with 68% band; green: 2008–2022. Sign and hump shape kept; the shorter sample gives somewhat smaller peaks
- DAP is the most timing-sensitive series: on the shorter sample it peaks on impact

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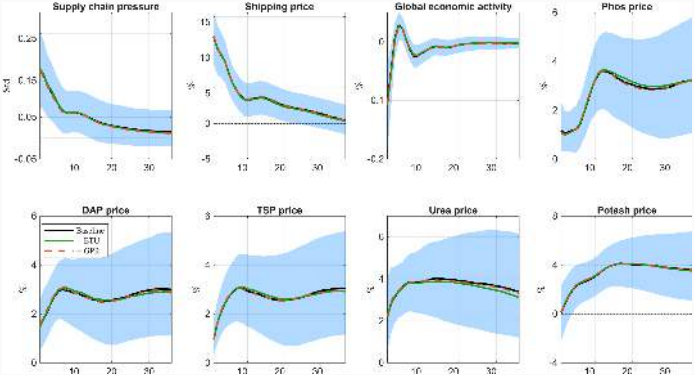
Controlling for uncertainty: ETU and geopolitical risk



- Baseline (black, 68% band) against specifications adding the Energy Transportation Uncertainty index (green) or the Geopolitical Risk index (dashed)
- Responses stay positive and lie almost exactly on the baseline

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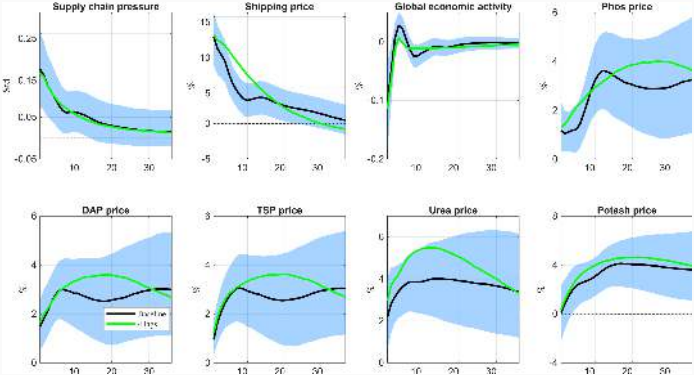
Lag length: four lags



- Magnitudes differ from the baseline at four lags; hump shape, peak ranking and the unrestricted potash response are preserved
- Six and nine lags track the baseline closely

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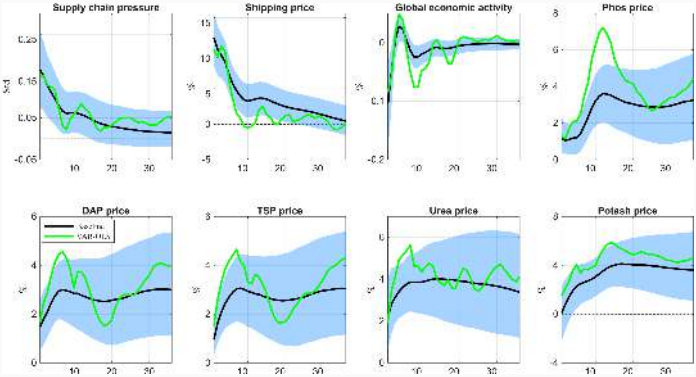
Prior sensitivity: minimal shrinkage (VAR-OLS)



- Directionally consistent, with larger potash and urea responses; the paper attributes this to the absence of prior shrinkage toward stationarity
- Normal-Wishart, independent Normal-Wishart, alternative hyperparameters, identity $\mathbf{S}_0$ and no sum-of-coefficients prior track the baseline

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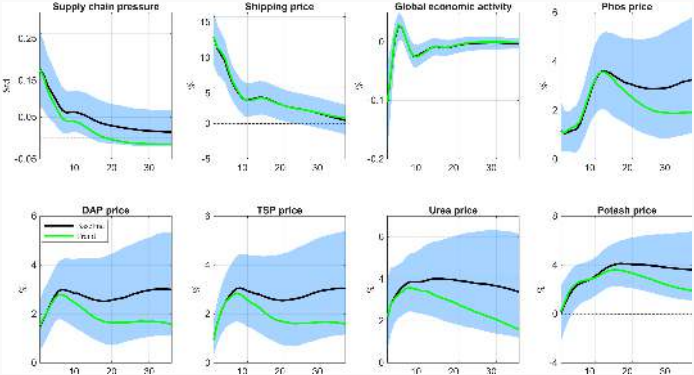
Deterministic components: linear trend



- Baseline with 68% band against a specification adding a linear trend; responses stay positive, and the paper concludes the results are not driven by this choice
- In the figure, long-horizon responses of DAP, TSP and urea are lower with the trend

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Historical decomposition with prices in log-changes

- Baseline enters fertilizer prices in log levels. Re-estimated with prices in **log-changes**, AR prior means set to zero, and the historical decomposition recomputed
- The shock contributes negatively over the pre-pandemic 2010s and turns strongly positive through the 2020–22 surge: **same sign** as in levels
- Cumulated over 2020–22, it accounts for about **40%** of the DAP increase and **38%** of the urea increase
- Larger than the level shares because differencing removes the persistent level drift; the two normalise by different bases, so the shares are **not directly comparable**
- The upper-bound caveat for 2022, where shipping and gas-cost channels cannot be separated, applies to both

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