

The economic consequences of fertilizer supply shocks

Food Policy, 2025

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Motivation

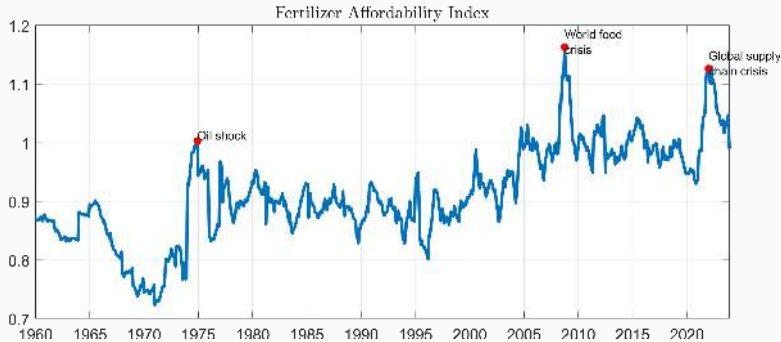
Fertilizers matter for food, and their supply is fragile

- Commercial fertilizers contribute **30–50%** of global crop yields (Stewart et al. 2005)
- Fertilizer prices have trended up relative to grain prices since the 1970s oil shock, with volatility intensifying; large surges coincided with the 2008 crisis and Covid-19 supply chains (Beghin and Nogueira 2021)
- The industry has a history of **cartelization** (Newman 1948; Gnutzmann and Spiewanowski 2014); phosphorus and potash reserves are geographically concentrated
- Fertilizers are about 44% of food commodity costs, more than direct energy use (Gnutzmann and Spiewanowski 2016)

Question

A major input in many food supply chains, hence a **potential stagflationary** source: how do fertilizer supply disruptions propagate to the food industry and the macroeconomy?

Fertilizer prices relative to grains: recurring spikes



Notes: Ratio of the World Bank fertilizer price index (DAP, phosphate rock, potassium chloride, TSP, urea) to its grains price index. Marked: the oil shock, the world food crisis, the global supply chain crisis.

- The pattern reflects the industry's oligopolistic nature and its exposure to supply disruptions (paper's reading)

What the paper does

- Builds a **fertilizer supply news index**: text mining of English-language newspaper articles from over 30 countries, following Baker et al. (2016)
- Estimates a **structural Bayesian VAR** for the Portuguese food industry: turnover (domestic and non-domestic), output prices (home and foreign), hours worked, gross wages
- **Identifies** the shock with three layers: correlation with the news index, block exogeneity, and sign, zero and variance restrictions
- Feeds the shock into a recursive VAR to trace **macroeconomic effects**

Why Portugal

Small open economy, food importer. The monthly industrial survey has labor (hours, wages) and home versus foreign market variables, often missing from similar studies.

Preview of results

- **Output prices** rise immediately, in home and foreign markets; the paper reads this as firms passing costs to consumers, with **turnover** rising, more so at home
- **Hours and wages** do not move on impact and rise after several months
- Fertilizer supply shocks explain **39% (home) and 26% (foreign)** of output price forecast error variance on impact, 52% and 47% at 24 months
- Macro: industrial production falls, unemployment and economic policy uncertainty rise, share prices fall, core consumer prices rise; the paper reads the shock as a genuine **supply shock**

Identified under assumptions (block exogeneity, zero and sign restrictions); the mechanisms are the paper's interpretation, not tested separately. One country, one industry.

Related literature and contribution

1. **Supply bottlenecks and the macroeconomy:** container shipping (Kilian et al. 2023), semiconductor export restrictions (Funke and Wende 2022), reorientation of supply chains (Clancy et al. 2024; Finck and Tillmann 2023), energy (De Santis 2024). Little evidence on fertilizer or food supply chains
2. **Fertilizer and agricultural economics:** mostly micro, development and spatial (Marenya and Barrett 2009; Barrett et al. 2010; Sheahan and Barrett 2017; Spielman et al. 2022; Amare et al. 2024; Abay et al. 2024)
3. **Macro and financial effects of fertilizer prices:** a niche area (Walker 2017; Ott 2012)

Contribution

(i) A fertilizer-specific news index, built like the text indices of Baker et al. (2016), Young et al. (2021) and Burriel et al. (2024) but with a longer history and a wider country scope; (ii) industry-level evidence including labor and foreign-market variables; (iii) an identification scheme the paper offers as replicable for other traded commodities.

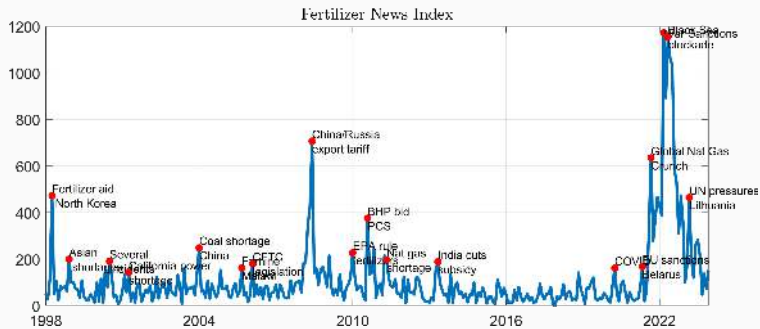
Data and Method

The fertilizer supply news index

- A supply constraint is any disruption or adverse event affecting fertilizer supply chains, **anticipated or realized** (Young et al. 2021; Burriel et al. 2024): export bans, tariff hikes, subsidy cuts, sanctions, shortages of natural gas or coal, aid agreements, soil health policies
- Relative frequency of English-language articles from over 30 countries, with keywords in two blocks (Baker et al. 2016):
 - **Fertilizer**: “fertilizer”, “potash”, “ammonia”, or fertilizer-industry news
 - **Supply**: “shortage”, “scarcity”, “backlog”, “disruption”, “bottleneck”
- A fertilizer keyword must appear in the headline or leading paragraphs; length above 99 and up to 2,000 words
- Excluded: news summaries, calendars, corporate digests, rankings, routine financial updates, interviews, commentaries
- A proxy for **actual and anticipated** supply shocks

Events table

The index tracks documented supply events



- The paper reviews the articles behind each peak. Labelled peaks include the 2008 Chinese export tariffs, the 2010 BHP bid for Potash Corp., the 2021 natural gas crunch and EU sanctions on Belarus, the 2022 war, sanctions and Black Sea blockade, and the 2023 UN pressure on Lithuania
- Many peaks are policy or geopolitical events, which supports its use as a source of supply variation

Variable	Block	Source
Fertilizer price index	Commodity	World Bank
Brent oil price, real	Commodity	FRED
Turnover, domestic and non-domestic	Food industry	INE industrial survey
Output prices, home and foreign market	Food industry	INE industrial survey
Hours worked and gross wages	Food industry (labor)	INE industrial survey

- Monthly, January 2005 to December 2023 (text), spanning the 2007–08 food crisis and the recent commodity boom; seasonally adjusted with X12; annual growth rates
- Brent: production and transport costs and a barometer of global uncertainty
- Macro variables, added later: industrial production, consumer prices, unemployment, share prices, policy uncertainty

[Data series](#)[All variables](#)

Model: a Bayesian VAR with a Minnesota prior

$$y_t = \sum_{\ell=1}^L \mathcal{A}_\ell y_{t-\ell} + x_t + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \Sigma), \quad y_t = (\zeta_t, p_t^o, t_t, t_t^*, \pi_t, \pi_t^*, w_t, h_t)$$

- ζ : fertilizer price; p^o : real Brent; t, t^* : domestic and non-domestic turnover; π, π^* : home and foreign output prices; w : gross wages; h : hours
- $L = 12$ lags; x_t holds a constant and the economic policy uncertainty index for Portugal (Morão 2024)
- **Minnesota prior** (Litterman 1986): tightness $\lambda_1 = 0.2$, cross-variable $\lambda_2 = 0.5$, lag decay $\lambda_3 = 1$, exogenous $\lambda_4 = 10^5$; sum-of-coefficients and initial-observation priors ($\lambda_6 = \lambda_7 = 1$) (Sims and Zha 1998)
- 5,000 draws, 2,000 discarded; hyperparameters standard in the literature (Dieppe et al. 2016)
- Structural form $\varepsilon_t = \mathcal{D}\eta_t$: the supply shock is $\eta_{1,t}$, the first column of $\mathcal{D}$

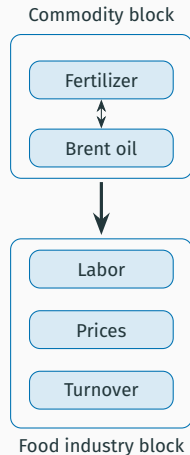
Identification, layer by layer

1. **Correlation restriction** (Ludvigson et al. 2021):

$$\text{corr}(S_t, \eta_{1,t}) \geq \bar{c}$$

with S_t the news index, external to the VAR. Price rises that coincide with index spikes are classed as supply

2. **Block exogeneity**: commodity prices affect Portuguese variables, not the reverse; fertilizer does not affect Brent
3. **Sign, zero and variance restrictions**, with the algorithm of Arias et al. (2018)



Sign, zero and variance restrictions

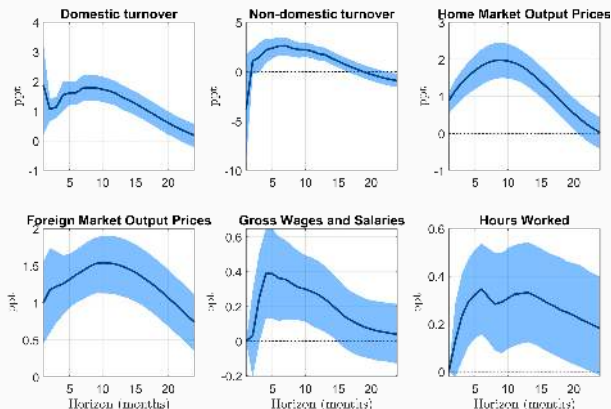
Shock / variable	ζ_t	p_t^o	t_t	t_t^*	π_t	π_t^*	h_t	w_t
Fertilizer supply	↑	o			↑	↑	o	o

Notes: Table as in the paper; blank cells carry no restriction in the table. The text also says turnover does not react on impact.

- **Zero on real activity:** real variables react with an adjustment lag; this separates the shock from aggregate supply and demand shocks
- **Prices up:** fertilizer prices matter for crop yields; Brunelle et al. (2015): annual rises of 1 to 3% imply yield drops of 6 to 13% by 2050. Sign restrictions hold on impact and in the first month
- **Zero on Brent:** separates fertilizer-specific supply from broader commodity shocks
- **Variance:** the shock accounts for the majority of fertilizer price variation on impact (Weale and Wieladek 2016)

Results

Impulse responses: prices first, labor later



Notes: Posterior median and 68% credible bands, horizon in months.

- **Output prices:** both rise immediately, peaking around month 10; the home peak is 0.5 percentage points above the foreign
- **Domestic turnover:** rises and stays positive for about two years
- **Non-domestic turnover:** a lag before the increase
- **Wages and hours:** no clear reaction on impact, then both rise

How the paper reads these responses

- **Cost pass-through:** higher input costs and inelastic food demand let producers raise prices without large drops in sales; turnover rises, though the paper notes this need not protect margins
- **Home versus foreign:** the paper offers more inelastic home demand, home market power and export logistics costs as explanations for the larger home price response
- **Foreign turnover lag:** possibly contracts negotiated in advance and initial resistance of elastic foreign demand
- **Labor:** slow, as wage adjustment needs negotiations and fixed-term contracts; wages and hours rise as inflation expectations adjust

Caveat

These channels are interpretations of the impulse responses, not separately tested. The paper writes “can be attributed” and “likely”.

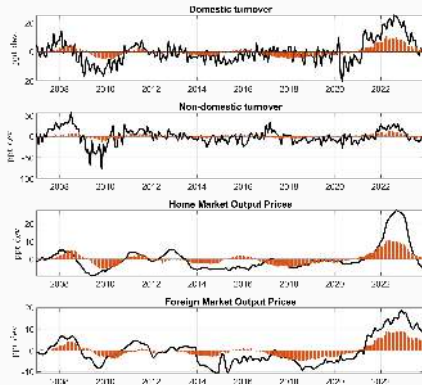
How much do the shocks explain? Variance decomposition

Horizon (months)	t	t^*	π	π^*	h	w
0	10.31	9.58	38.58	26.21	0.00	0.00
12	13.83	9.97	42.66	31.90	0.54	0.69
24	29.36	15.12	51.84	46.78	3.74	4.78
48	29.27	15.07	43.78	46.66	4.37	6.24

Notes: Share of forecast error variance explained by fertilizer supply shocks, per cent. t , t^* : domestic and non-domestic turnover; π , π^* : home and foreign output prices; h : hours; w : wages.

- **Prices** absorb most: 39% home and 26% foreign on impact
- **Labor** stays near zero at 12 months and reaches 4–6% at 48 months
- Domestic turnover more than doubles its share by month 24 (14% to 29%)

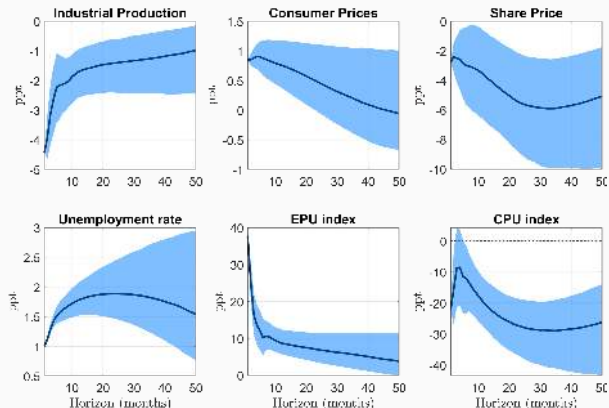
Historical decomposition: three episodes



Notes: Line: actual series; bars: contribution of the shock (reading of the figure). Four panels: turnover and output prices.

- **2007–08 food crisis**: the contribution grows as the crisis unfolds; the paper notes that droughts, oil and transport costs also played a part
- **2011–12**: the shock cannot account for the movements. The paper reads this as a **contrast**: demand-driven (biofuels, Abbott et al. (2011)), not fertilizer supply
- **2020–22**: Covid-19, then Russia's invasion: EU sanctions on Belarusian and Russian potash producers and natural gas constraints
- At the peak, the shocks account for about **50% (foreign) and 40% (home)** of output price variation

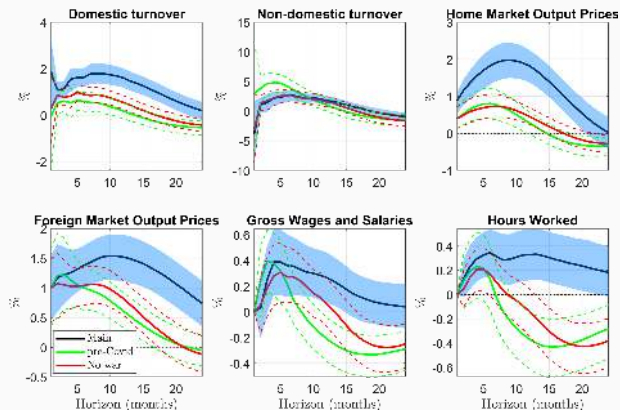
Macroeconomic effects: a supply shock



Notes: Shock ordered first in a recursive VAR; normalized to raise consumer prices by 1 point on impact; median and 68% bands.

- **Industrial production:** immediate fall, sustained for about three years
- **Core consumer prices:** rise for about two years; the paper calls it cost-push inflation
- **Share prices** fall; **unemployment** is hump-shaped, peaking at the start of year three
- **Economic policy uncertainty** rises; **climate policy uncertainty** falls, which the paper reads as a temporary shift of policy priorities
- Activity down and prices up: the signature of a supply shock

Sensitivity to the sample: Covid-19 and the war



Notes: Main model (blue) against a pre-Covid sample (green) and a sample excluding the Russian invasion (red).

- **Same signs on impact**, but **less inflation and lower persistence** without these events: prices decay faster
- Non-domestic turnover responds immediately before Covid, with a lag after
- **Labor** effects are weaker, with negative values after the second year; the paper links this to lower inflation expectations in 2008–12
- The size and persistence of the main results depend on the sample

Other robustness checks

- **Alternative fertilizer price:** DAP, triple superphosphate, urea, phosphate rock, potassium chloride, and the European natural gas price
- **Specification:** add the real effective exchange rate; drop the policy uncertainty regressor; VAR(3) and VAR(6)
- **Priors:** Normal-Wishart, diffuse, Normal-Wishart diffuse, $\lambda_1 = 1$ and $\lambda_2 = 2$, grid-searched hyperparameters, diagonal S_0 , no sum-of-coefficients, no cointegration prior
- **Deterministic terms:** linear trend; no constant

Paper's assessment

The results are robust to a substantial degree of change in specification. The figures are in the paper's appendix; the paper does not tabulate numerical differences.

DAP price VAR(3)

Conclusion

Limits

- **One small open economy, one industry:** the paper suggests extending to other countries and regions
- **Identification rests on assumptions:** block exogeneity, zero restrictions on real variables and Brent, sign restrictions on prices
- The news index is a **proxy**: article frequency, not a measured quantity of supply
- Mechanisms (pass-through, elasticities, contracts, wage setting) are **interpretations** of the responses
- Magnitudes depend on the sample: weaker and less persistent without Covid-19 and the war

Next step

Other countries and regions; the news index in broader macroeconomic models, to follow effects beyond the food industry.

Conclusion

- A fertilizer supply news index and a structural BVAR show that supply shocks raise food-industry **output prices** immediately, with **turnover** up and **labor** adjusting later
- Shocks explain a large share of price variation (up to about 52% at 24 months) and shaped the 2007–08 crisis and the Covid-19 and war period, but not 2011–12
- Macro effects look like a **cost-push supply shock**: output down, prices up
- **Policy**, as the paper argues: ease supply-side vulnerabilities and price spikes, e.g. research on alternatives such as green ammonia, market diversification, and farming practices that use fertilizer more efficiently

Thank you!

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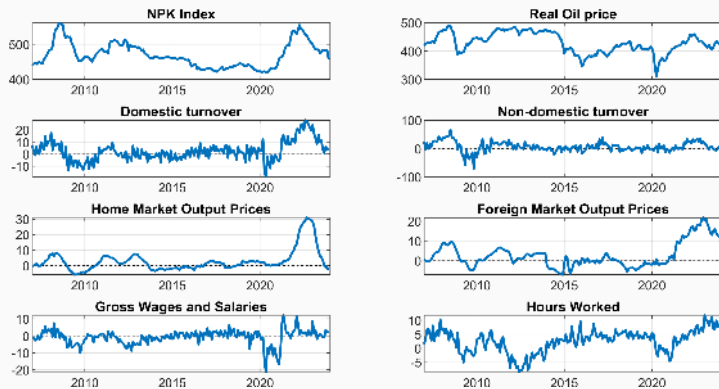
Backup

Selected events behind the index peaks

Date	Source	Description
1998m4	Reuters	North Korea proposes talks with South Korea on fertilizer aid
2004m1	China Chemical	Coal shortage in Shanxi halts many nitrogenous fertilizer producers
2008m4	Financial Times	Beijing imposes export tariffs of up to 135% on fertilizer
2010m8	The Globe and Mail	BHP Billiton's hostile bid for Potash Corp.
2011m5	Hindustan Times	Natural gas shortages in India affect fertilizer production
2020m4	The Times	UN warns of a food supply crisis as Covid-19 restrictions limit farmers' access to inputs
2021m5	The Globe and Mail	Potash prices rise over 25% amid expected sanctions on Belaruskali
2022m3	South China Morning Post	Russian invasion and sanctions disrupt fertilizer supply to Africa
2022m5	DJ News	Black Sea blockade prevents Ukrainian grain exports
2023m3	Baltic Daily	UN committee recommends Lithuania review its Belarusian fertilizer transit ban

Notes: Condensed from the paper's news appendix (15 events).

The food industry series in the baseline model



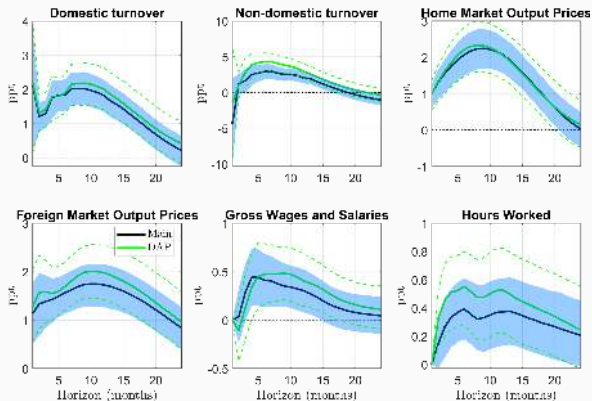
Notes: Figure from the paper: the food industry series in the baseline model, 2007 onward.

Data description and sources

Variable	Source
Fertilizer price index; phosphate rock, potassium chloride, DAP, urea, TSP (USD/MT)	World Bank
Brent oil, real (deflated by euro area HICP)	FRED
Natural gas in the EU, real	World Bank
Domestic and non-domestic turnover, output prices (home, external), hours worked, gross wages (Base 2015)	INE / own
Industrial production, consumer prices, unemployment rate, share prices (Portugal)	FRED
Economic policy uncertainty index for Portugal	Morão (2024)
Climate policy uncertainty index for Portugal	not stated in the table

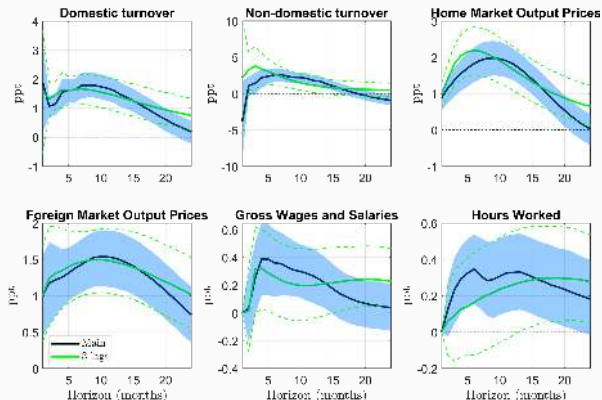
Notes: The appendix table states monthly data for 2005m1–2022m12; the text states January 2005 to December 2023.

Robustness: DAP price as the fertilizer price indicator



Notes: Figure from the paper's sensitivity appendix.

Robustness: VAR(3)



Notes: Figure from the paper's sensitivity appendix: results from a VAR(3).

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