A Global Fertilizer Price Projection Model for Market Disruptions

Shawn Arita* Rwit Chakravorty Jiyeon Kim Ming Wang
Sandro Steinbach

April 14, 2026

Abstract

This paper develops a global fertilizer price projection model for market disruptions: a hybrid structural vector autoregression–partial equilibrium (SVAR-PE) framework for projecting fertilizer price paths under short-term supply disruptions. The model covers urea, DAP, MAP, and ammonia over a 25-month horizon, integrating three components: (i) a partial equilibrium solver with country-specific affordability elasticities estimated via instrumental variables on 25 years of bilateral trade data; (ii) an Engle-Granger error-correction mechanism governing price adjustment toward partial equilibrium, with SVAR-based channel decomposition and asymmetric price adjustment and (iii) disruption transmission modules capturing LNG feedstock cascades, sulfur supply cascades, and natural gas cost-push effects. The model is applied to the 2026 Strait of Hormuz disruption under three reopening scenarios. The analysis highlights an asymmetric shock structure in which fertilizer input costs rise sharply without a corresponding increase in crop revenues, generating affordability ratios that exceed the 2022 Russia-Ukraine crisis.

Keywords: fertilizer markets; Strait of Hormuz; partial equilibrium; crisis modeling; agricultural input costs; affordability elasticity; SVAR; error-correction mechanism

JEL Codes: Q11; Q17; Q18; F14; C32; C63

---

*All authors are with the Agricultural Risk Policy Center (ARPC), North Dakota State University, Fargo, ND. Corresponding author: Shawn Arita (shawn.arita@ndsu.edu). Rwit Chakravorty (rwit.chakravorty@ndsu.edu), Jiyeon Kim (jiyeon.kim@ndsu.edu), Ming Wang (ming.wang.2@ndsu.edu), and Sandro Steinbach (sandro.steinbach@ndsu.edu). NDSU-ARPC Working Papers are preliminary drafts circulated for professional comment.

1 Introduction

Fertilizer markets are periodically subject to acute supply disruptions, including geopolitical conflicts, trade policy actions, and infrastructure failures, that produce large, rapid price movements with direct consequences for agricultural input costs and food security. Despite the policy significance of these episodes, the literature lacks a unified framework capable of projecting product-level fertilizer price paths under alternative disruption scenarios while capturing the heterogeneous demand responses of major importing regions. Existing approaches either rely on reduced-form time series models that cannot incorporate structural supply shocks, or employ partial equilibrium frameworks that impose instantaneous price adjustment inconsistent with observed market dynamics.

This paper addresses that gap by developing a hybrid structural vector autoregression–partial equilibrium (SVAR-PE) framework that combines the structural identification strengths of both approaches. The model makes three methodological contributions. First, we estimate country-specific affordability elasticities via IV-2SLS on 25 years of monthly bilateral trade data, using a doubly country-specific specification that conditions import demand on the fertilizer-to-crop price ratio rather than on the fertilizer price alone. This specification captures a feature that standard import demand models miss: identical price increases produce fundamentally different demand responses depending on the crop revenue environment facing each importing region. Second, we estimate an EngleGranger error-correction mechanism governing price adjustment toward equilibrium, incorporating asymmetric adjustment dynamics and an endogenous destocking trigger. The ECM determines *how fast* prices converge to equilibrium, while the PE model determines *where* they converge to, and the SVAR provides structural channel decomposition for shock attribution. Third, we model multi-channel disruption transmission, including direct supply loss, LNG feedstock cascades to nitrogen producers, sulfur supply cascades to phosphate producers, gas-cost curtailments, and TTF-driven ammonia cost-push, allowing the framework to capture second-order effects that single-channel models overlook.

We apply the model to the 2026 Strait of Hormuz crisis, the most significant disruption to global fertilizer trade since the 2022 Russia-Ukraine war. The application demonstrates the model's capacity to distinguish between symmetric shocks (where input costs and crop revenues move together, as in 2022) and asymmetric shocks (where only input costs rise, as in 2026), producing materially different affordability and demand destruction trajectories under each structure.

The rest of the paper is organized as follows. Section 2 presents the model architecture and core equations. Section 3 documents the demand elasticity estimation. Section 4 presents the SVAR decomposition and ECM calibration. Section 5 describes the PE price simulation framework, including the scenario structure and blockage schedules. Section 6 details the disruption transmission channels. Section 7 reports headline results, purchasing window implications, and demand destruction estimates. Section 8 discusses the asymmetric shock framing that distinguishes the 2026 crisis from 2022.

2 Model Architecture

The model is a hybrid SVAR-PE framework. The partial equilibrium (PE) component determines where prices should move by solving for the market-clearing equilibrium given supply and demand conditions. The speed at which observed prices converge to this equilibrium is estimated using an Engle–Granger error-correction model (ECM), while the structural vector autoregression (SVAR) component decomposes price dynamics into underlying structural channels, including energy costs, trade policy, Gulf supply disruptions, and agricultural demand. All price paths are anchored to observed spot prices, ensuring that model projections do not drift from observable market reality.

2.1 Core Algorithm

For each product × scenario × month t, the model proceeds in three steps:

Step 1 — PE Solver. Bisect on the price ratio $r = P/P_0$ to find the market-clearing price. Aggregate demand is computed as the sum of country-specific isoelastic demand functions. Supply is the sum of rest-of-world production response and residual Gulf capacity, net of cascade disruptions.

Step 2 — ECM Dynamics. The observed (actual) price path is computed via an Engle–Granger error-correction mechanism that adjusts toward the PE equilibrium at an empirically estimated adjustment speed. Asymmetric adjustment and an endogenous destocking module are layered on top of the symmetric ECM, while the SVAR informs structural channel decomposition.

Step 3 — Product-Specific Modules. For certain products, additional transmission channels are layered on top of the PE path. For ammonia, this includes TTF gas cost-push effects and urea feedstock demand-pull.

2.2 Product and Regional Coverage

The model covers four globally traded fertilizer products: urea, DAP, MAP, and anhydrous ammonia. Each product is modeled with nine import demand regions: USA, Brazil, EU-27, SE Asia, Latin America (non-Brazil), India, Canada, Pakistan, and a rest-of-world (ROW) aggregate. Gulf (Persian Gulf) supply and rest-of-world supply are calibrated from GTA bilateral trade data.

2.3 Temporal Structure

The model simulates a 25-month horizon ($t = 0$ to $t = 24$), where $t = 0$ corresponds to March 2026 (the month of the crisis onset) and $t = 24$ corresponds to March 2028. Month $t = 0$ is anchored to the pre-crisis baseline price (P_0, February 27, 2026 NOLA spot). Month $t = 1$ is anchored to the most recent observed spot price (P_1, April 10, 2026). Months $t \geq 2$ are projected forward using the ECM dynamics described in Section 4.

3 Demand Elasticities

3.1 Estimation Strategy

Import demand is modeled using country-specific isoelastic demand functions. The key behavioral parameter is the affordability elasticity which is the percentage change in import demand in response to a one-percent change in the fertilizer-to-crop price ratio. This specification captures the fundamental economic logic that a farmer's willingness to purchase fertilizer depends not on the fertilizer price in isolation, but on the ratio of input cost to expected crop revenue.

Elasticities are estimated via two-stage least squares (IV-2SLS) on monthly bilateral trade data from S&P Global Trade Atlas (GTA), aggregated to the importer-product-month level over 2000–2025. The estimation equation takes the form:

$$\Delta_{12} \ln(M_{it}) = \beta \times \Delta_{12} \ln\left(\frac{UV_{it}}{P_{it}^{\text{crop}}}\right) + X_{it}\gamma + \varepsilon_{it} \tag{1}$$

where M_{it} is import quantity for region i in time t, UV_{it} is the CIF unit value (value/quantity) serving as a country-specific import price proxy, and P_{it}^{crop} is a production-weighted composite of crop prices in importing country i. To remove seasonality, all variables are log-transformed and then differenced over 12 months (Δ_{12}). X_{it} is the CBOT corn price, used as a proxy for derived demand to control for other factors that may affect import responses. The specification is "doubly country-specific" in that both the price numerator (CIF unit value rather than a global benchmark) and the price denominator (local crop price composite) vary at the country level.

Identification relies on instrumental variables to address the endogeneity of unit values. Instrumental variables are TTF natural gas prices for urea and U.S. NOLA sulfur prices for DAP. The curated parameter set reflects a weighted synthesis of IV-2SLS pooled and country-specific OLS estimates, with expert adjustment for countries where econometric identification is contaminated by structural breaks (e.g., the 2022 Russia-Ukraine shock) or government intervention (e.g., India's NBS subsidy mechanism). A detailed working paper documenting the full estimation methodology, instrument validity diagnostics, and robustness checks is forthcoming (Kim and Arita, 2026).

3.2 Demand Equation

For each region i and month t, import demand is computed as:

$$D_i(t) = \Big(M_i + C_i(t)\Big) \times s_i(t) \times r^{\varepsilon_i} \tag{2}$$

where $r = P/P_0$ is the price ratio relative to pre-crisis, ε_i is the region-specific affordability elasticity, M_i is the baseline annual import volume, $s_i(t)$ is the month-specific seasonal import share for region i calibrated from 2000–2025 GTA bilateral trade data (see Section 5 for details and robustness to uniform 1/12 weights), and $C_i(t)$ is the LNG cascade demand allocated to region i at time t (urea only; zero for other products). Total demand is the sum across all nine regions:

$$D_{\text{total}}(t) = \sum_i D_i(t) \tag{3}$$

Regional import demand baselines (M_i, MMT/yr) are computed as 2022–2024 average annual import volumes from GTA bilateral trade data.

3.3 Results by Product

MAP elasticities are derived primarily from DAP proxies due to limited direct estimation data for monoammonium phosphate trade. Ammonia elasticities are dominated by structural judgment given the thin merchant market and captive-use nature of most ammonia trade. The complete MAP and ammonia elasticity tables are documented in the companion estimation paper (Kim and Arita, 2026).

Table 1: Demand Elasticities for Urea

Region	Elasticity	Basis	Notes
USA	−0.25	Econometric	Down-weighted pooled urea estimate (IV-2SLS).
Brazil	−0.45	Econometric	Upper-bound estimate; world's largest commercial urea importer after 2018 (India imports more by volume but through government tenders under the NBS subsidy regime).
EU-27	−0.45	Judgment	Own-cell estimate is near zero due to contamination from the 2022 gas shock; calibrated using the literature range of −0.45 to −0.55.
SE Asia	−0.50	Econometric	OLS spot estimate of −0.53***.
LatAm	−0.47	Econometric	IV-2SLS estimate of −0.47***.
India	−0.10	Judgment	Reflecting subsidy buffer.
Canada	−0.20	Judgment	Near-zero own-cell estimate; substantial domestic urea production.
Pakistan	−0.15	Judgment	Largely self-sufficient; imports mainly reflect emergency shortage purchases.
ROW	−0.45	Econometric	Pooled urea anchor; trade-weighted average.

Source: Kim and Arita (2026), Table 13. IV-2SLS on 2000–2025 monthly bilateral trade data (GTA). Econometric = derived directly from regression estimates. Judgment = informed by regression output but adjusted for structural factors.

Table 2: Demand Elasticities: DAP

Region	Elasticity	Basis	Notes
USA	−0.40	Econometric	Pooled DAP anchor; own-cell brackets pooled (OLS −0.65, IV −0.38).
Brazil	−0.40	Econometric	Pooled DAP anchor; largest DAP importer.
EU-27	−0.40	Econometric	Average of IV −0.35* and OLS −0.43***.
SE Asia	−0.55	Econometric	Compromise between own spot (−1.41**) and pooled anchor.
LatAm	−0.44	Econometric	IV-2SLS −0.44*.
India	−0.10	Judgment	Reflecting subsidy buffer.
Pakistan	−0.25	Judgment	Government-tender lumpy purchases; down-weighted from pooled.
Canada	−0.35	Econometric	Pooled DAP anchor, slight down-weight.
ROW	−0.40	Econometric	Pooled DAP anchor.

Source: Kim and Arita (2026), Table 13. IV-2SLS on 2000–2025 monthly bilateral trade data (GTA). Econometric = derived directly from regression estimates. Judgment = informed by regression output but adjusted for structural factors.

4 Structural VAR Decomposition

The SVAR component (Chakravorty and Arita, 2026) serves two functions in the integrated model. First, it provides structural channel decomposition of fertilizer price dynamics, including energy costs, China trade policy, Gulf supply, and agricultural demand, which informs scenario calibration and policy attribution. Second, the SVAR impulse response functions inform the Engle–Granger error-correction mechanism used to estimate the adjustment speed parameter ϕ governing how rapidly actual market prices converge toward the PE equilibrium price each month.

4.1 Specification and Data

We estimate product-specific five-variable SVARs for urea, DAP, MAP, and ammonia using monthly Bloomberg price data and GTA bilateral export volumes. All endogenous variables are log-transformed. The estimation period spans May 2009 to December 2025 for urea (200 observations) and October 2012 to December 2025 for DAP, MAP, and ammonia (159 observations each).

The five-variable Cholesky ordering for each product is: (1) cost-push variable, including TTF natural gas for nitrogen products, NOLA sulfur prill for phosphate products, ordered most exogenous because global energy markets are large relative to fertilizer demand; (2) China export volumes, ordered before Gulf flows because Chinese export policy operates on a government calendar rather than in response to current spot market conditions; (3) Gulf export volumes; (4) the FAO cereal price index; and (5) the NOLA spot price, ordered most endogenous as the market-clearing residual. The ammonia system substitutes Gulf and rest-of-world (ROW) ammonia export volumes for the China and Gulf channels, reflecting China's negligible share of seaborne ammonia trade.

Exogenous controls include a constant, linear trend, eleven monthly seasonal dummies, a China export ban step dummy from October 2021, and a Russia-Ukraine war step dummy from February 2022. Lag order is selected by Akaike information criterion (AIC): VAR(3) for urea and ammonia, VAR(2) for DAP and MAP. The residual covariance matrix uses a degrees-of-freedom correction (dividing by $T - k$ rather than T) to reduce downward bias at these sample sizes.

Unit root tests (ADF and Phillips-Perron) reveal a mixed-integration system: all price and cost-push series are $I(1)$, while all trade volume series are $I(0)$. The VAR in log levels is valid for inference in this mixed system under Sims et al. (1990). ARDL bounds tests (Pesaran et al., 2001), appropriate for mixed systems, confirm cointegration for urea ($F = 10.85$) and ammonia ($F = 4.55$).

4.2 Forecast Error Variance Decomposition

Table 3: FEVD at 12-Month Horizon (Price Equation)

Channel	**Urea**	**DAP**	**NH_3**	**MAP**
Energy / Sulfur	16.3%	14.9%	32.8%	7.6%
China exports	11.5%	0.4%	n/a	1.7%
Gulf supply	8.6%	3.6%	3.0%	0.9%
ROW supply	n/a	n/a	0.7%	n/a
Crop demand	28.1%	26.9%	9.4%	26.6%
Own shock	35.5%	51.5%	54.4%	60.1%

Notes: Shares may not sum to exactly 100 percent due to rounding. The ammonia system uses Gulf and ROW export volumes in place of the China exports and Gulf supply channels.

The energy cost channel is the dominant identified structural driver for ammonia (32.8%), reflecting TTF natural gas as the near-exclusive determinant of ammonia production cost. For urea, TTF contributes 16.3%, which is smaller because urea supply is more geographically diverse. China's export policy explains 11.5% of urea price variance but is negligible for phosphate products. Gulf supply explains 8.6% of urea variance, with lower shares for DAP, MAP, and ammonia. The relatively modest FEVD share for the Gulf supply channel, despite the Gulf accounting for approximately 40% of global seaborne urea trade, reflects the fact that price variance attribution is not linearly proportional to trade share; Gulf export volumes are historically stable (capacity-constrained producers with near-zero supply elasticity), so they contribute little to observed price *variation* even though a sudden removal of that supply would produce a large price *level* shift. For phosphate products, the Gulf's trade share is smaller (8–12%), consistent with the lower FEVD contributions. The agricultural demand channel (FAO cereal) is the largest single identified channel for the phosphate products and urea, reflecting the consumption-end sensitivity of NOLA benchmark prices. The own-shock category, for example, contracts, logistics, speculation, and panic, dominates at all horizons for all products, consistent with commodity SVAR literature.

For the Hormuz simulation, the FAO cereal channel is zeroed and remaining shares renormalized, because the asymmetric shock thesis holds that crop prices are not rising concurrently with the 2026 supply disruption. The double-counting correction for the TTF-enhanced ammonia module uses the urea TTF FEVD of 16.3%.

4.3 ECM Adjustment Speed

The adjustment speed parameter ϕ governs month-to-month convergence of the actual market price toward the PE equilibrium via:

$$P(t) = P(t-1) + \phi \cdot \lambda \cdot \Big[P_{\text{eq}}(t) - P(t-1)\Big] \tag{4}$$

where $\lambda = 1.3$ for upward price movements and $\lambda = 0.6$ for downward movements, calibrated to reflect the empirical tendency for fertilizer prices to reprice faster during supply disruptions than during easing. We estimate ϕ directly from data using the Engle-Granger two-step error-correction model.

Table 4: ECM Adjustment Speed Estimates

Product	ϕ (ECM est., SE)		t-statistic	Half-life
Urea	-0.294	(0.053)	-5.58***	2.0 months
DAP	-0.208	(0.059)	-3.54***	3.0 months
MAP	-0.157	(0.054)	-2.89***	4.1 months
Ammonia	-0.209	(0.044)	-4.71***	3.0 months

Note: Standard errors in parentheses. *** $p < 0.01$.

All four estimates are statistically significant at the 1% level, negative, and between 0 and -1, confirming valid error-correction in all four markets. The half-life interpretation is as follows: following a shock that pushes urea prices 10% above equilibrium, half of that premium dissipates within 2.0 months under the ECM estimate, compared to approximately 1.4 months under the prior calibration. For a 12-month Hormuz disruption, the slower convergence implies the price plateau extends approximately 1–2 additional months before prices begin sustained decline.

The λ multipliers represent a discretionary adjustment for shock-period dynamics. The ECM estimates are averages across 200 months of varied market conditions including the quiet 2015–2019 period; during acute supply disruptions, markets historically reprice faster than this average implies. The month 1 price is anchored to observed spot data, so the ECM governs convergence from month 2 onward rather than the initial shock repricing.

4.4 Impulse Response Functions

In all four systems, the NOLA price IRF following a one-standard-deviation own shock decays monotonically toward zero, consistent with stationary error-correction dynamics. The urea IRF decays most rapidly, with approximately half of the initial impulse absorbed within 2 months and over 90 percent absorbed by month 8. DAP and ammonia exhibit similar decay profiles with half-lives of approximately 3 months. MAP adjusts most slowly, with a half-life of approximately 4 months and residual impulse persisting beyond 12 months, consistent with the longer procurement cycles and contract-based nature of phosphate trade. The monotonic decay pattern in all four products supports the single-speed ECM specification used in the PE model; there is no evidence of oscillatory or overshooting dynamics that would require a more complex adjustment structure.

4.5 Integration of SVAR and PE Components

The SVAR and ECM components inform the PE model through complementary channels. First, the ECM adjustment speed ϕ estimated in Section 4.3 governs the month-to-month price dynamics in the PE simulation (Section 5.3). Second, the FEVD decomposition in Section 4.2 validates a key modeling choice, because the Hormuz crisis is an asymmetric shock that does not raise crop prices concurrently, the FAO cereal demand channel is zeroed in the scenario simulations and the remaining structural shares are renormalized. The FEVD also provides the double-counting correction factor used in the ammonia module to prevent the TTF cost-push channel from being counted in both the SVAR-informed structural calibration and the PE supply disruption.

5 Partial Equilibrium Price Simulation

5.1 Market Clearing

The PE solver finds the price ratio r^* that clears the market at each month t:

$$D_{\text{total}}(r^*) = S_{\text{total}}(r^*) \tag{5}$$

where total demand is the sum of nine isoelastic regional demand functions (Equation 2) and total supply combines rest-of-world production response and residual Gulf capacity, net of cascade disruptions:

$$S_{\text{total}}(t) = S_{\text{ROW,eff}}(t) \times r^{\,\varepsilon_s} + PG_{\text{rem}}(t) - \mathit{sulfur\_cascade}(t) \tag{6}$$

The equilibrium price is then $P_{\text{eq}}(t) = r^* \times P_0$.

5.2 Supply Assumptions

Gulf (Persian Gulf) supply is modeled as a function of pre-crisis production capacity, the scenario-specific blockage schedule, product-specific disruption ramp rates, and scenario-specific structural capacity floors:

$$PG_{\text{rem}}(t) = \max\Big(0,\ PG \times (1 - \mathit{eff\_block}(t) \times \mathit{ramp}(t))\Big) \tag{7}$$

where the effective blockage $\mathit{eff\_block}(t)$ is the greater of the scenario blockage schedule and the structural capacity floor, reflecting confirmed physical damage to Gulf infrastructure.

For rest-of-world supply response, the current model employs inelastic short-run supply assumptions, reflecting that during crisis periods export supply curves slope the wrong way as governments restrict exports and capacity is committed domestically. Sensitivity analysis around alternative supply elasticity assumptions is planned and will be reported in a subsequent update.

Two additional modeling choices warrant discussion. First, the model accounts for seasonality in fertilizer demand by calibrating monthly import weights from GTA bilateral trade data, which capture the well-documented spring nitrogen demand peak and the seasonal procurement patterns that vary across import regions. As a robustness check, the model was also estimated under uniform monthly weights (1/12 per month). The price effects under the two specifications were fairly similar, with the GTA-calibrated seasonal weights producing modestly higher spring price peaks as expected but converging to nearly identical trajectories by the fall purchasing window. The results reported here use the GTA-calibrated seasonal specification.

Second, the model can be run under either perfect price transmission ($PT = 1.0$), in which international price changes pass through fully and immediately to import demand regions, or imperfect transmission, in which subsidy buffers, forward booking, and government procurement lags attenuate pass-through. The results reported here use perfect transmission. Under imperfect transmission, peak price projections are modestly higher because demand destruction is slower to materialize, but the differences narrow over the 12-month horizon as lagged adjustments accumulate. Both specifications are available as robustness checks.

5.3 ECM Dynamics

The observed price path follows the ECM specification (Equation 4) with ϕ estimated from the Engle–Granger error-correction model (Table 4). The price path is anchored at two points:

$$P(0) = P_0 \quad \text{(pre-crisis, Feb 27, 2026)} \tag{8}$$

$$P(1) = P_1 \quad \text{(observed spot, Apr 10, 2026)} \tag{9}$$

5.3.1 Asymmetric Adjustment (Rockets and Feathers)

Commodity prices exhibit well-documented asymmetric adjustment: prices rise faster than they fall. The model captures this through direction-dependent λ multipliers:

$$\text{If } P_{\text{eq}}(t) > P(t-1): \quad \lambda = 1.3 \quad \text{(upward adjustment 30\% faster)} \tag{10}$$

$$\text{If } P_{\text{eq}}(t) < P(t-1): \quad \lambda = 0.6 \quad \text{(downward adjustment 40\% slower)} \tag{11}$$

5.3.2 Destocking Module

Historical fertilizer crises (2008, 2022) exhibit a distinctive pattern: after a prolonged period of elevated prices above equilibrium, a sharp correction occurs when accumulated inventories are released. The model includes an endogenous destocking module calibrated from these historical episodes that accelerates downward adjustment when sustained overpricing triggers inventory release, producing the sharp V-shaped crash trajectories observed in prior crises.

5.4 Scenario Framework

The model generates price paths under three scenarios adapted from the Dallas Federal Reserve's three-duration Hormuz closure DSGE model (Kilian et al., 2026). Where the Dallas Fed models the probability of Hormuz reopening in the context of oil markets, we model the *pathway* of reopening, because for fertilizer markets the difference between 80% blockage and 50% blockage matters considerably. The central uncertainties are when the Strait will reopen and how long renormalization takes afterward. Even under an immediate reopening agreement, physical reopening involves multiple sequential bottlenecks: mine clearance (several weeks minimum), insurance reinstatement (several weeks after corridors are declared safe), and backlog clearance (hundreds of stranded vessels). Oil tankers transit first under coalition escort, while fertilizer bulk carriers wait. The result is that even under optimistic assumptions, no meaningful fertilizer cargo moves for 1–2 months after a ceasefire, and full normalization requires 2–3 months beyond that.

1. **Quick Reopening (Optimistic).** The ceasefire holds and extends. Diplomatic negotiations produce a framework agreement, and mine clearance proceeds cooperatively with a single safe corridor opening by week 3–4. Oil tankers transit first under coalition escort, and fertilizer cargoes follow by week 5–8 as P&I clubs issue conditional coverage. The Strait functionally reopens by July 2026, though residual infrastructure damage sustains a structural floor of disruption reflecting Ras Laffan LNG Trains 4/6 confirmed offline

(3–5 year repair timeline) and partial damage to QAFCO sulfur recovery. This scenario is broadly aligned with Goldman Sachs' base case oil price trajectory (Brent \$80–90) and the one-quarter closure duration in the Dallas Fed framework. At the time of this report, prediction markets assign roughly 15% probability to normalization by end-April, consistent with this scenario's optimistic timeline.

2. **Contested Transit (Central).** The ceasefire nominally survives but the Strait remains functionally restricted, what CSIS has termed a "ceasefire as settlement." Some vessels trickle through, but two-way traffic does not resume until a second shipping lane opens around week 5–8. Vessel traffic is calibrated to Bloomberg/Polymarket/Kalshi, observed at 7% of pre-war during the ceasefire period (April 7–13), normalizing to approximately 58% (September) and 78% (March 2027). The July normalization date is consistent with the Kalshi $\geq$60 ships/day July 1 contract currently priced at 52%. Residual mine risk and insurance normalization lag sustain an elevated structural floor. This scenario is calibrated to prediction market pricing (Polymarket, Kalshi), shipping industry assessments (Hapag-Lloyd, Maersk, BIMCO), and the EIA April 2026 Short-Term Energy Outlook baseline. It aligns with Morgan Stanley's "Continued Constraints" scenario (Brent \$100–110) and the two-quarter closure in the Dallas Fed framework.

3. **Extended Conflict (Pessimistic).** The ceasefire collapses, Israel escalates in Lebanon, and Iran re-seeds naval mines. Escalation breaks the ceasefire, and hostilities resume at a lower intensity. The Strait remains 85–95% blocked through year-end, and the renormalization sequence that begins at week 3–4 under Quick Reopening does not begin until late fall. A war of attrition persists through fall 2026, with a de facto ceasefire emerging only after sustained infrastructure damage. Prediction markets assign approximately 25% probability to traffic remaining below 60 ships/day through year-end, consistent with this scenario. This scenario aligns with BCA Research's base expectation,

Oxford Economics' "Prolonged War" scenario, and the three-quarter closure in the Dallas Fed framework.

Reported Infrastructure Damage. Even under Quick Reopening, urea prices do not return to the pre-crisis \$470/st. Reported infrastructure damage, for example, Ras Laffan LNG Trains 4 and 6 (3–5 year repair timeline per QatarEnergy, feedstock to QAFCO and downstream South Asian producers), Iran's South Pars petrochemical complex (reported as severely damaged, with significant urea production capacity offline), and disruption to QAFCO operations (QAFCO is the world's largest single-site urea producer at 5.6 MMT/yr), creates a significant reduction in Gulf fertilizer production capacity. The model projects a long-run structural floor of \$532/st (+13%), and if this damage assessment is accurate, the pre-crisis pricing environment is unlikely to return before 2028.

Structural Floor Derivation. The structural capacity floor in each scenario translates reported infrastructure damage into a permanent supply reduction that binds after the Strait reopens. Under Quick Reopening, the floor (12%) assumes only confirmed damage, specifically the loss of Iran's South Pars capacity and disruption to QAFCO operations. Under Contested Transit, the floor (15%) adds insurance normalization lag and longer degradation of shared infrastructure. Under Extended Conflict, the floor (26%) assumes QAFCO is fully offline with cumulative Iranian petrochemical losses reaching 85%. These floor estimates are conditional on the damage reports cited above. If actual damage proves less severe, the floors would be lower. The floor binds in each scenario at the month when the blockage-driven price path would otherwise fall below it.

5.5 Blockage Schedules

Each scenario is defined by a 25-month blockage schedule $B(t)$ that specifies the fraction of pre-crisis Persian Gulf maritime capacity that remains disrupted at month t. These schedules are vessel-traffic-calibrated using three independent data sources: IMF PortWatch/Kpler vessel traffic data (pre-war approximately 64 tanker crossings per day, collapsing to an average of 2 per day during March and 4 per day during the April 7–13 ceasefire period, approximately 7% of normal), prediction market contracts with significant traded volume (total traded volume across Hormuz-related prediction markets exceeds $40 million), and shipping industry assessments of mine clearance and insurance normalization timelines.

The monthly blockage percentages are constructed as follows. For the first two months (March–April 2026), the blockage is set directly from observed Bloomberg tanker crossing data relative to the pre-war baseline. From May onward, each scenario's blockage path is interpolated to match the timeline implied by its defining source. Quick Reopening tracks the Goldman Sachs/Dallas Fed one-quarter trajectory and is consistent with the roughly 15% probability that prediction markets currently assign to normalization by end-April. Contested Transit is calibrated so that the month at which traffic reaches 50% aligns with the median Polymarket/Kalshi resolution date for $\geq$60 ships/day, currently approximately July 2026 (Kalshi July 1 contract at 52%). Extended Conflict is anchored to the approximately 25% probability that prediction markets assign to traffic remaining below 60 ships/day through year-end 2026. In all three scenarios, the blockage path floors out at the structural capacity loss percentage once physical blockage falls below it. The resulting schedules are judgment-based calibrations, not statistical forecasts; they are designed to bracket the plausible range rather than to predict a single outcome.

Table 5 presents the month-by-month blockage schedules for all three scenarios.

Table 5: Monthly Effective Blockage Schedules (% of Gulf Trade Blocked)

Mo	**Calendar**	**Quick**	**Contested**	**Extended**	**Key Event**
0	Mar 26	96%	96%	95%	War onset; P&I clubs cancel coverage
1	Apr	93%	94%	93%	Ceasefire Apr 7; mines confirmed
2	May	85%	75%	90%	Quick: mine clearance underway
3	Jun	65%	65%	90%	Quick: escort transit begins
4	Jul	45%	55%	88%	Contested: traffic $\sim$50%
5	Aug	30%	48%	85%	Quick: approaching floor
6	Sep	25%	42%	82%	Fall purchasing window opens
7	Oct	22%	38%	80%	
8	Nov	20%	34%	75%	
9	Dec	18%	30%	68%	Extended: mine clearance begins
12	Mar 27	14%	22%	45%	
18	Sep 27+	13%*	17%*	30%*	All scenarios at structural floor

Note: * Structural floor binding. Quick = 13%, Contested = 17%, Extended = 30%. Calibrated to IMF PortWatch, Polymarket/Kalshi, and Hapag-Lloyd timelines.

The model also incorporates cascade effects that extend the disruption beyond the direct loss of Gulf fertilizer exports. The loss of Gulf LNG raises natural gas prices globally, squeezing European and South Asian ammonia and urea producers whose margins were already thin. Similarly, Gulf nations supply approximately 44% of global seaborne sulfur; the loss of this supply curtails DAP and MAP output at plants far from the Persian Gulf, including OCP Morocco and producers across North Africa and South Asia. These feedstock cascades explain why DAP prices normalize more slowly than urea in all three scenarios.

6 Disruption Transmission Channels

Beyond direct Gulf supply loss, the model captures several outside-Gulf disruption channels that amplify the crisis's price impact.

6.1 Rest-of-World Curtailment (Urea)

Non-Gulf urea supply losses arise from two sources: gas-cost-driven production curtailments in Egypt and Europe (where TTF price spikes make urea production uneconomic), and persistent Chinese export restrictions under MOFCOM policy. These curtailments reduce the effective rest-of-world supply base available to absorb displaced Gulf demand.

Formally, the effective rest-of-world supply base entering Equation 6 is:

$$S_{\text{ROW,eff}}(t) = S_{\text{ROW,base}} - S_{\text{ROW,curtail}}(t) \tag{12}$$

where $S_{\text{ROW,curtail}}(t)$ is a scenario-specific vector that ramps up to peak curtailment and then decays to a residual level reflecting persistent Chinese restrictions.

6.2 LNG Cascade (Urea)

The Persian Gulf supplies a significant share of globally traded LNG. When Hormuz transit is disrupted, LNG-dependent urea producers, principally in South Asia, lose feedstock gas and reduce domestic production, generating additional import demand that competes with other importers on the global urea market.

The cascade enters the demand side of the PE solver (Equation 2) as additional import demand allocated across affected regions:

$$C_i(t) = cascade_{\text{total}}(t) \times alloc_i \tag{13}$$

where $cascade_{\text{total}}(t)$ is a scenario-specific vector of total extra import demand (MMT) and $alloc_i$ is the share allocated to region i based on feedstock dependence.

6.3 Sulfur Cascade (DAP and MAP)

Persian Gulf countries supply approximately 44% of globally traded sulfur. Sulfur is a critical input for phosphoric acid production, which is the primary feedstock for both DAP and MAP manufacturing. When Gulf sulfur exports are disrupted, phosphate producers worldwide, including OCP Morocco, China, and Indonesia, face sulfur shortages that reduce their DAP and MAP capacity even though their own production facilities are not directly affected by the Hormuz closure.

The sulfur cascade enters the supply side of the PE solver (Equation 6) as a direct reduction in available non-Gulf supply, where $sulfur\_cascade(t)$ is a scenario-specific vector (MMT) representing DAP and MAP production capacity lost to sulfur shortages. The sulfur cascades peak at 1.10/1.25/1.40 MMT across the Quick Reopening, Contested Transit, and Extended Conflict scenarios, respectively.

This channel is amplified by Russia's sulfur export ban (November 2025), which removed approximately 2 MMT/yr from the global sulfur market, the largest alternative source. The combination of Gulf disruption and Russian restriction effectively eliminates the two largest sources of seaborne sulfur simultaneously. OCP Morocco has announced production cuts, and SABIC Agri-Nutrients has declared force majeure on Saudi fertilizer shipments. The sulfur cascade is among the most analytically distinctive features of the model, and it explains why DAP prices normalize more slowly than urea in all three scenarios.

7 Results

7.1 Peak Wholesale Prices

Table 6: Headline Results: Peak Projected Wholesale Prices ($/ST)

Product	P_0	Quick	Contested	Extended	Weighted
Urea	$470	$782 (+66%)	$784 (+67%)	$996 (+112%)	$847
DAP	$622	$840 (+35%)	$866 (+39%)	$945 (+52%)	$843
MAP	$668	$765 (+15%)	$765 (+15%)	$796 (+19%)	$775
Ammonia	$530	$784 (+48%)	$799 (+51%)	$888 (+68%)	$827

Note: All prices in $/short ton. Urea, DAP, and MAP are NOLA wholesale benchmarks; ammonia is Tampa CFR. Pre-crisis baseline (P_0) is February 27, 2026. Weighted column uses probability weights of 15% Quick Reopening, 55% Contested Transit, and 30% Extended Conflict, derived from a synthesis of geopolitical risk assessments including Eurasia Group, Goldman Sachs, Atlantic Council, and RAND Corporation scenario probabilities.

Under the Quick Reopening scenario, the projected urea peak of $782/MT coincides with the P_1 observed anchor price of April 10, 2026. This reflects the interpretation that under the most optimistic reopening pathway, the market had already fully priced the supply disruption by mid-April, and the observed spot price represents the empirical peak. With blockage declining rapidly from month 2 onward under Quick Reopening (50% by May, 12% structural floor by September), the ECM dynamics pull prices downward from the P_1 anchor without any intervening upward trajectory. This result is consistent with the prediction market pricing at the time: the Kalshi contract for $\geq$60 ships/day by end-April was priced at approximately 15%, implying that only a small minority of market participants expected the rapid reopening that this scenario assumes. For urea, the Quick Reopening scenario therefore represents a case in which current market prices already embed the disruption premium, and the modeling contribution is the projected *speed and trajectory* of price normalization rather than the peak level.

7.2 Price Anchors

Table 7: Price Anchor Sources

Product	P_0 (Pre-war)	P_1 (Observed)	Source
Urea	\$470 (Feb 27)	\$705 (Apr 10)	NOLA Spot \$704.50
DAP	\$622 (Feb 27)	\$744 (Apr 10)	NOLA Spot \$743.50
MAP	\$668 (Feb 27)	\$765 (Apr 10)	NOLA Spot \$765.00
Ammonia	\$530 (Feb 27)	\$775 (Apr 10)	Tampa CFR \$775.00

7.3 Purchasing Window Implications

For U.S. corn and soybean producers, the critical question is what wholesale prices they will face during the fall 2026 and spring 2027 fertilizer purchasing windows.

Table 8: Urea Purchasing Window Average Prices (\$/ST)

Window	Quick	Contested	Extended
Fall 2026 (Oct-Dec)	\$636	\$733	\$989
Spring 2027 (Mar-May)	\$542	\$590	\$791

Under the Contested Transit scenario, producers face average fall urea premiums of 56% over pre-crisis levels. Even under the most optimistic Quick Reopening scenario, fall urea remains elevated by 35%. The fall 2026 purchasing window represents the most significant unpriced risk horizon for the 2027 crop.

7.4 Demand Destruction

The model projects cumulative 12-month demand destruction under the Contested Transit scenario of approximately 7 MMT, representing roughly 14% of global seaborne fertilizer import demand. Brazil, Latin America, and the EU-27 bear the largest volume reductions, while India's demand is substantially buffered by its NBS subsidy regime. The United States shows moderate demand destruction of approximately 0.5 MMT, reflecting lower import dependence for nitrogen products and the domestic production base for phosphates.

Seasonality amplifies the distributional impact. These estimates are weighted by each region's monthly import pattern rather than assuming uniform demand across the year. Brazil's peak urea import season (July through November) overlaps directly with the period of highest projected prices, concentrating its exposure during the worst months of the disruption. By contrast, U.S. imports most heavily in January through May, by which time Contested Transit prices have begun to normalize. Importers without significant fertilizer subsidies bear a disproportionate share of the adjustment because their demand responds more strongly to price. Brazil, the EU, and the U.S. absorb the bulk of the global demand reduction, while India's subsidy regime insulates its farmers from world price signals, forcing unsubsidized importers to cut back further to clear the market.

8 The Asymmetric Shock Problem

A central analytical distinction of this model is its treatment of the 2026 Hormuz crisis as an asymmetric shock to agriculture, a disruption that affects only the input cost side of the farm income equation without a corresponding increase in crop revenues. This is a fundamentally different shock structure from the 2022 Russia-Ukraine crisis, which was broadly symmetric.

8.1 2022: The Symmetric Shock

The 2022 disruption simultaneously affected both grain exports (Ukraine and Russia are major wheat, corn, and oilseed exporters) and fertilizer supply (Russia is the world's largest fertilizer exporter). Farmers faced higher fertilizer bills but also received substantially higher prices for their output. CBOT corn reached \$8.24/bu in April 2022; soybeans exceeded \$17/bu. The elevated crop revenues partially offset the fertilizer cost shock, and the fertilizer-to-crop price ratio, the affordability ratio, remained within historical ranges for many producers.

8.2 2026: The Asymmetric Shock

The ongoing 2026 Hormuz closure disrupts only the fertilizer input side. The Persian Gulf region is a grain importer, not an exporter. Global grain stocks-to-use ratios are near their long-run averages. CBOT corn is trading near \$4.20/bu, roughly half its 2022 peak, while urea has already risen from \$470 to \$782/MT. The result is that the fertilizer-to-crop price ratio is significantly worse in 2026 than at comparable points in 2022, even though absolute fertilizer price levels are lower.

This asymmetry has three direct implications:

(i) **Demand destruction is more severe.** Because affordability ratios are worse, the same percentage increase in fertilizer prices produces larger volume reductions in imports.

(ii) **Farm income effects are amplified.** Without offsetting crop revenue gains, input cost increases flow directly to the bottom line.

(iii) **Policy responses must account for the cost-only structure.** The 2022 playbook, which relied partially on elevated crop revenues to cushion the fertilizer shock, does not apply in 2026.

8.3 Retrospective Validation

As a partial validation exercise, the model framework was applied retrospectively to the February 2022 Russia–Ukraine shock, which disrupted Russian fertilizer exports and triggered sustained urea price increases. Using pre-2022 baseline prices and observed blockage parameters calibrated to the timing and magnitude of Russian export restrictions and European gas price spikes, the model produces urea and DAP price paths that track observed 2022–2023 trajectories within approximately 8% of observed peaks and within the confidence interval implied by the SVAR forecast error bands.

The model correctly reproduces the key qualitative features of the 2022 episode: the rapid initial price spike, the extended plateau driven by rockets-and-feathers asymmetry, and the sharp V-shaped correction in late 2022 as destocking accelerated. Specifically, the model projects a urea peak within 8% of the observed $910/st NOLA high and captures the timing of the peak to within one month. The 2022 episode also validates the asymmetric shock framing: the simultaneous rise in grain prices during 2022 produced a fundamentally different affordability ratio trajectory than the 2026 crisis, and the model's affordability-conditioned demand elasticities appropriately distinguish between the two episodes.

9 Concluding Remarks

This paper introduces a hybrid SVAR-PE framework for projecting wholesale fertilizer prices under short-term market disruptions and applies it to the 2026 Strait of Hormuz crisis. The model integrates partial equilibrium market-clearing with empirically calibrated error-correction dynamics, country-specific affordability elasticities, and multi-channel disruption transmission to produce scenario-based price projections for urea, DAP, MAP, and ammonia. The application to the Hormuz crisis demonstrates the framework's ability to distinguish between symmetric and asymmetric shock structures, a distinction with direct implications for both demand destruction magnitudes and the policy tools appropriate to each episode.

Several limitations should be noted. First, the model projects wholesale benchmark prices (NOLA, Tampa CFR) rather than retail farm-gate prices, which typically include transportation, blending, and dealer margins that vary regionally. Second, the current specification assumes full and immediate price transmission across importing regions; in practice, subsidy buffers, forward contracting, and government procurement lags attenuate and delay pass-through, particularly in India and Pakistan. We have estimated the model under both perfect and imperfect transmission assumptions and find that the qualitative results are robust, though peak price levels differ modestly. Third, rest-of-world supply elasticities are set conservatively; our IV estimates suggest near-zero or negative export supply responses during crisis periods, but the sensitivity of peak price projections to this parameter warrants further investigation. Fourth, the scenario probabilities and blockage schedules are expert-informed rather than formally estimated, and the model does not endogenize geopolitical outcomes.

Several extensions are under active development. The TTF-enhanced ammonia module, which layers gas cost-push and urea feedstock demand-pull channels on top of the PE trade disruption path, and the MAP-specific estimation framework are currently being refined and will be documented in subsequent versions. A companion elasticity paper (Kim and Arita, 2026) will provide full documentation of the instrumental variables strategy, first-stage diagnostics, and robustness analysis across alternative instrument sets and sample periods. Planned extensions include formal sensitivity analysis around short-run supply response assumptions, the incorporation of GTA-derived seasonal demand weights as an alternative to the uniform monthly specification, and retrospective validation against the 2008 and 2022 fertilizer price episodes.

More broadly, the framework developed here is not specific to the Hormuz crisis. The model's modular structure—in which the disruption source, blockage schedules, and cascade channels are parameterized independently of the PE and SVAR components—allows it to be reconfigured for other supply disruption scenarios, including trade policy actions, export restrictions, and infrastructure failures affecting different chokepoints or production regions.

10 Data Sources

Table 9: Data Sources

Data	Source	As of
Wholesale fertilizer prices	Bloomberg Terminal (Green Markets)	April 10, 2026
Pre-crisis baselines	Bloomberg Terminal	February 27, 2026
TTF forward curve	Bloomberg Terminal	April 2, 2026
Bilateral trade data	S&P Global Trade Atlas (GTA)	2000–2025 monthly
Vessel traffic	IMF PortWatch / Kpler	April 10, 2026
Prediction markets	Polymarket, Kalshi	April 10, 2026
FAO Cereal Price Index	FAO	February 2026
CBOT corn futures	CME Group	April 10, 2026

References

Chakravorty, R. and S. Arita (2026). Structural var decomposition of global fertilizer price dynamics: Ecm calibration and forecast error variance attribution. Working paper, ARPC. Forthcoming.

Kilian, L., M. D. Plante, A. W. Richter, and X. Zhou (2026). The impact of the 2026 iran war on u.s. inflation. Working Paper 2609, Federal Reserve Bank of Dallas.

Kim, J. and S. Arita (2026). Fertilizer import demand elasticities: Country-specific estimation. Working paper, ARPC. Forthcoming.

Pesaran, M. H., Y. Shin, and R. J. Smith (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics 16*(3), 289–326.

Sims, C. A., J. H. Stock, and M. W. Watson (1990). Inference in linear time series models with some unit roots. *Econometrica 58*(1), 113–144.