Why Markets Shut Down: Leverage, Opacity, and Higher-Order Beliefs in the 2022 LME Nickel Crisis

1. Introduction

On 4 March 2022, the price of nickel on the London Metal Exchange closed up 13% on the day. Over the weekend, Tsingshan Holding Group, a Chinese stainless-steel producer holding short positions across LME and OTC venues, faced margin calls beyond what its principal counterparties had previously inferred from on-exchange data. Trading reopened on Monday into a market that had effectively no sellers: fewer than 30 lots were available within 1% of the best ask against a normal level of 820, bid-ask spreads peaked at $5,500/t against a typical $18, and the two principal buyers had ceased ordering. Profit-taking even at prices above $100,000/t amounted to fewer than 100 lots (Oliver Wyman, 2023). By 06:00 on 8 March, after a 270% three-day rise, the order book was no longer functioning as a two-sided market. The exchange suspended trading at 08:15 and subsequently cancelled approximately $8bn of executed trades.

Standard accounts of market breakdown explain price discontinuities within markets that continue to clear. They do not explain markets in which price formation itself breaks down. This paper asks whether three frictions — leverage constraints, opacity, and higher-order beliefs — can jointly drive a market into *endogenous shutdown*, defined as the failure of equilibrium price formation itself.

The paper makes three connected contributions. First, opacity's effect on equilibrium existence is non-monotone. A closed-form sign condition partitions the parameter space into three regimes: opacity destabilises under high momentum and as the public belief approaches certainty, but on an interior interval it *stabilises* the market by inflating the bid above partially-shielded informed sellers' reservation prices. The sign-flip yields a distinguishing empirical prediction that adverse-selection benchmarks cannot generate: a non-monotone bid-ask spread path along the squeeze. Second, calibration places the 2022 trajectory in the destabilising regimes: shutdown probability rises roughly eight-fold across the opacity range, and the three frictions are jointly necessary. Third, equilibrium had already failed in the model's sense by 8 March, reframing the LME's halt and cancellation as institutional responses to, not preventions of equilibrium failure.

2. Literature

Glosten and Milgrom (1985) established how order flow aggregates private information, but assumed unconstrained informed traders and exogenous uninformed flow. Gennotte and Leland (1990) and Brunnermeier and Pedersen (2009) showed constraint-driven flow generates feedback and price discontinuity, but treated inference as parametric and breakdown as a price jump. Allen, Morris and Shin (2006) demonstrated coordination motives amplify public-signal weight in environments without forced trading. Pairwise extensions exist, notably Cespa and Vives (2015), but no integrated treatment connects all three frictions to equilibrium failure.

3. Model

3.1 Setup

Time is discrete. A competitive, risk-neutral MM posts ask A_t and bid B_t each period. Traders arrive sequentially. Informed traders arrive with probability α, holding a binary signal of fundamental value $V \in \{0, 1\}$ with precision $p > 1/2$. The remainder are liquidity traders and *leverage-constrained traders* whose orders are mechanically triggered by accumulated stress on short positions.

3.2 Stress and forced buying

Stress M_t accumulates with the positive part of the mid-price return (Brunnermeier and Pedersen, 2009):

$$M_{t+1} = \rho M_t + \kappa_{stress} max\left\{\frac{(A_t+B_t)/2-(A_{t-1}+B_{t-1})/2}{(A_{t-1}+B_{t-1})/2},\ 0\right\}$$

The max operator captures asymmetric mark-to-market pressure: price dips do not subtract from stress, they merely allow it to decay at rate ρ. The forced-buy probability is logistic in M_t:

$$\psi_t = \psi_{min} + (\psi_{max} - \psi_{min}) \frac{1}{1+exp(-\lambda_\psi(M_t-m_0))}$$

with m_0 the stress level at which leveraged agents transition from discretionary positioning to mandatory liquidation.

3.3 Opacity

Opacity is the MM's structural inability to observe ψ_t. The MM operates on a perceived intensity:

$$\phi_t = \omega \phi_0 + (1 - \omega) \psi_t$$

with $\omega \in [0, 1]$ indexing opacity.

Define the opacity wedge $\Omega_t := \psi_t - \phi_t$.

Along squeeze trajectories $\Omega_t > 0$: the MM under-perceives forced buying and misreads it as informed signal.

3.4 Price quoting and equilibrium failure

The MM searches over monotone candidate trader regimes (Avery and Zemsky, 1998) and posts the regime-conditional Bayesian zero-profit quote. The most informative candidate is the BS regime — informed buyers with high signals, informed sellers with low — under which the ask and bid are:

$$A_t = \frac{\pi_{t-1}\lambda_H^{Buy}(\phi_t)}{\pi_{t-1}\lambda_H^{Buy}(\phi_t)+(1-\pi_{t-1})\lambda_L^{Buy}(\phi_t)}$$

$$B_t = \frac{\pi_{t-1}\lambda_H^{Sell}}{\pi_{t-1}\lambda_H^{Sell}+(1-\pi_{t-1})\lambda_L^{Sell}}$$

The perceived intensity ϕ_t enters the buy-side likelihoods only; the sell-side is structurally clean.

Informed traders combine the Bayesian posterior π_t^{priv} with a forecast $\hat{P}_{t+1}$ of the next-period mid-price:

$$D_t = (1 - \beta)\,\pi_t^{priv} + \beta\,\hat{P}_{t+1},$$

where β captures concern with mark-to-market returns over short horizons — the higher-order belief channel of Allen, Morris and Shin (2006), since traders may need to liquidate before terminal value is realised. $\hat{P}_{t+1}$ is built from an exponentially-weighted moving average of past mid-price returns.

A rational expectations equilibrium (REE) requires the prices implied by a regime to be consistent with the actions that regime presumes. The BS regime is an REE only if, at the implied A_t and B_t, H-signal traders prefer to buy ($D_t^H > A_t$) and L-signal traders prefer to sell ($D_t^L < B_t$). Endogenous shutdown is the period τ at which no candidate regime satisfies this consistency. Operationally in the squeeze, the L-trader's reservation rises with the momentum-driven forecast and crosses the bid while no alternative regime supports consistent pricing; the order book ceases to be a two-sided market.

4. Results

4.1 The central analytical result: opacity is not uniformly destabilising

Standard intuition holds opacity destabilises uniformly. Differentiating the critical coordination weight β_t^* at which the BS regime collapses with respect to Ω yields a closed-form sign condition: $\partial\beta_t^*/\partial\Omega_t > 0$ iff $g(\pi) - (1 - \beta_t^*)\,f(\pi) - \beta_t^*\gamma_t > 0$, where $g(\pi)$ is the bid's full Bayesian responsiveness, $f(\pi)$ the L-trader's partially-shielded responsiveness, and γ_t a momentum amplification factor from the EMA recursion.

The mechanism: the MM, holding no private signal, accepts the contaminated public belief wholesale into the bid; the L-trader's posterior is partially shielded by the private signal. When the contaminated bid runs ahead of the L-trader's reservation, the L-trader recognises it as overpaying relative to their barely-moved private posterior and willingly sells into it. The MM is fooled by forced buying, and the L-trader profits — exactly what private information is meant to enable in a Glosten–Milgrom market.

The sign condition partitions the parameter space into three regimes (proof in Appendix B). **Under high momentum**, γ_t is large; each contaminated update moves the L-trader's reservation faster than it moves the bid, so opacity destabilises globally (Corollary A). **Under low momentum**, the bid responds fully to belief contamination while the L-trader's reservation moves only with their shielded private posterior; on an interior interval (π_{low}, π_{high}) the bid runs ahead of the reservation and opacity stabilises, with the standard regime returning outside, giving the trajectory *two* sign-flips (Corollary B). **As $\pi \to 1$**, the L-trader's posterior approaches certainty faster than the bid does, so $g(\pi) - f(\pi) < 0$ unconditionally on momentum strength, restoring destabilisation near the boundary (Corollary C). The 2022 trajectory falls in Corollary A and C territory, but the regime structure delivers a distinguishing empirical prediction: under Corollary B the spread narrows, widens at π_{high}, then partially corrects, a path-dependence pure adverse-selection dynamics cannot generate (Figure 2).

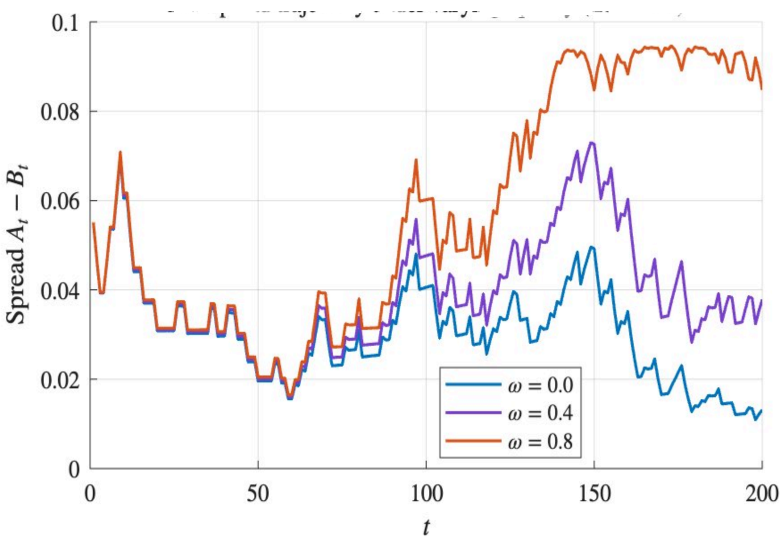

Figure 2: Bid-ask spread along simulated squeeze trajectories. At ω = 0 the spread narrows as the MM resolves the binary state; at ω = 0.8 it widens monotonically; at ω = 0.4 it narrows, widens through t ≈ 150, then partially corrects

4.2 Calibrated quantitative evidence

The model is calibrated to the 2022 episode with parameters anchored to Easley et al. (1996), Brunnermeier and Pedersen (2009), and Heilbron (2024). The coordination weight β = 0.35 is anchored bottom-up: physical traders (e.g., Tsingshan) with β ≈ 0; financial traders (e.g., Elliott Associates) as extrapolators with β ≈ 0.6–0.9 in the sense of Barberis, Greenwood, Jin and Shleifer (2018), weighted by participant split.

Across 1,000 Monte Carlo trajectories per opacity level, finite-time shutdown probability rises from 7% under transparency (ω = 0) to 61% under full opacity (ω = 1). The relationship is convex: each contaminated posterior becomes the next period's prior. Belief contamination at shutdown (Panel A2) is non-monotone in ω, with a dip near ω = 0.6 — the simulation-side counterpart of Corollary B.

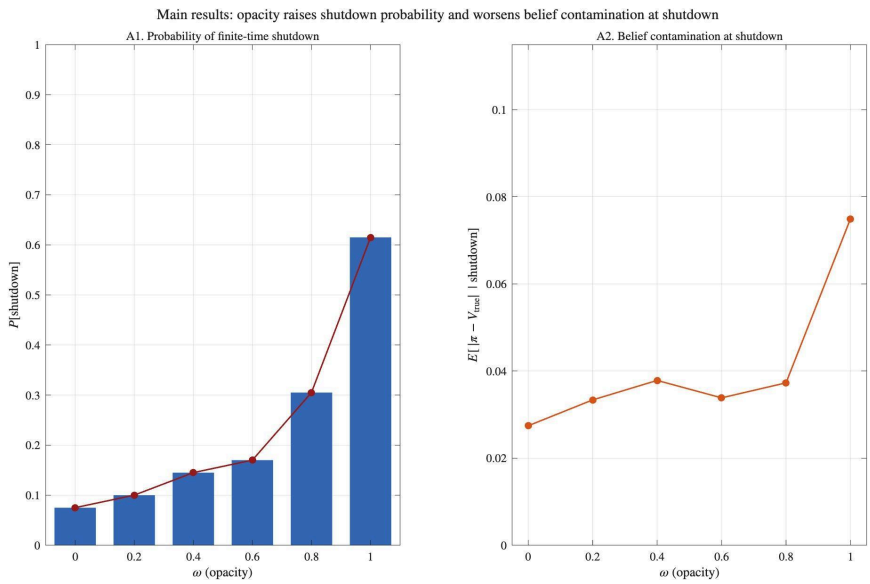

Figure 1: Main results. Panel A1: probability of finite-time shutdown across opacity levels. Panel A2: expected belief contamination at shutdown.

At a representative high-opacity calibration ($\omega = 0.8$), removing the higher-order belief channel ($\beta = 0$) eliminates shutdown entirely; removing opacity reduces shutdown probability from 29% to 9%. Within this calibrated regime, opacity accounts for the majority of baseline shutdown probability conditional on $\beta > 0$.

Table 1. Joint necessity of higher-order beliefs and opacity within the squeeze regime.

Configuration	P[shutdown]
Full model ($\omega = 0.8$)	0.29
No higher-order beliefs ($\beta = 0$)	0.00
No opacity ($\omega = 0$)	0.09
Neither	0.00

5. Policy

Transparency policy is regime-conditional. Post-2008 disclosure regulation (MiFID II, EMIR, Title VII of Dodd–Frank) is premised on a one-directional view that greater transparency improves price discovery. The model is consistent with that view in the high-momentum and asymptotic regimes characteristic of crises, where the 2022 episode sits. The sign-flip identifies a structural condition under which the comparative static inverts, suggesting interventions should be calibrated to the prevailing parameter conjunction — momentum, stress, and proximity to the regime-entry threshold — rather than applied uniformly.

OTC disclosure has the highest marginal effect on Ω_t for the lowest political cost. Tsingshan's short position straddled LME and OTC venues; the OTC component drove most of the gap between true and perceived forced-buy intensity. Mandatory disclosure of large physical-commodity short positions held against OTC counterparties operates *directly* on the opacity wedge without requiring margin reform or position-limit changes. Oliver Wyman recommendations 1.2 and 2.3 point in this direction; the model complements them with a mechanism-based justification grounded in the opacity wedge's role in the inference channel.

6. Conclusion

The most distinctive contribution is the non-monotonicity of opacity's effect on equilibrium existence, established through a closed-form sign condition. The 2022 trajectory falls in the destabilising regimes; calibration shows shutdown probability rising roughly eight-fold across the opacity range, with the three frictions jointly necessary. The non-monotonicity reframes transparency policy as regime-conditional, with OTC disclosure the cleanest lever operating directly on the opacity wedge. The binary state space and single-episode calibration bound external validity to comparative-static evidence within the calibrated regime; the spread-path prediction provides a structural test that would separate this framework from monotone benchmarks.

Appendix A: Robustness

Figure A1 reports local sensitivity of P[shutdown] within ±15% of baseline calibration for the three operating-intensity parameters most directly governing the active mechanism: momentum strength κ_{mom}, stress tipping point m_0, and logistic steepness κ_ψ. Across all three heatmaps the qualitative pattern is preserved: shutdown probability rises monotonically in opacity at every parameter perturbation, and at full opacity yields P[shutdown] $\in$ [0.46, 0.59] across the perturbation window, broadly consistent with the headline 0.61. The model is locally robust to mechanism-strength calibration while structurally sensitive to the conditions defining the squeeze regime itself.

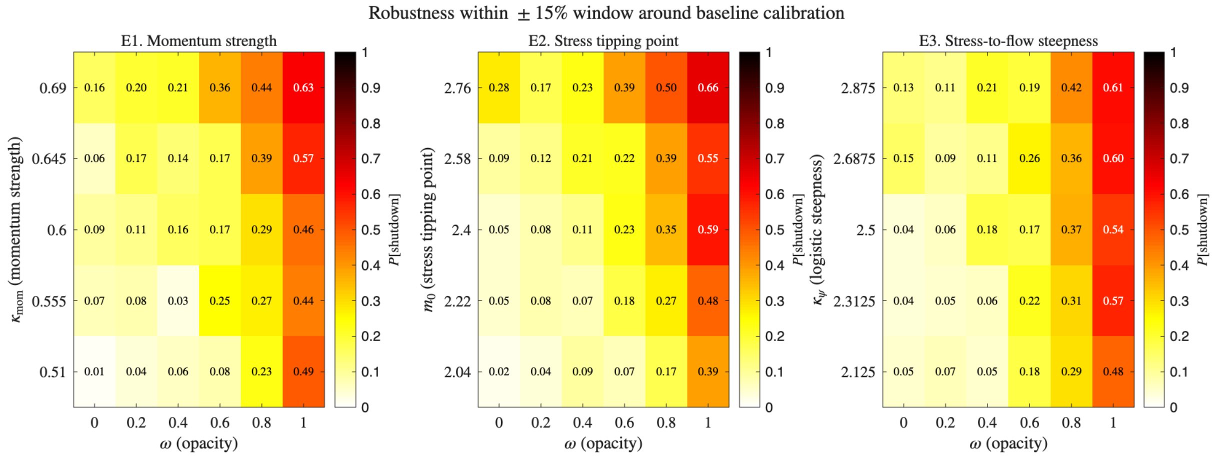

Figure A1: Robustness heatmaps

Table 2. Local sensitivity of P[shutdown] at ω = 0.8. Cells report parameter value followed by P[shutdown].

Parameter	−15%	Baseline	+15%
K_{stress}	0.5950: 0.435	0.7000: 0.350	0.8050: 0.280
EMA_0	0.0255: 0.375	0.0300: 0.335	0.0345: 0.375
M_0	0.0850: 0.265	0.1000: 0.345	0.1150: 0.325

Appendix B: Sign Characterisation of ∂β*/∂Ω (Proof Sketch)

The critical coordination weight at which the BS regime collapses, taking H-buyers and L-sellers as the regime's prescribed actions, is

$$\beta^*_t = (B_t - \pi^{L,priv}_t) / (P_{t+1} - \pi^{L,priv}_t).$$

Lemma 1 (Sign characterisation). Along squeeze trajectories with $P > B > \pi^{L,priv}$,

$$sign(\partial\beta^*/\partial\Omega) = sign[g(\pi) - (1 - \beta^*)\, f(\pi) - \beta^*\, \gamma_t],$$

where $g(\pi)$ is the bid's full Bayesian responsiveness, $f(\pi)$ the L-trader's partially-shielded responsiveness, and $\gamma_t := (\partial P/\partial\Omega)/(\partial\pi/\partial\Omega) \geq 1$ the momentum amplification factor from the EMA recursion.

Proof. Direct quotient differentiation gives $\partial\beta^*/\partial B = 1/(P-\pi^L) > 0$ (the bid channel widens the L-trader's selling margin); $\partial\beta^*/\partial\pi^L = (B-P)/(P-\pi^L)^2 < 0$; and $\partial\beta^*/\partial P = -(B-\pi^L)/(P-\pi^L)^2 < 0$ (the L-posterior and momentum channels narrow it).

Unrolling the EMA recursion yields a per-period lower bound $\gamma_t \geq 1 + \kappa_{mom}\cdot EMA_t\cdot(1-\lambda)$ at the start of opacity exposure, and an asymptotic upper bound $\gamma_t \leq 1 + \kappa_{mom}\cdot EMA_t$ at saturation. Combining the partials, multiplying by $(P-\pi^L)^2/\Delta\pi_t > 0$, and substituting $\beta^* = (B-\pi^L)/(P-\pi^L)$ yields the stated condition, with $g(\pi) = \lambda^H_{Sell}\lambda^L_{Sell} / [\pi\cdot\lambda^H_{Sell} + (1-\pi)\cdot\lambda^L_{Sell}]^2$ and $f(\pi) = p(1-p) / [(1-p)\pi + p(1-\pi)]^2$. □

Corollary C (Asymptotic destabilisation). As $\pi \to 1$, $\partial\beta^*/\partial\Omega < 0$ unconditionally on γ_t, so opacity destabilises in a neighbourhood of $\pi = 1$.

Proof. As $\pi \to 1$, $g(\pi) \to \lambda^L_{Sell}/\lambda^H_{Sell} < 1$ (since $p > 1/2$ makes informed sells more likely under $V = 0$), while $f(\pi) \to p/(1-p) > 1$. Hence $g(\pi) - f(\pi) < 0$, and the right-hand side of Lemma 1 is negative regardless of γ_t. □

Define the threshold $\gamma^*(\pi) := f(\pi) + [g(\pi) - f(\pi)]\ (P-\pi^L)/(B-\pi^L)$, at which the right-hand side of Lemma 1 changes sign.

Corollary A (Global destabilisation under high momentum). When $\kappa_{mom}(1-\lambda)$ is large enough that $\gamma_t > \gamma^*(\pi)$ for all $\pi \in [\pi_0, 1)$, the $\beta^*\cdot\gamma_t$ term dominates and $\partial\beta^*/\partial\Omega < 0$ globally.

Proof. $\gamma_t > \gamma^*(\pi)$ is equivalent to $g(\pi) - (1 - \beta^*)\, f(\pi) - \beta^*\cdot\gamma_t < 0$. By Lemma 1, $\partial\beta^*/\partial\Omega < 0$ throughout. □

Corollary B (Interior stabilising interval under low momentum). When $\kappa_{mom}(1-\lambda)$ is small enough that $\gamma^*(\pi) > \gamma_t$ on a sub-interval $(\pi_{low}, \pi_{high}) \subset (\pi_0, 1)$, then $\partial\beta^*/\partial\Omega > 0$ there. The standard regime returns at the upper boundary by Corollary C and at low π where $\beta^*\cdot\gamma_t$ dominates again, giving the trajectory two sign-flips along the squeeze.

Proof. On (π_{low}, π_{high}), $\gamma^*(\pi) > \gamma_t$ implies $g(\pi) - (1 - \beta^*)\, f(\pi) - \beta^*\cdot\gamma_t > 0$; by Lemma 1, $\partial\beta^*/\partial\Omega > 0$ there. The upper boundary behaviour follows from Corollary C; at low π, $\beta^*\cdot\gamma_t$ dominates as $g(\pi) \to g(\pi_0)$ stays bounded while β^* grows. □

Full proof with regime-by-regime extension and joint sufficiency conditions: dissertation Appendix A.3 and A.6.

References

Allen, F., Morris, S. and Shin, H.S. (2006) 'Beauty contests and iterated expectations in asset markets', *Review of Economic Studies*, 73(3), pp. 719–752.

Avery, C. and Zemsky, P. (1998) 'Multidimensional uncertainty and herd behavior in financial markets', *American Economic Review*, 88(4), pp. 724–748.

Barberis, N., Greenwood, R., Jin, L. and Shleifer, A. (2018) 'Extrapolation and bubbles', *Journal of Financial Economics*, 129(2), pp. 203–227.

Brunnermeier, M.K. and Pedersen, L.H. (2009) ‘Market liquidity and funding liquidity’, *Review of Financial Studies*, 22(6), pp. 2201–2238.

Cespa, G. and Vives, X. (2015) ‘The beauty contest and short-term trading’, *Journal of Finance*, 70(5), pp. 2099–2154.

Easley, D., Kiefer, N.M., O’Hara, M. and Paperman, J.B. (1996) ‘Liquidity, information, and infrequently traded stocks’, *Journal of Finance*, 51(4), pp. 1405–1436.

Gennotte, G. and Leland, H. (1990) ‘Market liquidity, hedging, and crashes’, *American Economic Review*, 80(5), pp. 999–1021.

Glosten, L.R. and Milgrom, P.R. (1985) ‘Bid, ask and transaction prices in a specialist market with heterogeneously informed traders’, *Journal of Financial Economics*, 14(1), pp. 71–100.

Heilbron, J. (2024) ‘Central clearing and trade cancellation: The case of LME nickel contracts on March 8, 2022’, *Office of Financial Research Working Paper* No. 24-09, U.S. Department of the Treasury.

Oliver Wyman (2023) *Independent review of events in the nickel market in March 2022*. Technical report prepared for the London Metal Exchange.