Shipping Lanes and Inflation-at-Risk

Hub Shocks and Optimal Monetary Policy

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Three questions

- Why might the same hub shock impact one economy much more than another?
- What does the standard monetary framework miss?
- What is the right response? And what is beyond the central bank's reach?

The Core Result — A Preview

Thought experiment

Hit two economies with the same hub shock, the same mean inflation forecast, the same central bank. One faces an output cost roughly double the other — and monetary policy may be unable to close that gap.

The difference is not the shock, not the policy, not the forecast.
It is the geometry of their supply chains.

The Key Asymmetry

Mean inflation scales with Γ

Inflation-at-Risk scales with Γ^2

Same forecast. Very different tail. The gap is architecture.

Γ plays three roles:

- ① Cost propagation — amplifies the hub shock through supply chains
- ② Belief coordination — synchronises pricing decisions across firms
- ③ Welfare determinant — sets the structural cost beyond the reach of the policy rate

I. The Standard Framework and Its Limits

The Standard Playbook

- Assess persistence — temporary shocks raise the price level once; permanent ones shift the inflation process
- Tighten for permanent shocks; look through temporary ones

Greenspan's Risk-Management Principle

When costs of policy errors are asymmetric, optimal policy tilts toward the more consequential mistake. Left open: what determines the asymmetry — and by how much?

But Hormuz is different

- A peripheral shock originates at a point and decays — firms form independent views about persistence
- A hub shock arrives everywhere simultaneously — firms form views about each other's views
- Coordinated beliefs generate the repricing that validates them
- A framework built for independent signals will systematically misread what is happening

II. Production Architecture

Fig 1a: Global Supply Chain Network (Zhao, Duley & Gai, 2025)

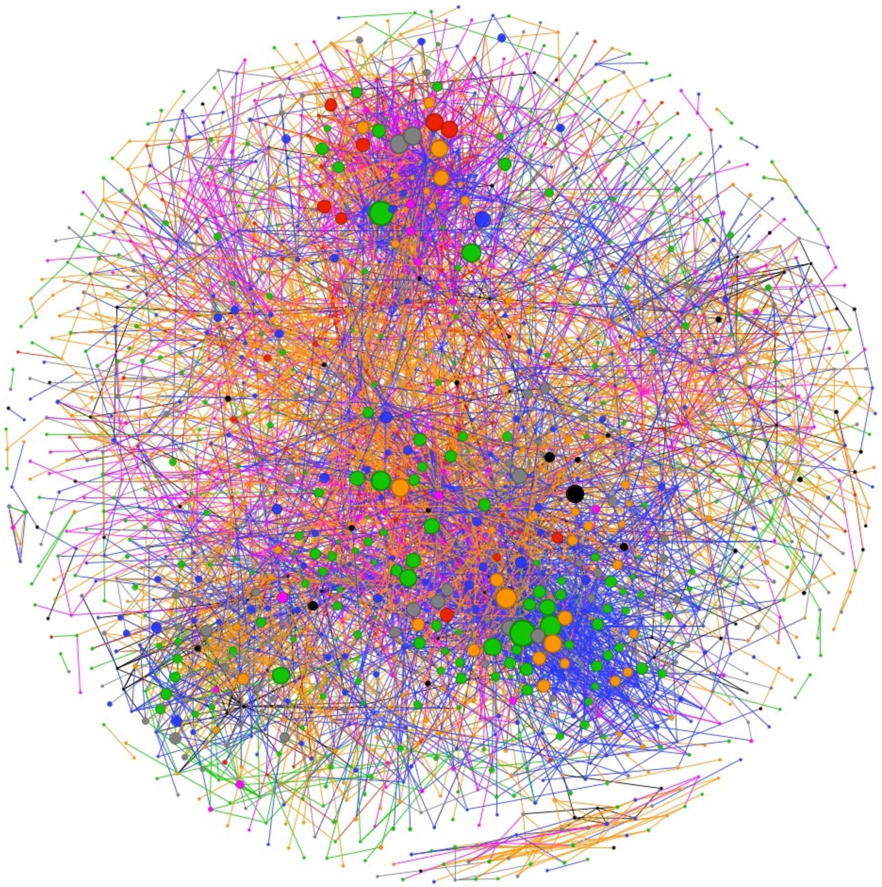
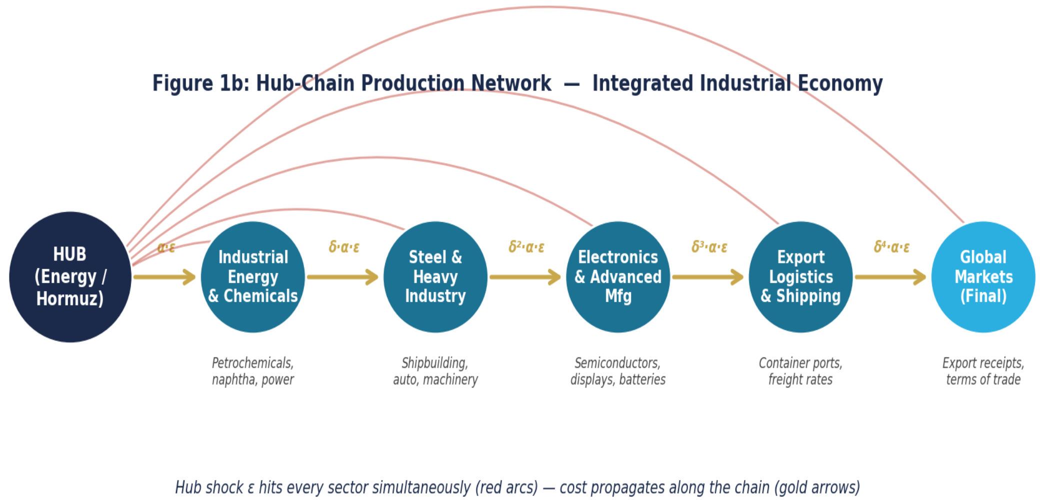


Fig 1b: Hub-Chain Production Network



- Hub-spoke is the empirically dominant form — 100,000+ firms, 190 countries
- The hub is the indispensable ingredient in every sector
- When the hub is struck, the question is not which sectors are affected — it is whether any are not

II–III. Cost Pass-Through and the Network Multiplier

Equation (1): Sector-level cost pass-through

$$\hat{p}_i = \frac{\alpha(1-\delta^i)}{1-\delta} \cdot \varepsilon$$

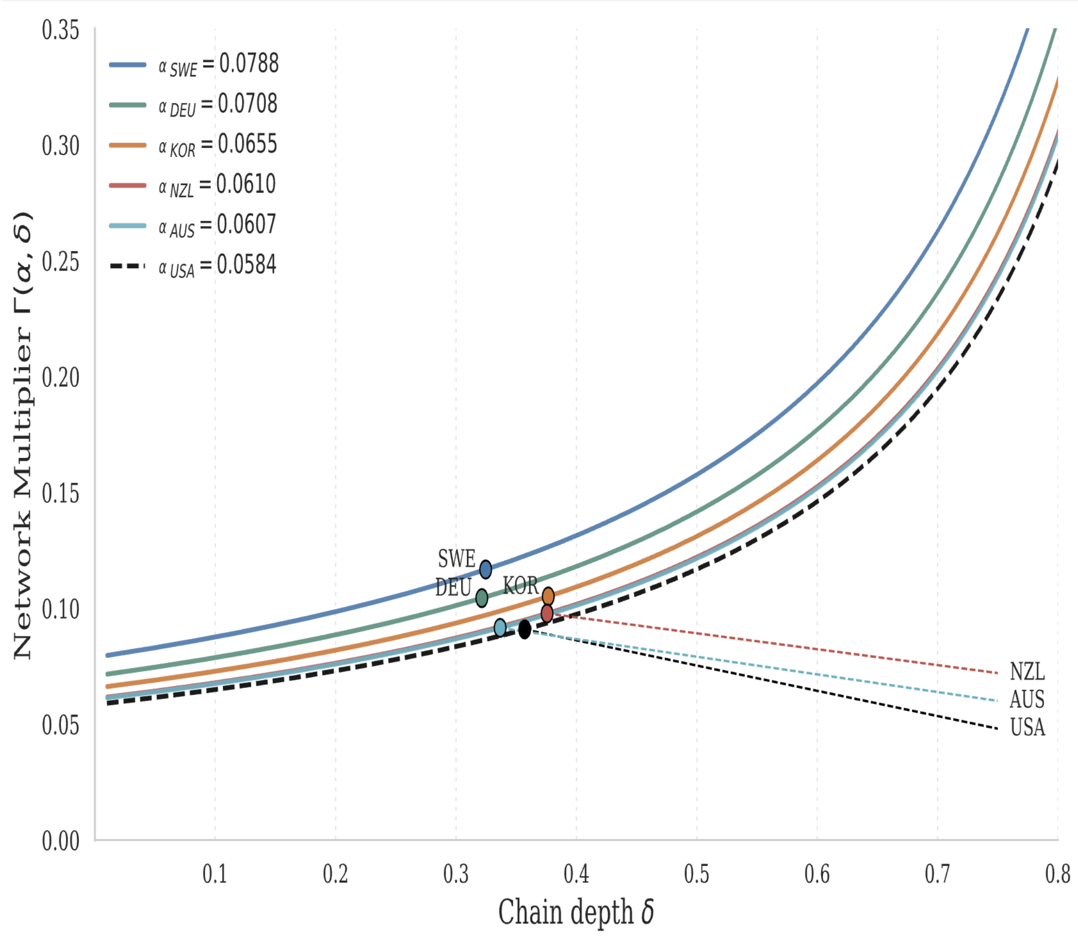
Equation (2): The Network Multiplier Γ(α, δ)

$$\Gamma(\alpha,\delta) \equiv \frac{\alpha}{1-\delta}\sum_j \omega_j \, (1-\delta^j)$$

α = hub intensity. δ = chain depth. Both from standard input-output tables.

All the complexity of global supply chains compresses into two parameters and one number.

Fig 2: Network Multiplier as a Function of Chain Depth



III. Γ Enters the Phillips Curve

Equation (3): New Keynesian Phillips Curve with Hub Shock

$$\pi_1 \;=\; \kappa x_1 + \beta\, \mathbb{E}[\pi_2] + \kappa\, \Gamma(\alpha, \delta)\, \varepsilon$$

κx_1
Demand term

Output gap drives inflation — monetary policy controls this through the IS curve.

$\beta\, \mathbb{E}[\pi_2]$
Expectations

Firms price today based on tomorrow. Forward guidance and credibility matter here if firms are forming independent views.

When beliefs coordinate around a common signal, anchoring becomes much harder to maintain.

$\kappa\Gamma\varepsilon$
Network cost-push

Determined entirely by production architecture before any pricing decision is made. The source is structural, not cyclical.

Monetary policy can only decide how much of the adjustment falls on output versus inflation.

$\kappa\Gamma\varepsilon$ shifts the Phillips curve upward by an amount written into production architecture — before any pricing decision is made

IV. Horns of a Dilemma

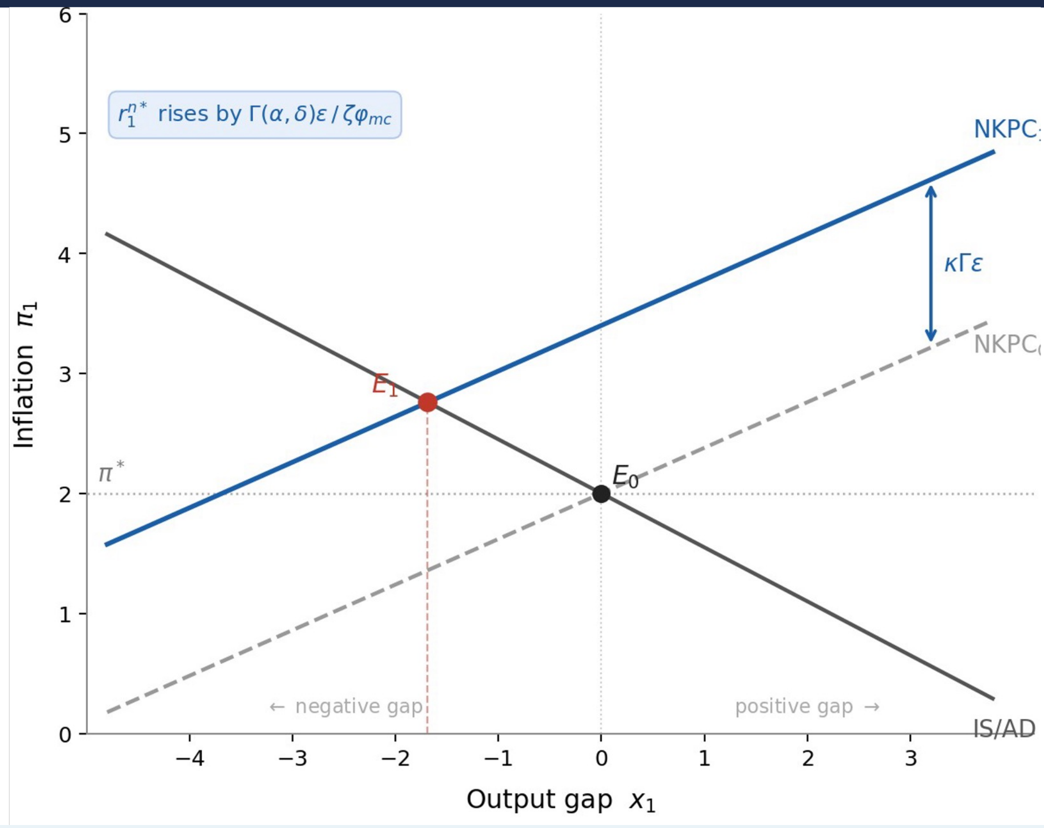
Equation (4): Hub Shock Raises the Neutral Rate

$$r_1^{n*} = \bar{r} + \frac{\Gamma(\alpha, \delta)\,\varepsilon}{\zeta \cdot \varphi_{mc}}$$

The Stagflation Dilemma

The hub shock raises inflation above target and raises the neutral rate.

- Raise rates further → damage already-contracted output
- Hold rates low → validate the inflation



ζ (household intertemporal substitution) and φ_{mc} (real wage sensitivity) differ across economies — the same Γ can produce different mixes of inflation and output loss.

V. Correlated Signals and Belief Coordination

Equation (5): Belief Weight on Common Signal ρ

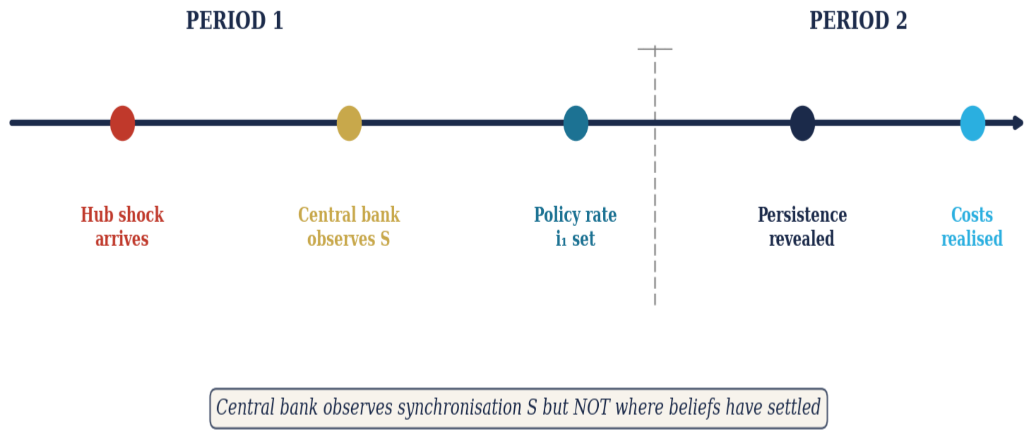
$$\rho(\alpha,\delta,\varepsilon) = \frac{K\varepsilon^2\tau^2(\alpha,\delta)}{K\varepsilon^2\tau^2(\alpha,\delta) + \sigma_\eta^2}$$

The Coordination Mechanism

When the hub is struck, every sector's cost signal contains the same common component. Freight rates, energy prices, delivery times all move in lockstep. Common signal swamps private experience.

Firms stop trusting their own judgement and start reading the room. ρ is governed by the same parameters as Γ. A hub intensive economy is more exposed to costs and more susceptible to belief entrenchment.

Figure 4: Model Timing — The Central Bank's Information Problem



Leading vs lagging indicator

Inflation expectations surveys are valuable but slow-moving. By the time they signal trouble, coordination has already occurred.

The synchronisation of cost pressures across sectors is a leading indicator.

VI. Network Stress and the Inflation Distribution

Equation (6): Network Stress S

$$S \equiv \frac{K\varepsilon^2\tau^2(\alpha,\delta)}{K\varepsilon^2\tau^2(\alpha,\delta) + \sigma_\eta^2}$$

Equation (7): Conditional Variance of Inflation

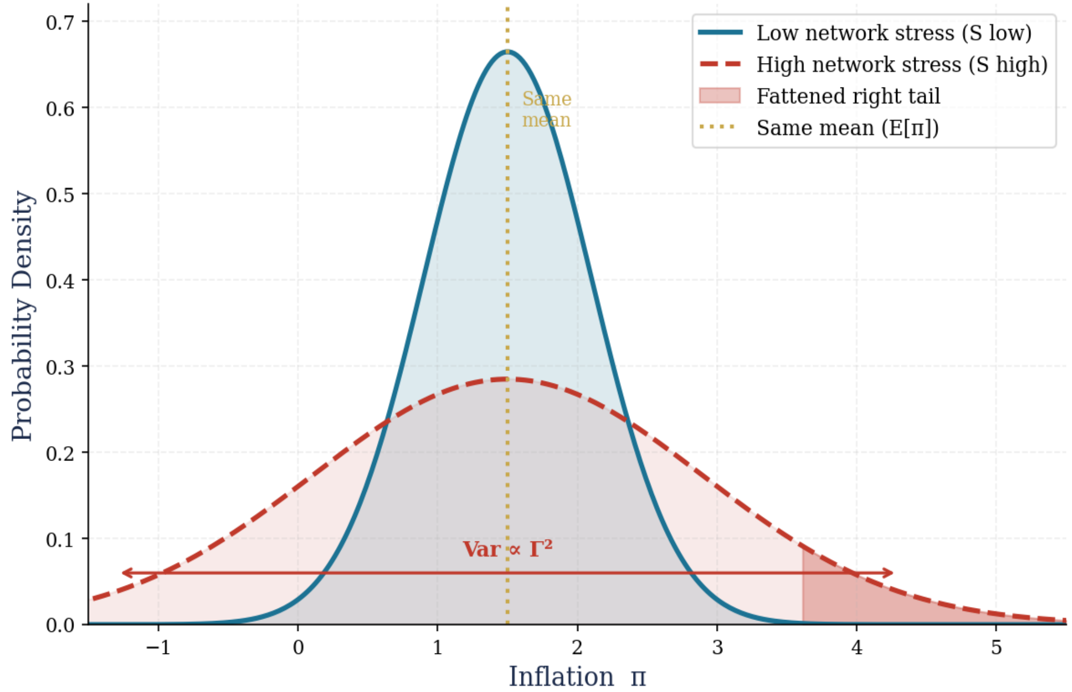
$$\Sigma^2(S) = \Gamma(\alpha,\delta)^2 \cdot \varepsilon^2 \cdot \tau_0^2 \cdot S + \sigma^2$$

The Key Asymmetry

Variance scales with Γ^2. Mean scales with Γ.

Same shock, same forecast. But the distribution is is stretched. The right tail moves faster than the centre.

Figure 5: Inflation Distribution at Low vs High Network Stress
Variance scales with Γ²; mean scales with Γ



S is observable. The CB can monitor synchronisation before beliefs have coordinated. The key is whether the components of a synchronization index all tell the same story.

VII. Welfare Decomposition

Total Welfare Loss = Policy-Responsive Cost + Network Welfare Cost F_S

Equation (8): Network Welfare Cost F_S

$$\mathcal{F}(S) = \frac{\psi_c}{2}\Gamma^2(\alpha, \delta)\varepsilon^2\tau_0^2(S)$$

Equation (9): Pre-emptive Policy Gap Δi

$$\Delta i = i_N^* - i_Q^* \propto r\Gamma(\alpha, \delta)\varepsilon$$

The Friction

The friction is one of timing, not information. The CB is constrained efficient. $\mathcal{F}(S)$ is not something monetary policy can address.

$\mathcal{F}(S)$

- Scales with Γ^2 and S. The policy rate cannot influence it.
- Calls for structural instruments: strategic reserves, supplier diversification, duplicate chains

Δi — the reducible component

- A forward-looking CB tightens more than the standard rule. Response scales linearly with $\Gamma \cdot \varepsilon$
- Does not require knowing shock duration. But production architecture is key.

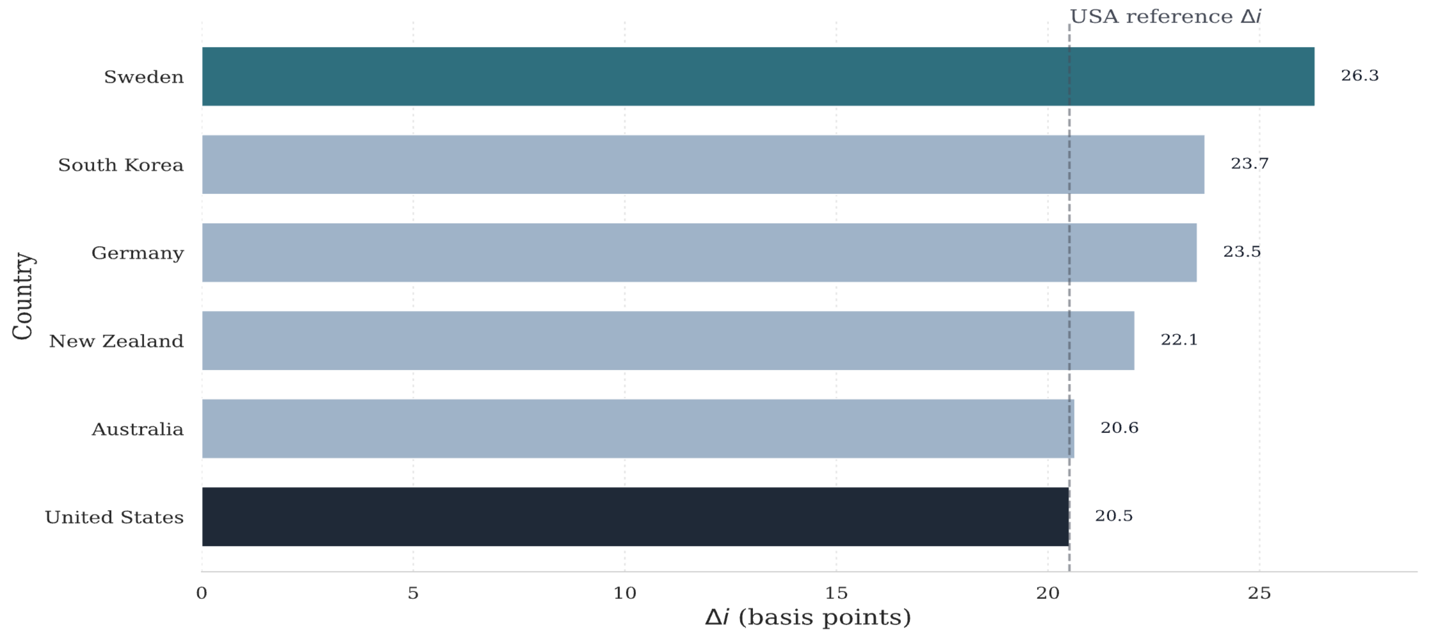
VIII. Not All Economies Are Alike — Policy Gap

Equation (10): Policy Differential Decomposed

$$i_A^* - i_B^* = \left(r_A^{n^*} - r_B^{n^*}\right) + (\pi_A - \pi_B) + \left(\Delta_{i,A} - \Delta_{i,B}\right)$$

Natural-rate wedge | **Mean inflation differential** | **Disinflation-cost premium**

Fig 6a: Pre-emptive Policy Gap Δi (basis points above standard rule)



Reading the chart

What is Δi?

The additional tightening a forward-looking CB should apply above the standard rule

The USA reference line

USA sits at the dashed line. Every other economy shown requires a larger pre-emptive tilt — because their Γ is higher.

Why Sweden first?

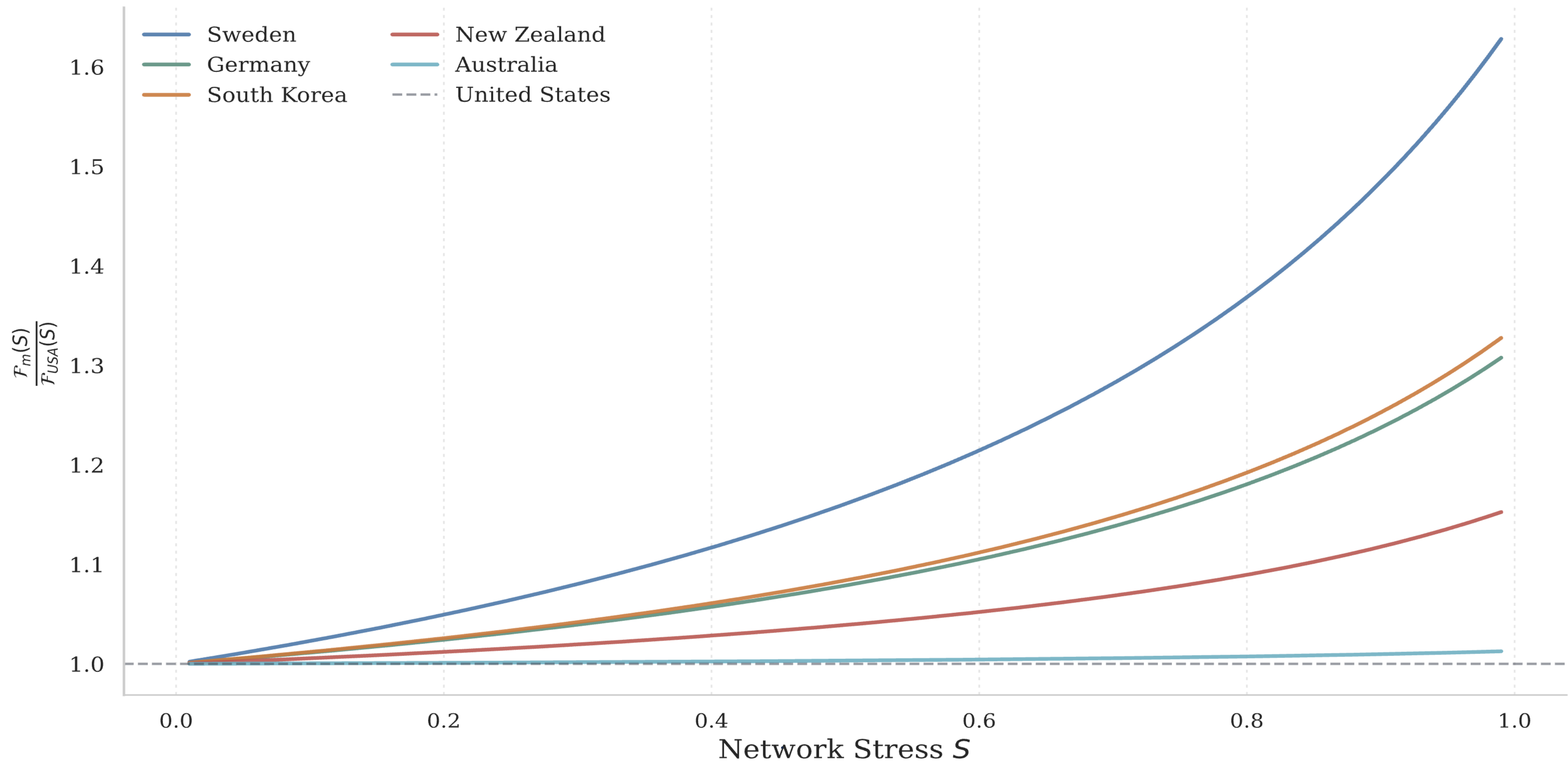
Higher hub intensity α → bigger Γ → bigger policy gap. The ordering follows Γ exactly.

What it is not

This gap does not capture $\mathcal{F}(S)$. The welfare cost requires a separate structural instrument.

VIII. Not All Economies Are Alike — Network Welfare Costs

Fig 6b: Network Welfare Cost $\mathcal{F}(S)$ relative to USA — as a function of network stress S



X. What Hormuz Teaches Us

The standard framework asked the right question, “is this shock persistent?”. But does not address a prior question

The first question is whether the production architecture makes **persistence the likely equilibrium**, and whether network geometry will coordinate beliefs before the shock can be independently assessed.

Figure 5 is an Inflation-at-Risk chart. Important parallels with tail risks in financial stability and Growth-at-Risk. Analysis amenable to quantile regressions.

Greenspan’s risk management approach has a structural answer: it is IaR vs mean inflation. The forecast is linear. The tail is quadratic. Monetary policy solves half the problem; $\mathcal{F}(S)$ calls for structural instruments.

Key Takeaways

IaR	The right tail of inflation conditional on S. The monetary policy analogue of Growth-at-Risk
$\boldsymbol{\Gamma}$	One number compresses all supply chain complexity (Cobb Douglas convenience)
$\boldsymbol{\Gamma^2}$	Governs IaR and structural welfare cost — beyond the reach of the central bank
$\boldsymbol{S}$	The conditioning variable for IaR — synchronisation of stress, not its level
$\boldsymbol{\mathcal{F}(S)}$	Network welfare costs from fat tails. Role for structural instruments