

## Policy Brief

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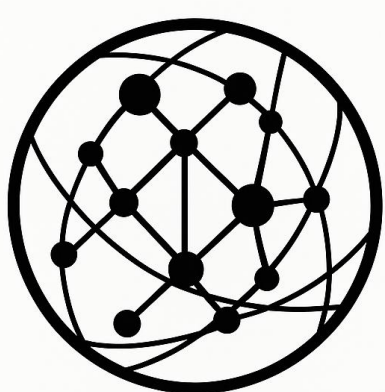
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## Beyond the Gulf:

### The Emergence of a Three-Channel, Threshold-Delaying Logistics System in Iran under Sustained Geopolitical Constraint

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### Key Judgments

- Iran's external logistics system has evolved into a constrained, three-channel network integrating maritime, rail, and road transport, operating below theoretical capacity.
- The system's strategic value lies not in replacing Persian Gulf maritime capacity, but in sustaining minimum viable flow and delaying systemic failure.
- The Caspian corridor functions as a shock absorber, characterized by high volatility but consistent recovery, enabling continuity under disruption.
- Rail and road networks provide adaptive redundancy rather than scalable capacity, reinforcing system persistence without fundamentally altering throughput limits.
- The Pakistan–Iran corridor expands connectivity and routing flexibility, but does not materially increase aggregate throughput, instead strengthening resilience through distribution.
- Effective system performance is governed by bottlenecks and coordination frictions, indicating that disruption of critical nodes can generate disproportionate system-wide effects.
- Under conditions of severe disruption to Persian Gulf maritime flows, Iran's alternative logistics network is likely capable of sustaining only a fraction of baseline throughput, on the order of tens of thousands of tons per day, sufficient for continuity but insufficient to replace primary capacity.

### Executive Summary

Iran's external logistics network is undergoing a structural transformation under sustained geopolitical constraint. While Persian Gulf maritime transport remains dominant in scale, the system increasingly operates as a multi-channel architecture integrating Caspian shipping, rail, and road corridors.

This brief finds that the system does not maximize throughput, but preserves continuity. Its primary function is to sustain a minimum viable flow that delays systemic degradation. The Caspian corridor serves as the backbone of this alternative network, combining volatility with consistent recovery capacity. Rail and road channels provide adaptive redundancy, while the Pakistan–Iran corridor expands connectivity without materially increasing aggregate throughput.

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Logistics capacity governs the tempo of disruption: sustained moderate throughput can stabilize the system and delay systemic breakdown despite structural constraints.

For external actors, this implies that disruption strategies targeting aggregate capacity may be less effective than those focusing on critical bottlenecks and system coordination. In this system, resilience defers vulnerability; it does not eliminate it.

### Methodology Note

This analysis draws on high-frequency vessel movement data across Iranian ports, aggregated at sub-daily intervals (typically 3–6 hours) over the observation period. Throughput estimates are derived from departure counts combined with calibrated cargo capacity ranges (2,000–15,000 tons per vessel), adjusted for utilization rates.

The **Regional System Health Index (SHI)** is constructed as a composite indicator capturing flow absorption, queue efficiency, and flow balance, providing a system-level measure of logistics performance under constraint.

Estimates should be interpreted as order-of-magnitude approximations rather than precise measurements

### 1. System Overview

Iran's external logistics system is best understood as a constrained, multi-layered network rather than a single dominant transport channel. Under conditions of geopolitical pressure and partial maritime limitation, the system has adapted by integrating three interdependent modes of transport.

Caspian maritime shipping provides the principal alternative to southern sea routes, enabling continuous inflow at moderate scale. Rail connections through Central Asia introduce a structured but capacity-limited corridor, constrained by infrastructural discontinuities and operational inefficiencies. Road transport, including the Pakistan–Iran transit corridor, functions as a flexible and adaptive layer capable of sustaining localized continuity under disruption.

The defining characteristic of this system is persistence rather than efficiency. Rather than optimizing for maximum throughput, it operates to sustain minimum functional continuity. Its strategic role therefore lies not in overcoming constraint, but in delaying systemic breakdown.

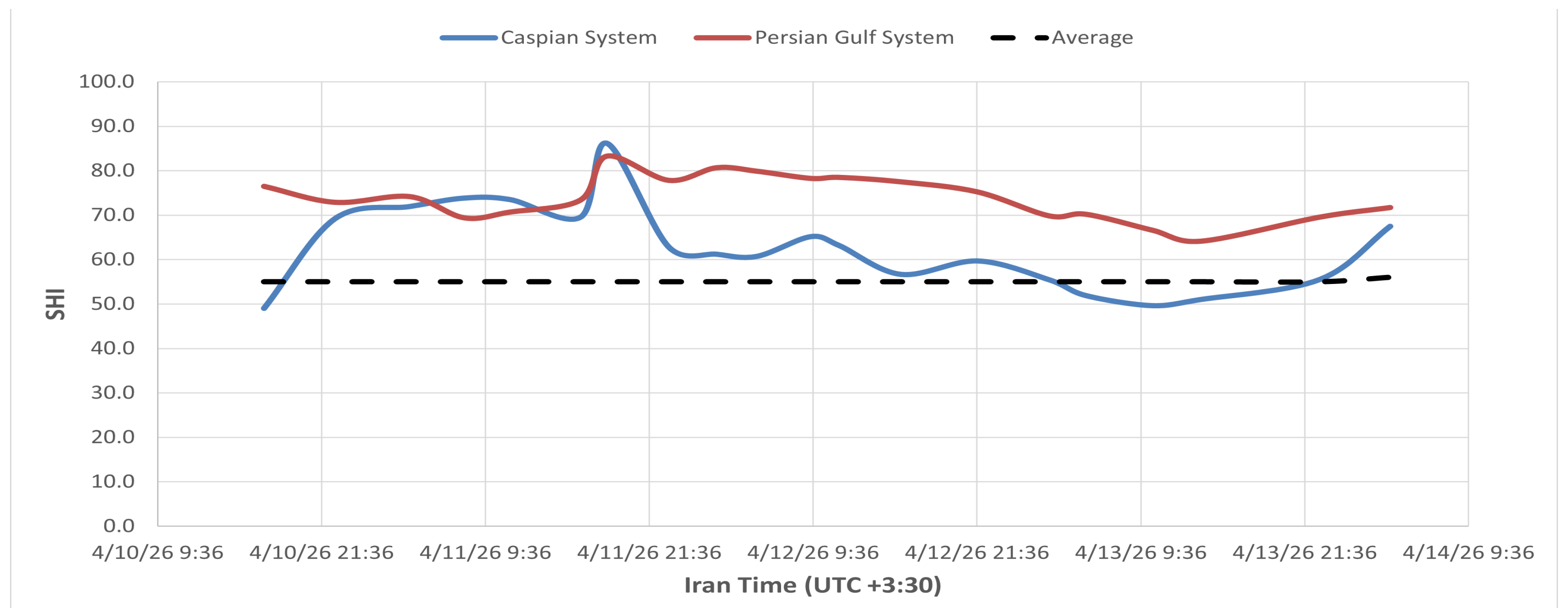
### 2. Empirical Evidence: System Behavior Under Constraint

System-level performance, as captured by SHI, reveals a persistent divergence between the northern and southern components of Iran's logistics network. The Caspian system is characterized by pronounced fluctuations, shifting rapidly between congestion and high-efficiency states. By contrast, the Persian Gulf system maintains a comparatively higher and more stable performance level, although a gradual downward trend is observable.

This divergence reflects a functional differentiation within the system. The Caspian corridor operates as a shock-absorbing mechanism, capable of rapid recovery following disruption but inherently unstable. The Persian Gulf system remains the primary throughput channel, providing scale and relative stability, yet its gradual decline suggests increasing systemic stress.

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As illustrated in **Figure 1**, the Caspian component exhibits wide oscillations, with efficiency levels ranging approximately between 50 and 85. The Persian Gulf system remains within a narrower band near 70–80, but trends downward over time. The system-wide average stabilizes near 55, indicating the presence of a structural threshold below which system performance may deteriorate nonlinearly.

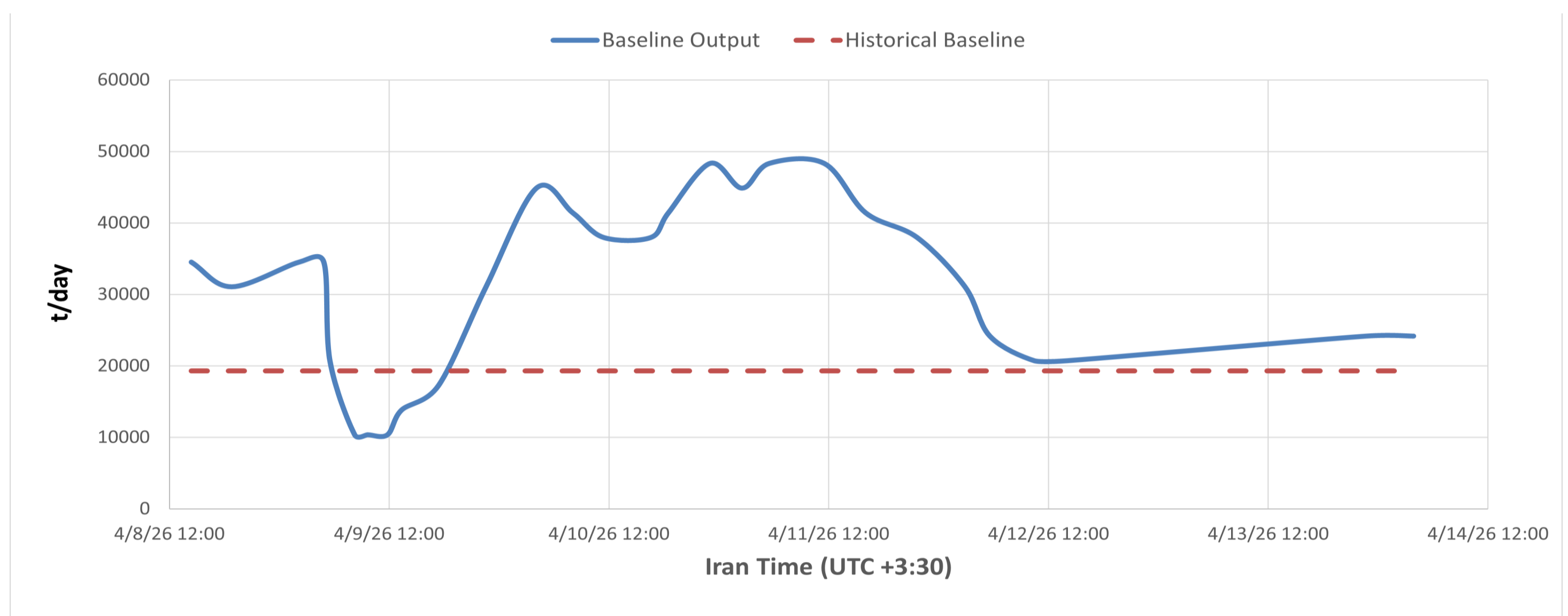


**Figure 1. Regional System Health Index (SHI) Dynamics**

Source: Author’s calculations based on vessel tracking data.

Note: SHI constructed from departures, arrivals, and anchorage ratios.

Caspian throughput data further reinforces this interpretation. As shown in **Figure 2**, the northern maritime system displays a recurring sequence of contraction, rapid recovery, and subsequent normalization. Output declines sharply to approximately 10,000 tons per day, rebounds to roughly 45,000–48,000 tons, and stabilizes at 20,000–25,000 tons. This pattern reflects a system that is both highly sensitive to disruption and capable of endogenous adjustment. Rather than indicating fragility, it demonstrates constrained resilience characterized by cyclical recovery.



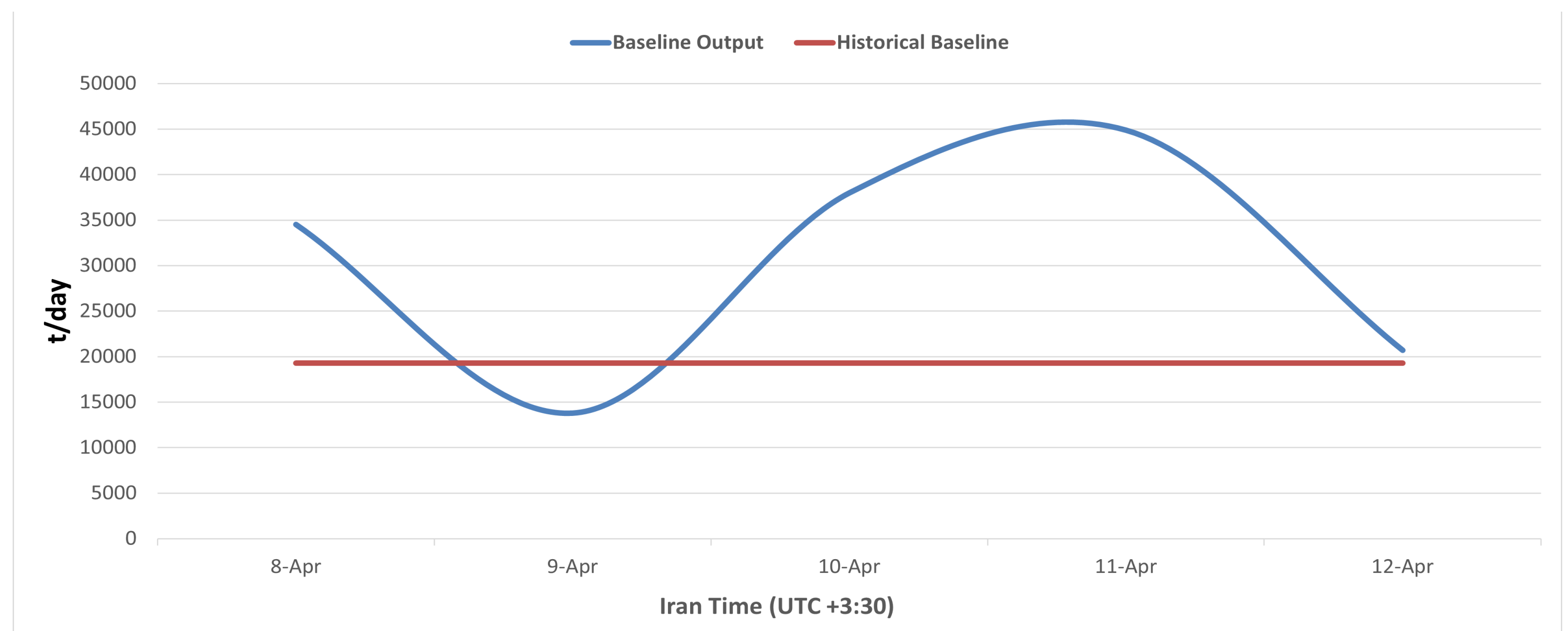
**Figure 2. Caspian Ports Throughput Variability**

Source: Author’s calculations based on vessel tracking data.

Note: Throughput estimated from vessel departures and calibrated capacity ranges.

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By contrast, the Persian Gulf system operates at a scale that exceeds northern channels by an order of magnitude, as illustrated in **Figure 3**. With throughput ranging from approximately 800,000 to 1,400,000 tons per day, it remains the dominant component of Iran’s external logistics. This disparity is structural and persistent, underscoring the central limitation of the northern system: it can sustain continuity, but it cannot substitute for southern maritime capacity.



**Figure 3. Persian Gulf System Output**

Source: Author’s calculations based on vessel tracking data.

Note: Throughput estimated from vessel departures and calibrated capacity ranges.

Under conditions of severe disruption to Persian Gulf maritime flows, the alternative network composed of Caspian maritime, rail, and road channels is likely capable of sustaining only a fraction of baseline throughput, on the order of tens of thousands of tons per day. This level of flow is sufficient to preserve systemic continuity, but insufficient to compensate for the loss of primary maritime capacity.

Taken together, these patterns indicate that the relationship between northern and southern channels is complementary rather than substitutive. The Caspian system provides adaptability and recovery capacity, while the Persian Gulf system supplies scale and baseline stability. System resilience emerges from their interaction rather than from any single channel.

**3. The Three-Channel Throughput Model**

The total nominal capacity of Iran’s external logistics network can be conceptualized as the sum of its three constituent channels—maritime, rail, and road. In theoretical terms:

$$TC_{nominal} = C_{sea} + C_{rail} + C_{road}$$

In practice, however, realized throughput remains consistently below this upper bound:

$$TC_{effective} < TC_{nominal}$$

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This gap reflects structural constraints within the system, including bottlenecks, coordination frictions, and interdependencies across channels, which limit the conversion of nominal capacity into sustained throughput. In complex logistics systems, throughput is typically governed by the most restrictive elements rather than aggregate capacity.

Within this constrained environment, each channel fulfills a differentiated functional role. Maritime transport across the Caspian Sea constitutes the backbone of the alternative network, as it is the only channel capable of sustaining moderate-scale flows. Rail transport provides a structured but capacity-limited layer, contributing stability while remaining constrained by infrastructural discontinuities and operational delays. Road transport functions as an adaptive redundancy mechanism, enabling localized rerouting and continuity under disruption, albeit at higher cost and lower efficiency.

The resulting system is interdependent rather than additive. Capacity in one channel cannot fully compensate for constraints in another, and overall performance is shaped by the alignment of channel-specific limitations. As a result, the most restrictive elements within the network exert a disproportionate influence on total throughput.

### 4. The Pakistan–Iran Corridor: Structural Implications

The activation of the Pakistan–Iran transit corridor represents a structural expansion of the logistics network rather than a breakthrough in throughput capacity. By extending connectivity toward South Asia and linking it with Central Asian routes, the corridor transforms a largely bilateral northern system into a more distributed regional network.

This expansion introduces additional routing flexibility and reduces dependence on any single pathway. At the same time, the reliance on road transport introduces a distinct operational profile characterized by lower visibility, higher adaptability, and greater sensitivity to local constraints. Consequently, the corridor enhances system resilience by increasing redundancy, while remaining limited in volumetric contribution.

Its strategic significance therefore lies in flexibility and distribution rather than scale.

### 5. Strategic Interpretation

Iran's logistics network reflects a shift from capacity maximization toward resilience preservation. Within this system, throughput functions as a dynamic variable that shapes the tempo of systemic change rather than a static measure of supply availability.

From the perspective of escalation dynamics, sustained throughput slows the accumulation of systemic stress and delays the onset of instability. Conversely, when throughput declines below critical thresholds, disruption propagates more rapidly across the network. Logistics capacity therefore governs the rate of system degradation.

From a cost perspective, the system redistributes rather than eliminates burden. Short-term continuity reduces immediate disruption costs, but sustained operation under constraint leads to cumulative exposure over time. The system absorbs shocks in the present while increasing long-term structural strain.

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Taken together, these dynamics indicate that Iran’s logistics network operates as a “threshold-delaying logistics system,” in which resilience is achieved not through capacity expansion but through the temporal redistribution of disruption. Its strategic value lies not in maximizing throughput, but in maintaining operation within a constrained equilibrium that persists until buffering capacity is exhausted.

### 5.1 Concept Box: Threshold-Delaying Logistics System

#### A. Definition

A threshold-delaying logistics system is a constrained logistics configuration in which system stability is maintained through the temporal redistribution of disruption, rather than through expansion of capacity. Its core function is to sustain minimum viable flow and delay the onset of nonlinear system degradation. It represents a distinct class of constrained systems in which resilience is achieved through temporal adaptation rather than capacity expansion.

#### B. Core Characteristics

- **Continuity over capacity:** prioritizes sustained minimum flow rather than maximum throughput.
- **Temporal buffering:** absorbs and redistributes disruption over time rather than eliminating it.
- **Threshold-dependent stability:** operates near critical performance boundaries, beyond which instability accelerates.
- **Non-substitutability:** alternative channels supplement but do not replace primary capacity.

#### C. Analytical Implication

In such systems, logistics capacity determines the tempo of degradation rather than the absolute level of supply, making sustained moderate throughput strategically significant.

### 6. Policy Implications

- **For policymakers:** Sustained moderate throughput can generate disproportionate stabilizing effects; policies targeting flow continuity may therefore be more effective than those focused solely on capacity disruption.
- **For sanctions design:** Targeting critical nodes within the network is likely to produce nonlinear system-wide effects, as system performance is governed by its most restrictive elements.
- **For monitoring and intelligence:** Continuous, high-frequency observation is essential, as system resilience is reflected in persistence over time rather than peak performance indicators.
- **For strategic planning:** Resilience should be assessed relationally across channels; disruptions in one channel cannot be assumed to be offset by capacity in others.

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### 7. Limitations

- This analysis relies on **indirect throughput estimation** based on vessel movements and calibrated capacity ranges; actual cargo volumes and utilization rates may vary.
- **Granular data on cargo composition, vessel characteristics, and routing decisions** remain limited, constraining precise differentiation across shipment types and operational priorities.
- The assessment captures **short-term system dynamics**, and may not fully reflect longer-term structural adjustments in infrastructure, policy, or trade patterns.
- The model assumes **relatively stable operational conditions across channels**, while real-world disruptions (e.g., weather, policy shifts, or security events) may introduce additional volatility.
- Findings are derived from a **single-case system (Iran)**, and while conceptually generalizable, require further validation in other constrained logistics environments.

### Conclusion

Iran's external logistics system has evolved into a constrained, multi-channel architecture designed to sustain continuity under persistent pressure. While it cannot replicate the scale of Persian Gulf maritime transport, it provides a durable mechanism for delaying systemic degradation and redistributing disruption over time. Under conditions of severe disruption to southern maritime flows, the system is likely capable of sustaining only a fraction of baseline throughput, on the order of tens of thousands of tons per day, sufficient for continuity but insufficient to restore primary capacity.

The strategic implication is clear: resilience in this system does not eliminate vulnerability, but defers its consequences. The central policy question is therefore not whether alternative supply routes exist, but whether system performance can be pushed below the threshold at which resilience mechanisms fail.