FINANCIAL INNOVATION

IMPLICATIONS FOR PAYMENTS AND POLICY

FEDERAL RESERVE BANK OF KANSAS CITY
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FEDERAL RESERVE BANK OF KANSAS CITY

Financial Innovation: Some Considerations on Sanctions

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Sanctions over history

- States have used trade as a weapon since antiquity: in 432 BCE Athens shut Megara out of the ports and markets of its empire.
- Sanctions became a standing instrument of peacetime statecraft only in 1919, with Article 16 of the League of Nations Covenant.
- Nicholas Mulder, The Economic Weapon (Yale, 2022), tells that story.
- Sanctions rarely work. Generous codings put the success rate near one third; skeptical ones near one in twenty.
- And they work worst where we want them most: against entrenched autocracies.

Why?

- Autocrats do not bear the cost. Shortages fall on the population, and the ruling coalition is small enough to be paid off.
- Worse, scarcity creates rents, and the regime decides who collects them.
- Firms find work-arounds: new intermediaries, new routes, new flags.
- Modern economies are networks. Cut a link and the network reroutes, often at modest cost.

How can we tell?

- Western governments have imposed oil sanctions on Iran, Syria, Venezuela, and Russia to cut their oil revenues.
- The sanctions have reduced recorded supply. They have also pushed the trade underwater.
- Dark shipping: vessels evade detection by switching off their Automatic Identification System (AIS) transceivers, among other deceptive practices.

AIS, and the gaps in it

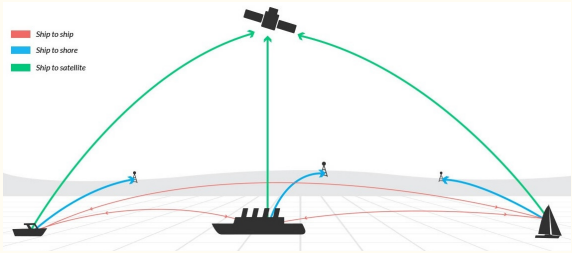

Figure 1: How AIS works

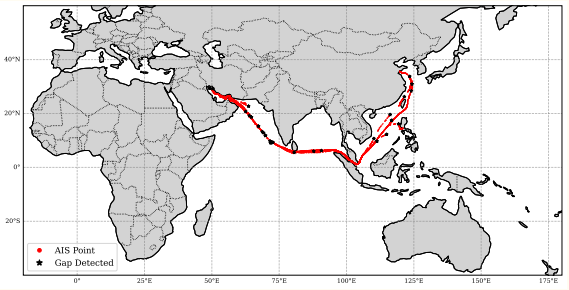

Figure 2: Transmission gaps: *Roma* (IMO: 9182291)

Notes. AIS observations (red points) for *Roma* in 2023, with the first observation after each 10-hour gap during which *Roma* disabled its transceiver (asterisks).

Our approach

- This part draws on "Charting the Uncharted: The (Un)Intended Consequences of Oil Sanctions and Dark Shipping," with Yiliang Li, Le Xu, and Francesco Zanetti (NBER WP 33486).
- We use AIS data for crude oil tankers:
  - Over 2,150 tankers, close to the entire global crude oil tanker fleet.
  - January 2017 to December 2023, updated as often as every two seconds.
  - About 330 million observations: IMO number, timestamp, speed, heading, and coordinates.
- We add ship metadata: age, flag, idle trip ratio, and others.
- With this many records, machine learning is the natural way to classify.

The machine learning algorithm

- We identify a dark ship by combining trip-level and ship-level evidence.
- Deceptive practices listed by the U.S. Department of State in May 2020:
  1. Visit to a suspicious port during an AIS gap.
  2. Ship-to-ship transfer during an AIS gap in a high-risk area.
  3. Navigational anomalies.
- Validation: satellite audits, Lloyd's List Intelligence, and the U.S. designations of July 30, 2025, where we agree on 12 of the 14 tankers.

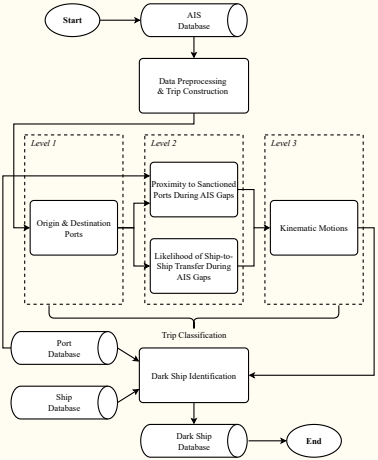

Figure 3: Model flowchart

Ship-to-ship transfer during AIS gaps

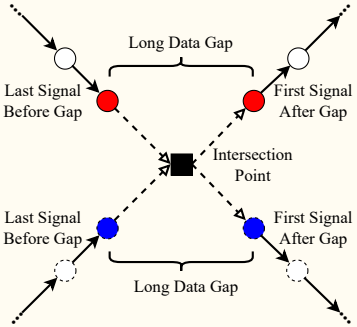

Figure 4: Mechanism

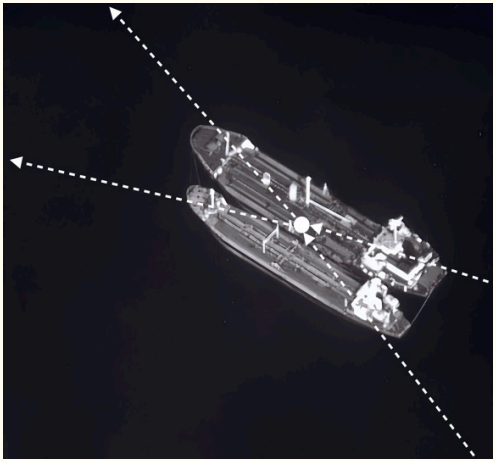

Figure 5: *Abyss* (IMO: 9157765) & *Shanaye Queen* (IMO: 9242118), Persian Gulf, Jan 28, 2022

Evolution of dark shipping

- 555 dark oil tankers operated in an average year between 2017 and 2023, one quarter of the global crude oil tanker fleet.
- The size of the dark fleet moved with geopolitical and economic events.
- Its share of the global fleet, however, fell steadily.

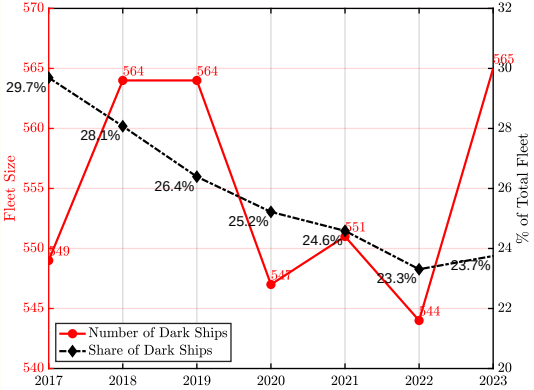

Figure 6: Scale and temporal dynamics of the dark fleet

Dark shipping offsets sanction-driven supply cuts

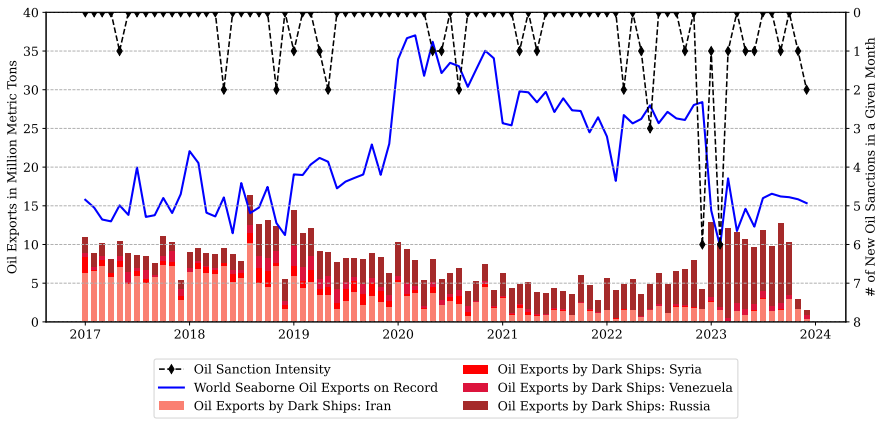

Figure 7: Dark-shipped oil exports, global seaborne oil exports, and sanction intensity

Notes. Global seaborne crude oil exports from UN Comtrade, HS code 2709, petroleum oils and oils from bituminous minerals, crude.

Gravity in the shadows

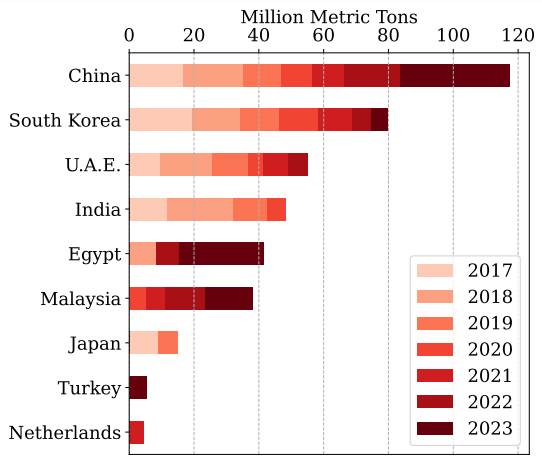

Figure 8: Major importers

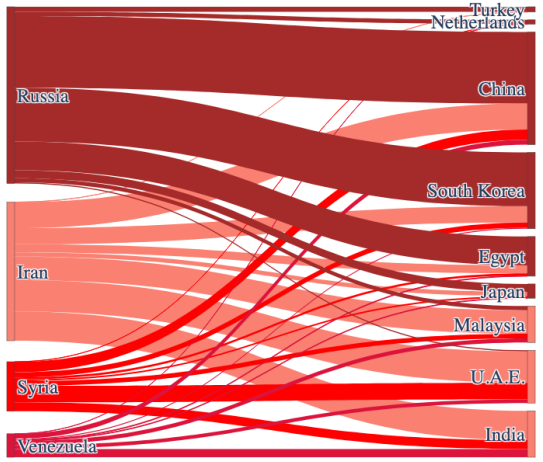

Figure 9: Dark-shipped oil flows

Do financial sanctions do better?

- They look more promising: the dollar system is a real bottleneck, and correspondent banking runs through few nodes.
- But the forces we documented for oil come back:
  1. Incidence: blocking payments hurts households. Elites hire lawyers and buy intermediation.
  2. Work-arounds: shell companies, nominee owners, and banks in Dubai, Istanbul, and Almaty are the financial equivalent of reflagging.
  3. Networks: payments reroute through CIPS, SPFS, longer correspondent chains, and stablecoins.
  4. Detection: as with AIS, enforcement rests on self-reported data. Evaders leave the transparent system rather than lie inside it.

What the dark fleet teaches us about finance

- Sanctions tax transactions; they seldom stop them. As the evasion technology matured, the discount on Russian crude narrowed.
- Evasion is an industry with fixed costs. Build the capacity once and it serves the next target: Iran's ghost fleet now carries Russian oil.
- The financial analogue is already visible: the shell structures and crypto rails built for one regime are being reused by the next, at lower cost.
- Enforcement also erodes its own base. Every use of the dollar as a weapon buys gold, reserve diversification, and non-dollar settlement.
- Freezing stocks works once. Policing flows leaks.