Economics of Sanctions

Part 3 — Macro Counterfactuals

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From firms back to general equilibrium

- Session 2 — firms exit, rewire, divert. **Granular** but **partial**.
- Today — close the loop in **general equilibrium**: prices, wages, multilateral resistances, IO linkages.
- Same shock, two lenses:
  - → 2014 + 2022 sanctions on Russia.
  - → KITE counterfactuals at the OECD ICIO 2022 sector grid.
- Why a model at all? Because welfare effects depend on **general-equilibrium reallocations** a regression cannot recover (Crozet et al., 2025).

Outline

NQTM and KITE

Case: Russia 2014

Case: Russia 2022

Designing better coalitions

Oil cap and energy

Dynamic / NQTM frontier

China decoupling

Bridge to Exercise 2

Take-aways

NQTM and KITE

Structural gravity, fast

Bilateral trade share (importer view) — Eaton–Kortum / Frechet form:

$$\pi_{ij} \;=\; \frac{X_{ij}}{X_j} \;=\; \frac{Y_i}{Y}\left(\frac{\tau_{ij}}{\Phi_j}\right)^{-\theta}$$

so $\sum_i \pi_{ij} = 1$ requires the importer multilateral resistance to soak up the supplier-side weights. Resistances are solved jointly as a fixed point:

$$\Phi_j^{-\theta} \;=\; \sum_i \left(\frac{\tau_{ij}}{\Omega_i}\right)^{-\theta} \frac{Y_i}{Y} \quad \text{(inward, importer } j\text{)}$$

$$\Omega_i^{-\theta} \;=\; \sum_j \left(\frac{\tau_{ij}}{\Phi_j}\right)^{-\theta} \frac{X_j}{Y} \quad \text{(outward, exporter } i\text{)}$$

Source: Anderson and Wincoop (2003); Head and Mayer (2014); Yotov (2024).

Structural gravity, fast (cont.)

- Trade elasticity θ governs how flows respond to costs.
- τ_{ij} absorbs tariffs, NTBs, and **sanctions wedges**.
- Sanctions = bilateral, sector-specific shift in τ_{ij}.
- $\{\Omega_i, \Phi_j\}$ are simultaneous; pinned by a fixed point.

Source: Anderson and Wincoop (2003); Head and Mayer (2014); Yotov (2024).

Exact hat-algebra — the punchline

Hat algebra ($\hat{x} \equiv x'/x$): we do *not* need to know the levels of τ, Ω, Φ, or wages. Only relative changes and baseline trade shares π_{ij}^{s}.

Multi-sector Caliendo–Parro: in each sector s, the bilateral share moves with the relative cost wedge,

$$\hat{\pi}_{ij}^{s} \;=\; \left(\frac{\hat{\tau}_{ij}^{s}\, \hat{c}_{i}^{s}}{\hat{\tilde{P}}_{j}^{s}} \right)^{-\theta_s}, \qquad \hat{c}_{i}^{s} = \hat{w}_{i}^{\gamma_i^{s}} \prod_{k} \left(\hat{\tilde{P}}_{i}^{k} \right)^{\gamma_i^{sk}}$$

- γ_i^s — labour share in sector s cost; γ_i^{sk} — intermediate share.
- Solve iteratively given the shock $\hat{\tau}^s$ and baseline $\{\pi^s, \gamma, \alpha, \theta_s\}$.

Source: Caliendo and Parro (2015); Costinot and Rodríguez-Clare (2014).

Exact hat-algebra — the punchline (cont.)

Closing the system in changes:

- Intermediate-input price index $\hat{\tilde{P}}_j^s = \left(\sum_i \pi_{ij}^s (\hat{\tau}_{ij}^s \hat{c}_i^s)^{-\theta_s} \right)^{-1/\theta_s}$; consumer price index $\hat{P}_i = \prod_s (\hat{\tilde{P}}_i^s)^{\alpha_i^s}$.
- Sector-level market clearing $Y_i^{s\prime} = \sum_j \pi_{ij}^{s\prime} X_j^{s\prime}$.
- Welfare $\widehat{W}_i = \hat{w}_i / \hat{P}_i$ (real-wage definition).
- Dekle–Eaton–Kortum closure: D_i fixed at baseline so the income identity $w_i' L_i = \sum_s \gamma_i^s Y_i^{s\prime} - D_i$ holds.

Source: Caliendo and Parro (2015); Costinot and Rodríguez-Clare (2014).

Multi-sector + input–output linkages — assumptions

- **Cobb–Douglas** in intermediates (shares γ_i^{sk}) and in final demand (shares α_i^s). Substitution across sectors fixed at unit-elasticity; *load-bearing* for tractability.
- **Within-sector** Fréchet/Eaton–Kortum heterogeneity with sectoral trade elasticity θ_s.
- **Deficit closure** — nominal trade deficits D_i held fixed at baseline values (Dekle–Eaton–Kortum 2007 closure).
- Welfare $\widehat{W}_i = \hat{w}_i / \hat{P}_i$ with $\hat{P}_i = \prod_s (\hat{\tilde{P}}_i^s)^{\alpha_i^s}$; shocks propagate through the IO network and feed back via $\hat{\tilde{P}}_i^k$.
- Calibration crosswalk: Caliendo–Parro θ_s are estimated for 20 ISIC-rev3 sectors; the ICIO 2022 grid is on 50 ISIC-rev4 industries. KITE ships a non-trivial concordance inside `initial_conditions`.

Source: Caliendo and Parro (2015); Crozet et al. (2025) §3.1; OECD ICIO, 2022 reference year.

The 2022 ICIO initial conditions

Public `julianhinz/KITE` ships with one snapshot:

Object	Symbol	Source / dimension
Gross output	Y_i^s	ICIO 2022, country $\times$ sector
Final expenditure	X_i^s	ICIO 2022, country $\times$ sector
Trade shares	π_{ij}^s	ICIO 2022, bilateral $\times$ sector
IO coefficients	γ_i^{sk}	ICIO 2022, use side
Final-demand shares	α_i^s	ICIO 2022, final-use side
Sectoral elasticities	θ_s	Caliendo and Parro (2015) table
Labour income	$w_i L_i$	ICIO 2022, value added
Trade deficits	D_i	ICIO 2022, balancing residual

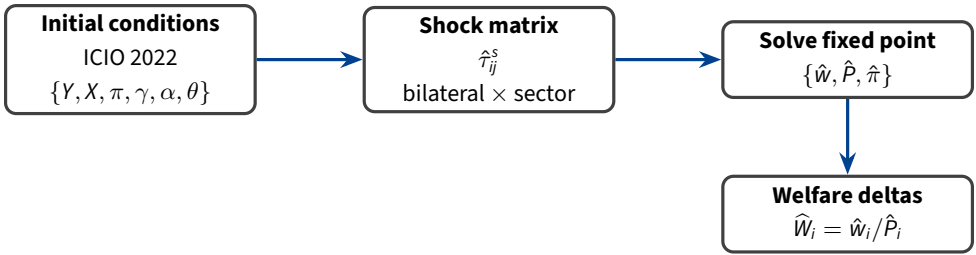
Source: OECD ICIO, 2022 reference year (OECD, 2021).

The 2022 ICIO initial conditions (cont.)

- 80 economies + ROW (81 total); 50 ISIC-rev4 industries. **No aggregation.**
- ISIC-rev3 θ_s (Caliendo–Parro 2015) mapped to ISIC-rev4 inside KITE; concordance is non-trivial and ships with the package.
- Stored as one `R` list, loaded by `00-setup.R`.

Source: OECD ICIO, 2022 reference year (OECD, 2021).

KITE pipeline end-to-end



- Three steps in `01-baseline.R`: load initial conditions, write shock, call `KITE::update_equilibrium()`.
- Solver: **Gauss–Seidel** on $\{\hat{w}_i, \hat{\tilde{P}}_i^s, \hat{\pi}_{ij}^s\}$ with under-relaxation; converges on $\|\hat{w} - \hat{w}_{\text{prev}}\|_\infty < 10^{-4}$.
- Same skeleton for any counterfactual — only the shock matrix changes.

Source: Public KITE: `julianhinz/KITE`.

Case: Russia 2014

2014 benchmark — coalition vs counterfactuals

Scenario (Crozet–Hinz–Šváb 2025 replication)	Russia welfare
S1: 2014 coalition + 2014 measures (current)	-1.06%
Global coalition + 2014 measures	$\approx -2.5\%$
2014-group total embargo (ceiling)	$\approx -3.8\%$

- KITE-style replication: 2014 EU+US+CAN+AUS coalition, sectoral and financial measures.
- **Current coalition**: Russia -1.06% welfare. **Hypothetical full embargo** more than triples that — ceiling, not policy.
- All Russia welfare numbers in this deck are CHŠ (2025) replication estimates of Chowdhry et al. (2024).

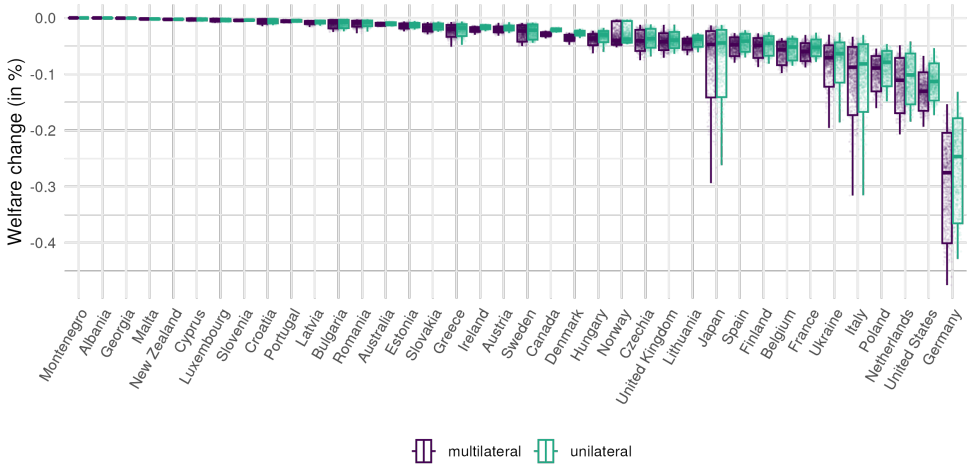
Source: Crozet et al. (2025); replicates Chowdhry et al. (2024).

Sender welfare losses, 2014 (S1)

- Russia -1.06%; senders cluster near zero.
- Baltics + Cyprus most exposed among senders ($\approx -0.4\%$).

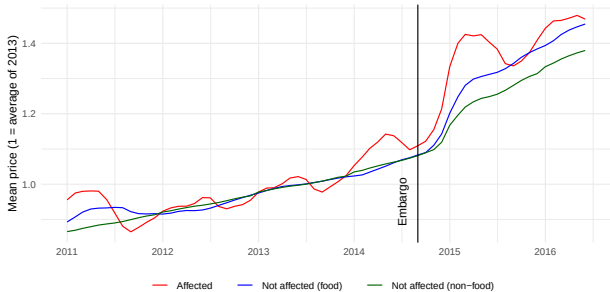
Source: Crozet et al. (2025) Fig. 4a, replication of Chowdhry et al. (2024).

Who imposed which share of Russia's 2014 loss?



Source: Chowdhry et al. (2024); coalition-incidence decomposition.

Russia 2014: consumer-price incidence in the target



- Russian counter-sanctions (Aug 2014 agri ban): embargoed-good prices $+7.7$ to $+14.9\%$ short-run (Hinz and Monastyrenko, 2022).
- Aggregate CPI $+0.33\%$; household welfare loss -1.84% — the macro number averages over a very unequal incidence.

Source: Hinz and Monastyrenko (2022); embargoed (treatment) vs non-embargoed (control) goods, Russia 2014.

Case: Russia 2022

Sender welfare losses, 2022 (S2)

- Russia -2.62% — $\approx 2.5\times$ the 2014 hit.
- Senders: EU avg $\approx -0.10\%$; UK -0.07%; US ≈ 0.

Source: Crozet et al. (2025) Fig. 4b.

Where did Russia's trade go? (2022–24)

- Russian exports redirected toward **China, India, Turkey, UAE** after Feb 2022.
  - → Oil to China + 150% (volume, USD); oil + refined products to India a near-cold-start ramp.
  - → Turkey and UAE: hubs for re-exports of EU-origin dual-use goods into Russia.
- Share of Russia's trade with sanctioning partners fell from $\sim 55\%$ to $\sim 25\%$ in 18 months.
- Chupilkin et al. (2026): bilateral mirror-stat reconstruction shows the Caucasus/Central-Asia roundabout for imports.
- Astrov et al. (2024) (Russia Monitor 3): maritime adjustment and the dark-fleet share of seaborne crude.
- Implication — the third-country margin in S3 vs. S2 (-7.23% vs. -2.62%) is exactly this redirection switched off.

Heterogeneity within senders

- Baltics + Cyprus carry $\approx -0.75\%$ — one-sixth of a typical 3% growth year.
- Germany -0.148% vs France -0.05% — explained by 2014 trade-share exposure + sectoral mix.
- UK -0.065%; US barely visible at the aggregate (despite leading enforcement effort).
- Mechanism — coalition-member exposure is **convex in pre-sanctions trade share** (Hausmann et al., 2024).
- Extraterritorial reach amplifies impact on third countries with US financial ties (Kwon et al., 2024).

Seven scenarios at a glance

#	Scenario	Russia welfare
S1	2014 coalition + 2014 measures	−1.06%
S2	2022 coalition + 2022 measures	−2.62%
S3	Global coalition + 2022 measures	−7.23%
S4	2022 minus the U.S.	−2.51%
S5	2022-group total embargo	−5.05%
S6	EU-only total embargo	−3.80%
S7	Global total embargo (autarky)	−20.67%

- S2 $\approx$ 13% of the S7 ceiling — much remaining lever.
- S7 = the Arkolakis et al. (2012) gains-from-trade bound for Russia on the ICIO 2022 grid.

Source: Crozet et al. (2025) Tab. 1.

Seven scenarios at a glance (cont.)

- S4 vs S2 tiny on the *trade* margin: the U.S. trade share with Russia was small. **Coalition breadth** matters more than U.S. participation here.
- *Caveat*: KITE is a real-trade model; the U.S. contribution via the CBR reserve freeze and SWIFT exclusion is NOT in these numbers — see Bianchi and Sosa-Padilla (2024) for the financial channel.
- Trade-elasticity vector θ_s from Caliendo and Parro (2015) (sectoral GMM, $\theta_s \in [4, 7]$); standard errors and Bayesian bands in Crozet et al. (2025) Tab. 1, suppressed here for clarity.

Source: Crozet et al. (2025) Tab. 1.

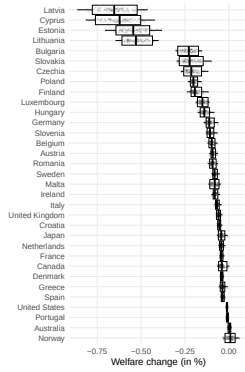
The bill, in dollars

- EU+UK welfare cost of S2 $\approx$ USD **41 B** over two years.
- Ukraine direct aid through early 2025 (Kiel Institute for the World Economy, 2024):
  - $\rightarrow$ EU + institutions: USD 77.7 B.
  - $\rightarrow$ UK: USD 9.1 B.
  - $\rightarrow$ US: USD 67 B ($+ \sim$ 61 B package).
- Including sanctions cost, Europe's war effort $\approx$ USD 127 B, $\approx$ one-third borne via sanctions.
- Russia 2.62% loss $\approx$ USD 40 B+ in absolute terms — of the same order as the sender bill.

Source: Crozet et al. (2025) §3.2; Kiel Institute for the World Economy (2024).

Designing better coalitions

What a global coalition would deliver



- S3: same 2022 measures, but *everyone* joins $\Rightarrow$ Russia -7.23% ($\approx 3\times$ S2).
- Third-country gains shrink: no neutral hub left.

Source: Crozet et al. (2025) Fig. 5a.

Convexity and deterrence

- Hausmann et al. (2024): effectiveness is **convex in coalition market share** at the HS6 level.
  - → Partial bans by partial coalitions buy little.
  - → Full bans by full coalitions buy disproportionately more.
- Mayer et al. (2026): pre-war decoupling *lowers* target exposure — but also *lowers* the opportunity cost of conflict.
  - → Deterrence value of sanctions is ambiguous in equilibrium.
- Policy upshot — credibility of **breadth** matters more than fine-tuning targeting.

Oil cap and energy

The oil price cap and the shadow fleet

- Spiro et al. (2025): design trade-off — cut Russian *revenue* without cutting world *supply*.
  - → Adaptation through discounted crude + maritime workarounds.
  - → **Shadow fleet**: >600 tankers off Western insurance and flagging by 2024.
- Fernández-Villaverde et al. (2025): “dark shipping” as an evasion technology.
  - → AIS gaps, flag-hopping, ship-to-ship transfers — measurement falls apart.
- Implication — the bilateral $\hat{\tau}$ wedge in KITE understates effective channels; an additional “compliance” margin is needed for energy.

The CBR reserve freeze

- February 2022: $\sim$ USD **300 B** of CBR foreign reserves frozen across G7 jurisdictions.
  - $\rightarrow$ Largest single sanction by dollar value ever imposed.
  - $\rightarrow$ Sits *outside* the trade-cost $\hat{\tau}$ wedge; KITE does not see it.
- Bianchi and Sosa-Padilla (2024): sovereign-default model with wartime fiscal needs.
  - $\rightarrow$ Reserve loss makes future fiscal stress **nonlinear** in sanction breadth.
  - $\rightarrow$ Cost of war rises faster than the static trade number suggests.
- Live policy debate — *repurposing of Russian assets* (windfall-tax on reserves vs. full confiscation; Foreign Affairs / Atlantic Council 2024–25 commentary).
- Implication for Session 3: every Russia welfare number on the previous slides is a **trade-only floor**.

Designing the price cap

- Johnson et al. (2023): the cap is a **hybrid trade–finance–shipping** instrument.
  - → Cap binds via G7 services (insurance, finance, flagging), not direct quantities.
  - → Enforceable only as long as buyers cannot self-insure — a moving target.
- Two-part lesson:
  - → Sanctions design now sits at the intersection of **financial plumbing** and **trade policy**.
  - → A KITE-style quantity model is necessary but not sufficient (Itskhoki and Ribakova, 2024).

Dynamic / NQTM frontier

Long-run capital and technology

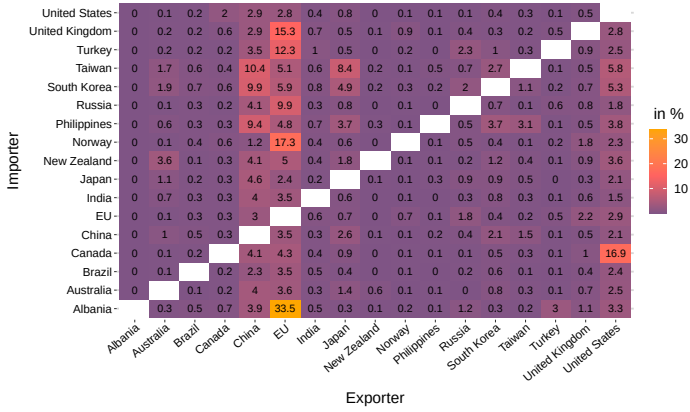
- Baqaee and Malmberg (2025): static welfare numbers *undercount*.
  - → Capital misallocation, lost access to frontier technology, lower future productive capacity.
  - → 10-year horizon: Russia welfare loss is several multiples of S2.
- Itskhoki and Ribakova (2024): synthesis — prices, FX, capital flight, oligarch behaviour outside the static gravity frame.
- For KITE: $\hat{\tau}$ captures the trade-cost wedge; *not* the dynamic capital wedge.

Dynamic NQTM with third-country spillovers

- Ghironi et al. (2024): third-country effects sit inside a *calibrated* macro–trade model, not added on after the fact.
- Ghironi et al. (2025): sectoral asymmetries generate transitional dynamics static gravity misses.
- Bachmann et al. (2024): an energy-stop counterfactual for Germany — numbers depend critically on substitution elasticities and adjustment frictions.
- Frontier direction — **merge NQTM with macroeconomic dynamics**; KITE is the static benchmark this richer class must beat.

China decoupling

Where does Europe sit on China?



- Imports from China as share of GDP — intermediates dominate.

Source: Felbermayr et al. (2023).

What decoupling would cost

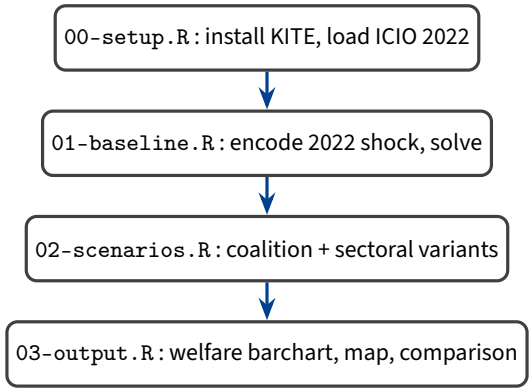
Scenario	EU welfare	China welfare	World welfare
EU decouples unilaterally	−0.81%	−0.22%	−0.13%
China decouples unilaterally	−0.40%	−1.34%	−0.18%
Mutual decoupling	−0.99%	−1.48%	−0.27%

- Same KITE machinery, same ICIO 2022 grid.
- **Smaller side bears more** — consistent with the convexity argument.
- Decoupling $\neq$ sanctions, but the welfare arithmetic is identical.

Source: Felbermayr et al. (2023); Braunschweig frame 42.

Bridge to Exercise 2

The KITE Russia exercise — pipeline




```
cd exercises/02-kite-russia && make
```

What each script computes

- `01-baseline.R` — 2022 measures encoded as three NTB wedges (dual-use, luxury, energy) on $\hat{\tau}_{ij}^{s}$; solve the fixed point; recover $\widehat{W}_i$.

  $\rightarrow$ Reproduces the **qualitative pattern** of S2 (Russia at single-digit-percent loss; Baltics worst-hit among senders); exact magnitudes depend on the sectoral wedge calibration, which we simplify here for pedagogy.

- `02-scenarios.R` — extend the coalition (**extended-coalition** variant adding China + India + Turkey + UAE + Kazakhstan as senders) and drop the energy lever.

- `03-output.R` — welfare bar chart, choropleth map of sender losses, scenario comparison table.

- Together — $\approx$ 45 minutes; output is a self-contained PDF + table students keep.

Take-aways

Three take-aways

1. NQTM + hat-algebra turns “what if?” sanctions questions into reproducible welfare numbers — but the **static** number is a lower bound on the dynamic one.
2. **Coalition breadth** dominates fine-tuning: S4 vs S2 barely moves; S3 triples. Convexity, not targeting, is the lever.
3. The frontier is **plumbing**: oil-cap design, dark shipping, financial channels, dynamic capital — all sit *outside* the static $\hat{\tau}$ model. KITE is the floor, not the ceiling.

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