

Container shipping disruptions and the economics of decarbonization

Energy Economics, 2026

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October 2026

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Decarbonization travels in containers

- Solar panels, wind turbine components, batteries and other manufactured inputs for clean energy move by **container ship**
- More than **60 percent** of global trade value travels in containers
- The system faces repeated disruptions: port congestion, extreme weather, geopolitical conflict, operational failures
- When a disruption hits, clean energy investment is not obviously spared

Question

Do containerized shipping disruptions slow the green transition and, if so, through which channels?

Scope: financial signals, not realized deployment

- The analysis traces transmission from **exogenous shipping shocks** to commodity markets and to climate finance variables
- It measures the **market signals** that shape decarbonization investment incentives: carbon prices, expected investment returns, equity valuations, climate risk indices
- Following the chain through to actual deployment and emissions cuts needs a longer horizon than the paper has
- How IMO emission mandates interact with supply chain resilience is a **distinct question**, outside this scope

Reading the results

When expected decarbonization returns stay low while fossil fuel stocks rise, the market signals that clean energy has become less profitable than the incumbent alternative.

- **Instrument:** exogenous price surcharges announced by the three largest container carriers, built by Bini (2025) from about 7,000 announcements, 2014–2024: **62 supply-side disruptions**
- **Method:** Bayesian structural VAR with the surcharge series as an **internal instrument** (Plagborg-Møller and Wolf 2021; Li et al. 2024)
- **Two specifications**
 - Commodity markets and macro: world industrial production, US CPI, oil, critical materials, supply chain pressure
 - Climate finance: transition and physical risk, carbon price and volatility, expected decarbonization investment, fossil fuel stocks, climate awareness
- **Output:** impulse responses, with checks on identification, sample, dynamics, priors and heterogeneity

Preview of results: three channels

- **Policy uncertainty:** the Transition Risk Index rises, the Physical Risk Index falls, carbon prices fall on impact. Attention moves from environmental urgency to economic security
- **Cost:** critical materials prices fall on impact, then rise; expected decarbonization investment returns drop
- **Credibility:** carbon prices recover as substitution toward carbon-intensive production lifts allowance demand; fossil fuel stocks stay elevated, which the paper reads as markets pricing weaker future climate policy
- Output contracts and consumer prices rise as freight costs pass through

The paper's reading rests on the full pattern of responses; the three channels are not separable in the data.

Related literature: two strands

1. **Climate finance and the green transition:** carbon risk premia and asset pricing (Bolton and Kacperczyk 2021; Hsu et al. 2023), climate policy uncertainty (Bouri et al. 2022), climate concerns and portfolios (Pástor et al. 2021; Engle et al. 2020), media-based transition and physical risk indices (Bua et al. 2024)
2. **Macroeconomic effects of supply chain disruptions:** inflation, industrial production and monetary policy (Benigno et al. 2022; Carrière-Swallow et al. 2023; Ascari et al. 2024; Finck et al. 2024)
 - Strand 1 studies climate events or climate policy shocks, not shocks that **originate outside the climate system**
 - Strand 2 stays with traditional macro outcomes
 - Also related: containerization as trade infrastructure (Bernhofen et al. 2016; Coşar and Demir 2018; Hummels 2007); geopolitical risk and critical mineral prices (Saadaoui et al. 2025)

- Show how **logistics disruptions** transmit through carbon markets, green investment channels and climate policy credibility
- Connect the two literatures: most work asks how climate policy affects the economy; this paper asks how **economic shocks affect decarbonization efforts**
- Identification: narrative exogenous surcharges (adapted from Baker et al. (2016)) within an internal-instruments SVAR

What it does not do

It does not measure realized investment or emissions, and it does not separate the three channels. The effects are averages over the 62 episodes.

Background and Method

Why a shipping disruption is an aggregate shock

- **Concentration.** With carrier capacity shares s_i and i.i.d. carrier-level cost shocks $\varepsilon_{i,t}$, the aggregate innovation $\eta_t = \sum_i s_i \varepsilon_{i,t}$ has

$$\text{Var}(\eta_t) = \sigma^2 H, \quad H = \sum_i s_i^2, \quad H \geq S_3^2/3 \approx 0.08$$

- The three largest carriers hold $S_3 \approx 0.5$ of capacity, so H **does not vanish** as carriers are added (Gabaix 2011)
- **Network centrality.** Maritime transport intermediates most traded goods; its influence in the production network stays away from zero (Acemoglu et al. 2012)
- **Inelastic short-run capacity.** Fleet capacity is fixed and modal substitution is costly, so a capacity loss δ_t gives $\Delta \log p_t = \delta_t/\epsilon$ with small ϵ

Identification: the surcharge isolates the supply component

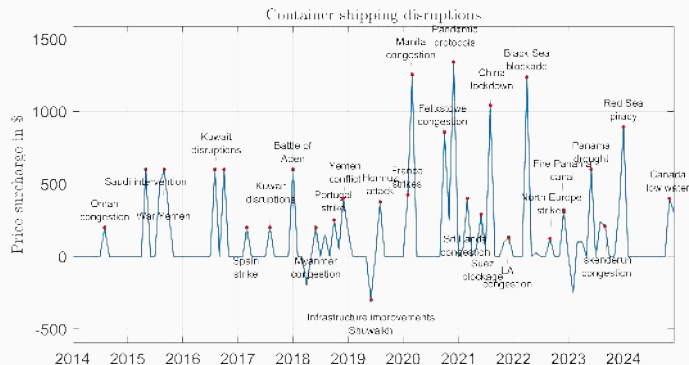
- Carriers price whole trade lanes. Marginal cost separates into a demand-correlated part and an exogenous supply-disruption part:

$$\Delta mc_t = \beta' \Delta d_t + u_t, \quad z_t = \rho \Delta mc_t, \quad z_t^* = \rho u_t, \quad \mathbb{E}[z_t^* \tilde{\zeta}_t^d] = 0, \quad \mathbb{E}[z_t^* u_t] \neq 0$$

- **Narrative screening** keeps an announcement only if the carrier text attributes the increase to a documentable supply-side event (port congestion, war, strikes, natural disasters) and drops those citing demand; candidates are validated externally (Bini 2025)
- The two conditions are the **exclusion restriction** and **relevance**
- Because a surcharge applies across a corridor, a local event raises the price faced by all shippers on the lane

The instrument pools events with energy, demand and geopolitical components (Covid-19, Ukraine); the paper checks this directly.

The instrument: exogenous price surcharges, 2014–2024



- Average surcharge across affected lanes and carriers, USD per FEU; **46 non-zero months**, February 2014 to December 2024
- Modest until 2019, then escalating from 2020: Manila (1,255 USD), pandemic protocols (up to 1,300), Black Sea rerouting (1,255), Red Sea piracy (about 900)
- The maximum is December 2020
- Three negative surcharges mark improved conditions

Estimation: Bayesian SVAR with an internal instrument

- Reduced form, with the surcharge z_t added as the **first endogenous variable**, $\bar{\mathbf{y}}_t = (z_t, \mathbf{y}_t')'$:

$$\mathbf{y}_t = \sum_{l=1}^p \mathbf{A}_l \mathbf{y}_{t-l} + \varepsilon_t, \quad \varepsilon_t = \mathbf{S}\eta_t, \quad \Sigma = \mathbf{S}\mathbf{S}'$$

- Relevance and lead-lag exogeneity identify dynamic causal effects **without imposing invertibility** (Plagborg-Møller and Wolf 2021; Li et al. 2024)
- Minnesota prior (Litterman 1986; Doan et al. 1984); **three monthly lags**; BEAR toolbox (Dieppe et al. 2016); 2,000 Gibbs draws after 1,500 burn-in
- Baseline recursive ordering: instrument, supply chain pressure, activity, CPI, oil, critical materials, coal-to-gas, oil inventories
- Climate-finance figure: shock scaled to raise the supply chain pressure index by 1 percentage point on impact; lines are posterior medians, bands are 68% credible

Data: two specifications, monthly, Sep 2013 – Dec 2024

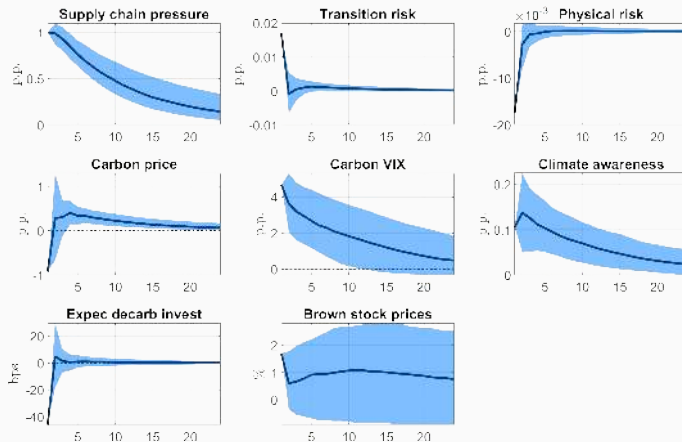
	Variables	Main sources
Both	Container shipping disruptions z_t (instrument); Global Supply Chain Pressure Index	Bini (2025); Benigno et al. (2022)
I: Global markets	World industrial production, US CPI, real oil price, critical materials index, coal-to-gas ratio, crude oil inventories	Baumeister, Korobilis, et al. (2022); FRED; US EIA; own/World Bank
II: Climate finance	Transition and physical risk, climate awareness, carbon price (changes), carbon VIX, expected decarbonization investment, brown stocks	Bua et al. (2024), Ardia et al. (2023), and Fuchs et al. (2024); STOXX Europe 600

- Critical materials index: first principal component of **copper, nickel and zinc**. Lithium, cobalt and rare earths lack continuous monthly series; the paper argues the index is then a lower bound on the transport-cost channel
- Climate finance block uses **European** market data (EU ETS prices; STOXX Europe 600)

Full table

Results

Climate finance responses to a supply chain shock



Notes: Shock raises the supply chain pressure index by 1 p.p. on impact. Black line: posterior median; shaded: 68% credible bands.

- **Transition risk** up, **physical risk** down on impact
- **Climate awareness** stays above baseline: attention is reallocated toward policy debate
- **Carbon price** falls on impact, then rises; carbon volatility jumps on impact and decays
- **Expected decarbonization investment** falls on impact
- **Brown stock prices** respond positively; bands are wide

Three channels, as the paper reads them

Channel	Timing	Evidence and interpretation
Policy uncertainty	On impact	Transition risk up, carbon price down: markets anticipate regulatory relief; physical risk down signals attention displacement, not milder hazards
Clean technology cost	Lagged	Critical materials fall on impact, rise after about month ten; expected decarbonization returns fall, which the paper reads as higher deployment costs
Credibility	Most persistent	Fossil stocks stay elevated after transition risk, physical risk, awareness, carbon volatility and oil prices normalize: a downward revision of expected policy stringency

- Carbon prices recover as higher energy costs push firms toward **carbon-intensive production**, raising allowance demand; the paper reads this as substitution dominating demand destruction
- Consistent with Bolton and Kacperczyk (2021) and Pástor et al. (2021): investors revise the distribution over future regulatory stringency

Is the carbon price drop just weaker demand?

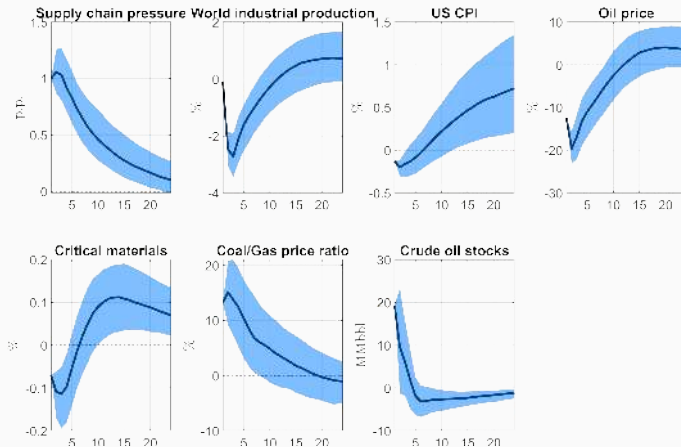
- A contraction in industrial production could lower allowance demand mechanically, with no role for policy expectations
- **Timing argument:** carbon market volatility spikes on impact, **before** industrial production falls (about three periods later). A demand-driven decline would move with or after the contraction
- Illustration: in January 2024 freight costs rose before measurable output loss, and carbon market uncertainty followed the surcharge announcement

The paper's own caveat

The argument rules out responses to *realized* production, not to *anticipated* demand destruction. It is necessary but not sufficient: separating the policy uncertainty channel from a forward-looking demand channel would need expected industrial production (for example PMI or forecaster data).

More caveats

Global macro and commodity responses



Notes: Impulse responses to a supply chain shock. Black line: posterior median; shaded: 68% credible bands.

- **World industrial production** falls, with a trough after about three months, then recovers
- **US CPI** rises gradually as freight costs pass through
- **Oil price** falls on impact, then recovers
- **Critical materials** fall on impact, then rise after about month ten
- **Coal-to-gas ratio** up on impact, back to baseline by the second year
- **Crude oil stocks** rise on impact, then normalize: precautionary stockpiling

Why credibility, not scarcity or risk-off? Alternatives considered

Alternative	Why the paper finds it a poorer fit
Energy scarcity rents	Oil prices normalize by period 18, fossil stocks stay elevated through period 20
Generic risk-off rotation	Carbon volatility stays elevated; appreciation is concentrated in fossil equities, not broad value stocks
Inflation-driven value revaluation	Predicts symmetric loading across fossil and clean value stocks; the responses diverge
Secular restructuring of energy	Response starts at impact and decays: a belief revision, not a trend
Cash-flow channels	Oil prices and production normalize while fossil stocks stay elevated

- **Not ruled out:** a sector-specific rotation, and updated beliefs about the physical feasibility of decarbonization. The paper treats these as linked to credibility; they predict the same IRF pattern and need firm-level data
- The 18 versus 20 gap is **fragile:** credible bands overlap at those horizons and no formal test is reported

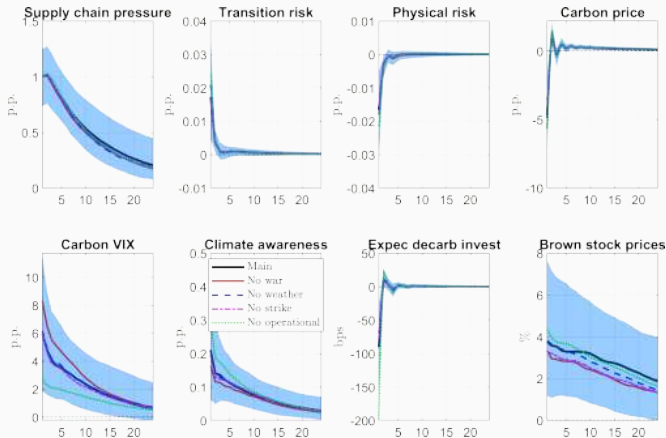
Robustness: identification, dynamics and priors

- **Confounding shocks:** adding energy transportation uncertainty, economic policy uncertainty and European geopolitical risk, or replacing industrial production with global economic activity: results remain stable
- **Covid-19 and Ukraine:** dummies for 2020m3–2020m6 and 2022m3–2024m12; responses remain similar
- **Ordering:** main patterns persist across orderings; the **size** of impact responses varies with the assumed timing
- **Sign and correlation restrictions** on the climate finance block (Ludvigson et al. 2021; Arias et al. 2018): direction and persistence preserved
- **Local projections** (Ferroni and Canova 2021): impact and short-run dynamics agree; at long horizons the LP responses of trending variables lie above the VAR, which stays the preferred estimator there
- **Lags, priors, deterministic terms:** four lags, other Minnesota tightness values, sum-of-coefficients and cointegration priors, no constant, linear or quadratic trend: comparable responses

LP vs. VAR

State dependence

Robustness: dropping each disruption type



- The instrument pools four event types; the model is re-estimated excluding armed conflict, weather, labor strikes and operational disruptions in turn. The paper reports stable responses
- Operational disruptions are 53 percent of identified episodes; excluding them leaves the transmission patterns unchanged
- In the figure, carbon volatility on impact is the series that moves most across exclusions

- **Averages** across the 62 episodes; responses are larger in high-stress episodes, and the linear model understates severe disruptions
- **Pooled instrument:** it cannot separate conflict, strike, weather and operational events; the episodes are concentrated in operational events
- **European** market data: whether the channels hold in emerging economies, with fragmented carbon pricing and costlier clean energy finance, is open
- **Financial signals**, not realized investment flows or emissions
- **Channels not separable:** the VAR gives the aggregate effect, not the feedback among channels
- **Open:** carbon price timing versus anticipated demand; sector-specific rotation versus credibility

Policy implications

- **Policy uncertainty:** automatic stabilizers in carbon markets. The EU ETS market stability reserve is a partial buffer; a price floor triggered by elevated carbon volatility could limit expectation-driven price drops
- **Clean technology costs:** strategic reserves for industrial metals; supply chain diversification requirements in subsidized clean energy procurement
- **Credibility:** precommitment, such as legislated carbon price trajectories and central bank climate mandates (Giglio et al. 2021), makes relief episodes less informative about long-run policy

These follow from the impulse responses; the paper does not test the policies.

Conclusion

- Exogenous carrier surcharges identify supply chain shocks in a Bayesian SVAR; the question is whether shipping disruptions slow the green transition
- A disruption **shifts policy attention** toward energy security, lowers expected clean investment returns, and is followed by fossil stock valuations that stay elevated after the climate indicators normalize
- Green investment faces headwinds while fossil assets gain an advantage that outlasts the disruption: the paper's **central result**
- Conditional on European data and on the averaged shock; the channels are not separable

Thank you!

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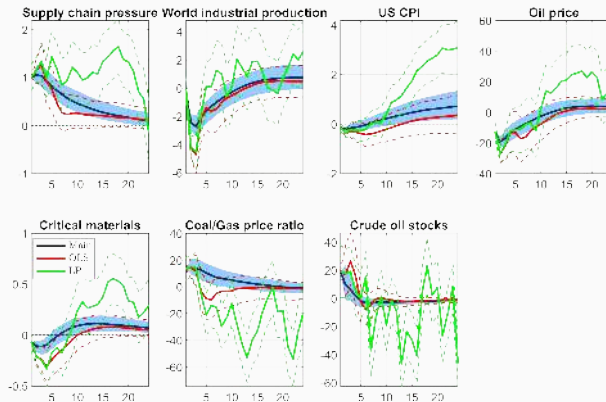
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Data description and sources

Label	Description	Source
z_t	Container shipping disruptions (instrument)	Bini (2025)
$gscpi_t$	Global Supply Chain Pressure Index	Federal Reserve Bank of New York
y_t^w	World industrial production	Baumeister and Hamilton (2019)
π_t	US consumer price index (ln)	FRED
p_t^o	Real oil price (ln)	US EIA
p_t^{crit}	Critical materials price index	Own/World Bank
$p_t^{coalgas}$	Coal-to-gas price ratio	Own/World Bank
Δi_t^{oil}	World crude oil inventories	US EIA
$risk_t^{trans}, risk_t^{phys}$	Transition and physical risk indices	Bua et al. (2024)
$p_t^{carb}, vix_t^{carb}, inv_t^{decarb}$	EU ETS carbon price (changes), carbon VIX, expected decarbonization investment	Fuchs et al. (2024)
$aware_t^{clim}$	Climate awareness index	Ardia et al. (2023)
p_t^{brown}	Brown (oil and gas) stock prices	STOXX Europe 600

Notes: Monthly data, September 2013 – December 2024.

Local projections versus the VAR



- Black: baseline VAR with 68% bands; red: OLS; green: local projections
- Impact responses coincide and signs and short-to-medium dynamics agree; at longer horizons LP responses of trending variables lie above the VAR

State dependence and other checks

- **Positive surcharges only** ($GSCS > 0$): responses unchanged, so the few rate-reduction episodes do not distort the baseline
- **High versus low stress** ($GSCS \geq 600$ vs. $0 < GSCS < 600$, split at the 75th percentile): larger in high stress, same sign and pattern
- **Largest months** ($GSCS \geq p_{90} = 885$ USD/FEU; five episodes: 2020m3, 2020m12, 2021m8, 2022m2, 2024m1): larger on impact for industrial production, critical materials and fossil stocks, similar decay; consistent with nonlinear amplification at the tail
- **Post-Paris** ($t \geq 2015m12$): the paper reports larger climate finance responses, consistent with Bolton and Kacperczyk (2021)
- **Emerging markets**: adding an EME shipping shock indicator leaves macro transmission unchanged; adding the EME dollar index, the dollar appreciates on impact

Caveats on separating the channels

- **Carbon VIX timing:** it rules out responses to realized production changes but not to anticipated demand destruction in a forward-looking cap-and-trade market. The medium-term rise of carbon prices above baseline is inconsistent with pure demand destruction, but the on-impact attribution to policy uncertainty remains a limitation
- **Risk-off:** ruling out generic risk-off does not rule out a rotation *within* the energy sector; investors may also update beliefs about the physical feasibility of decarbonization. Distinguishing these needs firm-level data linking supply chain exposure to equity repricing and investment plan revisions
- **Scarcity rents:** the timing gap between oil prices (period 18) and fossil stocks (period 20) is the main timing-based evidence; readers should weight the aggregate pattern, not the gap alone

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