Supply Chain Disruptions: Evidence from the Great East Japan Earthquake

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Research Question(s)

- **Micro-to-Macro:** Do idiosyncratic shocks to individual firms ”average out” (Lucas, 1977) or propagate through the network?
- **Propagation Directions:**
  - **Downstream:** Do supplier failures starve customers of inputs?
  - **Upstream:** Do customer failures reduce demand for suppliers?
- **Network Multiplier:** How much of the 2011 GDP decline was due to direct destruction vs. supply chain ”contagion”?

Economic Significance

- **Massive Scale:** Intermediate input trade accounts for over 50% of global trade and a similar share of domestic gross output.
- **The ”Network Multiplier”:** If substitution elasticities are low, a small shock to a ”hub” firm can have a disproportionate effect on aggregate volatility.
- **Policy Context:** Understanding these links is vital for disaster insurance, infrastructure resilience, and systemic risk monitoring.

The Natural Experiment: 2011 Earthquake

- **Exogeneity:** The earthquake, tsunami, and nuclear crisis were unanticipated and concentrated in the Tohoku region.
- **Directly Treated:** Firms located in the 41 designated ”disaster municipalities.”
- **Indirectly Treated:** Firms *outside* the disaster area that have:
  - A supplier in the disaster area (Downstream treatment).
  - A customer in the disaster area (Upstream treatment).

Identification Strategy: Difference-in-Differences

The authors estimate the impact on sales growth (Δy_{it}):

$$\Delta y_{it} = \alpha + \beta_{down}\text{Dist1\_Down}_i + \beta_{up}\text{Dist1\_Up}_i + \text{Controls} + \epsilon_{it}$$

- **Saturated Fixed Effects:** Control for industry, size, and geographic distance to the epicenter to isolate **network effects** from **spatial effects**.
- **Placebo Tests:** Verify that "indirectly treated" firms were on parallel trends with control firms prior to March 2011.

Results: Extensive and Intensive Margins

Immediate Impact (1-year post-shock)

- **Directly Hit Firms:** Sales growth fell by 25 percentage points.
- **Downstream Impact:** Being a customer of a hit firm → **3.6%** decline in growth.
- **Upstream Impact:** Being a supplier to a hit firm → **2.9%** decline in growth.

- **Decay:** Effects propagate to distance 2 (indirect partners) but vanish by distance 3.
- **Persistence:** The shock was temporary; most firms recovered within 2 years.

Aggregate GDP Impact

The authors use a General Equilibrium (GE) model to aggregate micro-shocks:

- **Finding:** The earthquake reduced Japan's real GDP growth by **0.47 percentage points**.
- **The Multiplier:** Network propagation accounted for roughly **half** of the total impact.
- **Substitution:** Low short-run elasticity across suppliers prevents firms from "switching" quickly, magnifying the disruption.

Caveats and Limitations

- **Inventory Buffers:** TSR data does not track inventories; ”just-in-time” firms likely suffered more, but this is unobserved.
- **Binary Linkages:** The model assumes all links are equal (unweighted network); large-volume links likely drive the results.
- **Bottleneck Inputs:** The model assumes Cobb-Douglas/CES; if certain inputs are ”essential” (Leontief), the multiplier could be even higher.

Conclusion

- Production networks are a first-order mechanism for macroeconomic volatility.
- Shocks spread **both ways**: demand-side upstream and supply-side downstream.
- **Final Takeaway:** Geography matters, but network topology determines how far a local shock can travel.