Spillovers and Redistribution through Intra-Firm Networks: The Product Replacement Channel

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Motivation

Q. How do regional shocks spill over across regions & reshape regional welfare?

- A long-standing question in macro/trade, relevant in within-county contexts
e.g., A sudden differential collapse in local housing markets in Great Recession

This Paper

- **Intra-firm networks** of producers who sell in multiple counties/states
  ⇒ important firms, but ambiguous direction of spillovers

- **Empirics**: provide causal evidence of within-firm regional spillovers and identify a novel mechanism behind

- **Model**: formalize the mechanism & discuss aggregate implications
Summary: Empiric

By exploiting a detailed micro-data including a million of barcodes and producer info. & sudden differential \(\downarrow\) in local house prices in 07-09,

(1) Firm's local sales **decrease** w.r.t. not only **direct local demand shock** but also firm’s **average indirect local demand shock** originating in its **other markets**
(2) **Why? We show that**

- Such *spillover* driven by *extensive margin response* from product replacement (while *direct local shock* $\Rightarrow$ *intensive margin* from continuing products)

- Product replacements typically *synchronized across many markets*
  - Shocks hitting other mkt$s$ induce product replacement even in “not hit” mkt
  - Firms *downgrade products* (organic $\rightarrow$ non-organic, expensive $\rightarrow$ cheap etc.)
1. What are real world examples of synchronized product replacements?

- Kraft Foods Inc. produces both organic and non-organic cheese

(a) Organic Cheese
(b) Non-organic Cheese

- Organic: sold in 11 states in 2007, exited all the states in 2009
- Non-organic: uniformly entered in the same states
- Despite a large variation in regional shocks: -5% (PA) to -23% (MD)

2. We address potential endogeneity concerns in depth
Summary: Theory

Empiric: replacing high- to low- value products, which are synchronized across many markets

(2) Mechanism

A. producers facing negative demand shocks lower their product quality
   - because of the (i) scale effect and (ii) non-homotheticity

B. in doing so, they do it in multiple markets simultaneously
   - because of the local-firm-specific fixed cost of product replacement

(3) Implication: mitigates the regional consumption inequality

- many regions face the same quality goods: a novel risk-sharing mechanism
- std(consumption growth) ↓ by 30% w/ the mechanism, ≈ $400 per HH
Related Literature

Networks, Spillovers, and Macroeconomy
- Multi-Market: Berman et al. 15, Ahn & Mcquoid 17, Almunia et al. 18, Erbahar 18
- Multi-Establishment: Carvino & Levchenko 17, Gilbert 18, Giroud & Mueller 19
- Trade & Supply Chain: di Giovanni & Levchenko 10, Acemoglu et al. 16, Stumpner 17, Caliendo et al. 18, Arkolakis et al. 18, Auerbach et al. 19, Boehm et al. 19
- Banking Networks (Acemoglu et al. 15, Gilje et al. 16, Mitchener & Richardson 19); Migration (House et al. 18); Social Networks (Bailey et al. 18)

Housing Market Collapse and the Great Recession
- Mian et al. 13, Mian & Sufi 14, Stroebel & Vavra 19, Kaplan et al. 16, Giroud & Mueller 17, Beraja et al. 19

Variety/Quality Changes & Distributional Implications
- Broda & Weinstein 10, Schmitt-Grohe and Uribe 12, Nakamura & Steinsson 12, Hottman et al. 16 Dingel 17, Jaimovich et al. 17, Argente et al. 18, Jaravel 18, Medina 20, Faber & Fally 20

Business Cycle Comovement
- Backus et al. 92, Frankel & Rose 98, Kose & Yi 06, Johnson 14, Liao & Santacreu 15, Cravino & Levchenko 17, di Giovanni et al. 18

Regional Risk-Sharing/Redistribution
- Asdrubali et al. 96, Lustig & Van Nieuwerburgh 10, Hurst et al. 16

Uniform Pricing in Retail Sector
- DellaVigna and Gentzkow 17, Cavallo 18, Hitsch et al. 19
Empirical Specification

- Data: regional house price + barcode-region level p,q + producer info.

\[ \tilde{S}_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}H P_r + \beta_2 \tilde{\Delta}H P_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]  

(1)

where \( r \): region (county/state), \( f \): firm, \( \tilde{\Delta}X \): growth rate of \( X \) in 07-09
\( \delta_s \): primary sector FE

- \( \beta_2 \): the effect of regional shocks hitting other markets of firm \( f \) conditional on direct local demand
  - Indirect Shock: \( \tilde{\Delta}H P_{rf} \text{ (other)} = \sum_{r' \neq r} \omega_{r'f} \times \tilde{\Delta}H P_{r'} \) - Also consider similarly constructed IVs
  - No prior on \( \beta_2 \) \( \Rightarrow \) We get \( \beta_2 > 0 \)

- \( \beta_1 \): the effect of direct regional shock in region \( r \)
  - Similar to Mian et al. (13), Kaplan et al. (16) \( \Rightarrow \) We expect \( \beta_1 > 0 \)
  - Also consider region x sector FE instead of including \( \tilde{\Delta}H P_r \)
Key Identifying Assumption

\[ \tilde{\Delta} S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta} HP_r + \beta_2 \tilde{\Delta} HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

Any confounding factor that affects firm’s local sales growth does not simultaneously affect its other market house price growth

Threats to identification

- Common or clustered regional shocks?

- Alternative channels?
Visualization

$$\tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf}$$

Local sales respond to both direct and indirect shocks

Scatter plots (25 bins based on ventiles) depicting the relationship between (residualized) $\tilde{\Delta}S_{rf}$ and either $\tilde{\Delta}HP_r$ or $\tilde{\Delta}HP_{rf}$ (other), where each point is the sales-weighted average across obs. within each bin. We use Frisch-Waugh theorem to tease out the effect.
Local sales respond to both **direct** and **indirect** shocks

\[ \tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

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*Note.* County controls: all controls in Mian and Sufi 14. County-firm controls: log initial county-firm specific sales, log initial firm-level sales, log initial number of local markets, and log initial number of product groups. Regressions weighted by county-firm initial sales. Standard errors double clustered at state-sector level.
Direct effect works through the intensive margin

\[ \tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

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Spillover effect works through the extensive margin

\[ \tilde{\Delta}S_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{\Delta}HP_r + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

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Spillover effect works through the extensive margin
⇒ robust to county x sector FE

\[ \tilde{\Delta} S_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta} H P_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

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Spillover effect works through the extensive margin through products replaced in multiple markets

\(\tilde{\Delta}S_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta}H_{rf}\) (other) + Controls\(_{rf}\) + \(\varepsilon_{rf}\)

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Spillover effect works through the extensive margin through products replaced in multiple markets from high- to low-valued products

\[ \tilde{\Delta}v_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

(1) (2) (3) (4) (5)

\[ \tilde{\Delta}v_{rf} \equiv \frac{v_{\text{enter},09} - v_{\text{exit},07}}{v_{rf}} \]

where \( v_{rf} = \frac{\text{sale per upc}}{\text{price group-adj.}} \cdot \frac{\text{organic sale}}{\# \text{ of upc}} \)

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<tr>
<th>( \tilde{\Delta}HP_{rf} \text{ (other)} )</th>
<th>0.52**</th>
<th>0.92**</th>
<th>0.70**</th>
<th>43.78**</th>
<th>-0.06</th>
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<td>461,672</td>
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Note. For organic share, we use state as a unit of region.
Spillover effect works through the extensive margin through products replaced in multiple markets
⇒ not through simple reduction of variety

\[ \tilde{\Delta}v_{rf} = \beta_0 + \delta_{rs} + \beta_2 \tilde{\Delta}HP_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

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where \( v_{rf} = \text{sale per upc} \) price \( \text{price}^{\text{group-adj.}} \) organic sale \( \# \text{ of upc} \)

\( \tilde{\Delta}HP_{rf} \) (other) | 0.52** | 0.92** | 0.70** | 43.78** | -0.06 |
| (0.21) | (0.44) | (0.34) | (17.88) | (0.17)  |

region × sector FE | ✓ | ✓ | ✓ | ✓ | ✓ |
region-firm controls | ✓ | ✓ | ✓ | ✓ | ✓ |
R-squared | 0.40 | 0.41 | 0.42 | 0.38 | 0.40 |
Observations | 464,423 | 461,672 | 461,672 | 27,930 | 464,423 |

Note. For organic share, we use state as a unit of region.
Key Identifying Assumption: Further Robustness Check

\[ \tilde{S}_{rf} = \beta_0 + \delta_s + \beta_1 \tilde{HP}_r + \beta_2 \tilde{HP}_{rf} \text{ (other)} + \text{Controls}_{rf} + \varepsilon_{rf} \]

Any confounding factor that affects firm’s local sales growth does not simultaneously affect its other market house price growth

Threats to identification

- **Common or clustered regional shocks?**
  - \( \tilde{HP}_{rf} \text{ (other)} \): exclude nearby counties
  - state-firm-level regression

- **Alternative channels?**
  - supply-side/collateral channel? \( \Rightarrow \tilde{HP}_{rf} \text{ (other)} \): exclude regions with plants
  - not driven by retailer
  - not driven by clientele effect
  - and many others ...

Further Results

- **Heterogeneous treatment effect**
Model Setup

**Purpose:** Formalize spillover mechanism & discuss aggregate implication ⇒

**Multi-region model with endogenous quality-adjustments by firms**

⇒ **Two key mechanisms** to match the empirical finding

(1) **producers facing negative demand shocks lower their product quality**
   - **scale effect:** Firms’ fixed cost increases with product quality
   - **nonhomotheticity:** HHs switch from high- to low-quality if income ⇓

(2) **firms choose uniform product quality across markets**
   - to avoid the local-firm-specific fixed cost of product replacement

∗ **Scale Effect:**

\[
\max_{\phi_f, \{p_{rf}\}_r} \pi_f = \sum_r [p_{rf} - mc(\phi_f; a_f)] Q_{rf} - [f(\phi_f) + f_0]
\]

⇒ **scale effect:** fixed cost \( f(\phi_f) \) increases in intrinsic product quality \( \phi_f \)
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   - to avoid the local-firm-specific fixed cost of product replacement

*Nonhomotheticity:*

\[
U_r = \left[ \int_{f \in G_r} (q_{rf} \xi_{rf})^{\frac{\sigma-1}{\sigma}} df \right]^{\frac{\sigma}{\sigma-1}}
\]

(\(r: \text{ region}, \ f: \text{ firm}, \ G_r: \text{ set of firms selling in market } r\))

⇒ \(\xi_{rf} \equiv (\phi_f)^{\gamma_r}\): “perceived” product quality of firm \(f\) in region \(r\)

⇒ nonhomothetic: \(\gamma_r \equiv \gamma(\text{Income}_r)\) increases with \(\text{Income}_r\)
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(2) firms choose uniform product quality across markets
   - to avoid the local-firm-specific fixed cost of product replacement

---

* Uniform vs Market-specific Product Quality:

\[
\max_{\phi_f, \{p_{rf}\}_r} \pi_f = \sum_r \left[ p_{rf} - mc(\phi_f; a_f) \right] Q_{rf} - [f(\phi_f) + f_0]: \text{Uniform}
\]

\[
\max_{\{\phi_{rf}, p_{rf}\}_r} \pi_f^m = \sum_r \left[ \left[ p_{rf} - mc(\phi_{rf}; a_f) \right] Q_{rf} - [f^m(\phi_{rf}) + f_{0r}^m] \right]: \text{Market-specific}
\]
Structural Equation: Intra-Firm Market Inter-Dependency

Region-Firm Sales Growth: Scale Effect and Non-homotheticity

\[ \Delta S_{rf} = \gamma_r \sum_{r'} \omega_{r'f} [\Delta S_{r'f} + \Delta(\gamma_{r'} - \xi)] + \text{other terms}_{rf} \]

where

\[ \gamma_r \approx \beta \left( \sigma - 1 \right) (\gamma_r - \xi) \times \]

sales or preference in r' \Rightarrow quality of f  

quality of f \Rightarrow sales in r

- \( \beta \): inverse elasticity of fixed cost w.r.t. quality, \( f(\phi_f) \equiv b\beta \phi_f^{1/\beta} \)
- \( \sigma \): demand elasticity
- \( \gamma_r \): how much households value the quality, \( \zeta_{rf} \equiv (\phi_f)^{\gamma_r} \)
- \( \xi \): elasticity of marginal cost w.r.t. quality (pass-through to price), \( mc(\phi_f; a_f) = \phi_f^\xi \)
Real Consumption Growth

**Benchmark:** uniform quality across markets, \( \text{std}(\tilde{\Delta} U_r) = 4.0 \)

e.g. Florida: real consumption growth = **-14.8%**, house price growth = **-43.2%**

Oklahoma: real consumption growth = **-0.4%**, house price growth = **+3.3%**
Real Consumption Growth

- **Counterfactual**: state-specific quality, \( \text{std}(\tilde{\Delta} U_r) = 5.2 \)
  - From counterfactual to benchmark: \( \text{std} \downarrow 30\% \approx $400 \) per HH redistribution

  e.g. Florida: real consumption growth = **-17.2%** (**-14.8%** in baseline)
  Oklahoma: real consumption growth = **+1.4%** (**-0.4%** in baseline)
Conclusion

**New Empirical Findings**: Regional Spillovers and behind Mechanism

- regional shocks spill over through the intra-firm networks created by multi-market firms
- by replacing high-valued products with low-valued products in multiple markets simultaneously

**Model and Implication**: Regional Redistribution (Risk-Sharing)

- quality downgrading through product replacement
- mitigates the regional consumption inequality
Thank you!