Estimating General Equilibrium Spillovers of Large-Scale Shocks

Summary Slides
Kilian Huber
General Equilibrium Spillovers

• Researchers often want to quantify GE spillovers: how shocks to some firms/households affect others
  • evaluate GE channels in models
  • convert estimates to other levels of aggregation
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  Browning et al. 1999; Acemoglu 2010; Nakamura and Steinsson 2018
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- Alternative: directly estimate spillovers using multi-layered variation
Related Literature

- Few studies in macro and finance directly estimate spillovers
  Dupor and McCrory 2018; Huber 2018; Bernstein et al. 2019; Auerbach et al. 2020; Gathmann et al. 2020; Helm 2020; Verner and Gyöngyösi 2020; Conley et al. 2021; Berg et al. 2021; Mian et al. 2022

- Methods tailored to labor and RCTs (“closed economies”, Egger et al.)
  Ammermueller and Pischke 2009; Epple and Romano 2011; Sacerdote 2011; Angrist 2014; List et al. 2019
Related Literature

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- Methods tailored to labor and RCTs (“closed economies”, Egger et al.) (Ammermueller and Pischke 2009; Epple and Romano 2011; Sacerdote 2011; Angrist 2014; List et al. 2019)

- This paper: framework and advice tailored to macro and finance
  - multiple spillover types
  - nonlinearities
  - mismeasurement (Ammermueller and Pischke 2009; Angrist 2014)
  - policy multipliers
1. Conceptual framework for estimating spillovers
This Paper

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2. Mechanical bias due to multiple spillovers
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4. Interpretation and policy multipliers
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5. Practical advice
Setup

• Identify a research question and shock.

• Define types of spillovers to be estimated, e.g., across firms/households in
  • same region
  • same industry
  • same lender
  • same country ...
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- Assign all firms/households to distinct groups.

- Assume shock is exogenous to both individual firms’/households’ and groups’ outcomes.
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- Application: effect of credit cut on firms, both directly affected firms and unaffected firms in same region and product market.
Framework

- Linear model:

\[ y_i = \beta x_i + \sum_{j \neq i, \text{reg.}}^{} \gamma^j x_j + \sum_{k \neq i, \text{ind.}}^{} \lambda^k x_k + \alpha + \epsilon_i \]
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• \( \beta \) = direct effect = change in \( y_i \) if \( i \) alone got treated

• \( \gamma^j \) = spillover = change in \( y_i \) due to treatment of firm \( j \) (same region)

• \( \lambda^k \) = spillover = change in \( y_i \) due to treatment of firm \( k \) (same industry)
Framework

- Assume spillovers in same region are homogeneous (or proportional to size).

\[ y_i = \beta x_i + \gamma x_r(i) + \lambda x_s(i) + \alpha + \epsilon_i \]

- Spillover coefficient multiplies the "leave-out mean" (or size-weighted mean):
  \[ x_r(i) = \sum_{j \neq i, r(j)=r(i)} x_j \frac{N_r(i) - 1}{N} \]

- Assume exogeneity, so biases not driven by endogeneity or "reflection problem":
  \[ E(x_i \mid \epsilon_i) = 0 \]

- Assume systematic variation across groups:
  \[ x_i = u_r(i) + u_s(i) + \nu_i \]
Framework

- Assume spillovers in same region are homogeneous (or proportional to size).
- Reduce dimensionality:

\[ y_i = \beta x_i + \gamma \bar{x}_{r(i)} + \lambda \bar{x}_{s(i)} + \alpha + \epsilon_i \]
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\[ x_i = u_r(i) + u_s(i) + \nu_i \]
Interpretation

- $\gamma = \text{estimated regional spillover, useful for models and aggregation}$

$$
\text{Average across regions: } y_r(i) = (\beta + \gamma) x_r(i) + \lambda x_s(i) r(i) + \alpha + \epsilon_r(i)
$$

- Total regional effect of average treatment
  $$
dy_r(i) dx_r(i) = \beta + \gamma
$$

- Direct effect of average treatment, assuming zero spillovers
  $$
dy_r(i) dx_r(i) \mid (\gamma = 0) = \beta
$$

More on how to calculate dollar multipliers etc. in paper.
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Application: Credit Cut

- A German bank (Commerzbank) cuts lending due to international losses (Huber 2018).
- Some firms depend on this bank for credit.
Application: Credit Cut

- A German bank (Commerzbank) cuts lending due to international losses (Huber 2018).
- Some firms depend on this bank for credit.
- Treatment: Indicator for direct dependence on the bank.
- Research question: amplification or dampening through spillovers?
Credit cut by Commerzbank

Ln lending stock (relative to 2004)


All other banks
Commerzbank
All other commercial banks
Product Market Spillovers

• IO economists write theories about product markets: demand versus technology spillovers.

• Test by constructing product market leave-out mean (industry for tradable and industry-region for non-tradables).

• Estimate:

\[ y_i = \beta x_i + \lambda \bar{x}_{s(i)} + \alpha + u_i \]
## Negative Industry Spillover

<table>
<thead>
<tr>
<th>Coefficient on $x_i$</th>
<th>Coefficient on $\bar{x}_{s(i)}$</th>
<th>Coefficient on $\bar{x}_{r(i)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.030***</td>
<td>-0.030*</td>
<td></td>
</tr>
<tr>
<td>(0.007)</td>
<td>(0.018)</td>
<td></td>
</tr>
</tbody>
</table>

**Sectors in sample** | **All sectors**  
**Observations**      | 45,252               | 45,252
There are other potential spillovers, e.g., region. But region and industry means are uncorrelated. So no OVB?
Mechanical Bias With Multiple Spillovers

- There are other potential spillovers, e.g., region. But region and industry means are uncorrelated. So no OVB?

- No, cannot take spillover estimate at face value.

- There will be mechanical bias if a true spillover is excluded, even if uncorrelated to other spillover.
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- There are other potential spillovers, e.g., region. But region and industry means are uncorrelated. So no OVB?
- No, cannot take spillover estimate at face value.
- There will be mechanical bias if a true spillover is excluded, even if uncorrelated to other spillover.
- Regional spillovers operate through demand versus agglomeration spillovers.
Add Regional Spillover

<table>
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<tr>
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<th>Coefficient on $x_i$</th>
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Understanding Mechanical Bias

• True model:

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• Excluded regional term correlated with direct effect, so all coefficients biased.
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• Suggestions:
  • if observed, include other spillover types
  • IV
  • heterogeneity in spillovers using theory
Heterogeneous Regional Spillover

Indirect effect on firm employment growth

- Producers of tradables
- Producers of part-tradables
- Producers of non-tradables

Low, Medium, High Innovation
## Heterogeneous Regional Spillover

<table>
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<tr>
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**Notes:**

-0.031**

(0.013)

-0.045

(0.031)

-0.213***

(0.077)

-0.026***

(0.009)

-0.007

(0.024)

-0.067

(0.055)
Mechanical Bias due to Mismeasurement

- Incorrectly specified regressors generate mechanical bias:
  - direct effect is nonlinear, but direct treatment is measured using linear regressor
  - measurement error in direct treatment

- For exposition, introduce measurement error in direct treatment
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### Measurement Error

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<th>None</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Coefficient on $x_i^*$</td>
<td>-0.027***</td>
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<td>-0.009</td>
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<tr>
<td></td>
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<tr>
<td>Coefficient on $x_{r(i)}^*$</td>
<td>-0.123**</td>
<td>-0.155***</td>
<td>-0.160***</td>
<td>-0.256***</td>
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<tr>
<td></td>
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<td>(0.054)</td>
<td>(0.058)</td>
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Understanding Mechanical Bias

- Individual measurement error gets averaged away in leave-out mean.

- Less error in leave-out mean than in direct effect.
Understanding Mechanical Bias

- Individual measurement error gets averaged away in leave-out mean.
- Less error in leave-out mean than in direct effect.
- True direct effect erroneously loads onto spillover coefficient.
- Analytical derivation for biases in paper.
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<td>$b_{1}$</td>
<td>-0.021** (0.010)</td>
<td>-0.004 (0.007)</td>
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<tr>
<td>$b_{2}$</td>
<td>-0.346*** (0.128)</td>
<td>-0.214** (0.094)</td>
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Mismeasurement Solutions

• Suggestions:
  • heterogeneity in spillover
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Mismeasurement Solutions

• Suggestions:
  • heterogeneity in spillover
  • IV

• Same intuition for nonlinear effect, very relevant for finance, e.g., borrowing and liquidity constraints.
• Show how to interpret spillover estimates.

• Bank debt: Direct effect = 0.47 mio decline at average firm.

• Employment: Total effect = 10 jobs.
Policy Multiplier

- Show how to interpret spillover estimates.

- Bank debt: Direct effect = 0.47 mio decline at average firm.

- Employment: Total effect = 10 jobs.

- Undo direct effect at 0.47 mio per firm, get 10 jobs in region.

- Provide 100k USD in debt, get 1.4 jobs.
  - Know only direct effect: would estimate 0.4 jobs.
  - Know only region effect: don’t know how to target direct firms.
Recommendations

• 1. Define spillovers of interest and exogenous variation.

• 2. Attempt to measure other omitted spillover types.

• 3. Try flexible functional forms to overcome bias from nonlinearity.

• 4. IV solves all forms of mechanical bias.

• 5. Identify theoretical mechanisms driving spillovers.
  regional: demand and agglomeration effects
  sectoral: competition and productivity
  cross region: trade, migration, capital mobility, and aggregate policy

• 6. Estimate heterogeneous spillovers as suggested by theory.
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Conclusion

• Macro shocks affect firms/households through many complex GE spillover channels.

• Need to know GE channels for modeling and policy → estimating spillovers is potentially powerful.

• More potential applications sketched in paper, ranging from sectoral, labor market, and country-level spillovers.

• Most challenging: estimating country spillovers requires exogenous country variation.
  • fiscal spending due to wars (Ramey 2019)
  • foreign policy (Jiménez et al. 2012)
  • political upheavals (Fuchs-Schündeln 2008)
  • idiosyncratic policy (Romer and Romer 2004)