Discussion of
"Input Diffusion and the Evolution of Production Networks"
Carvalho and Voigtländer (2015)

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NBER EFJK Growth Group Meeting
Federal Reserve Bank of San Francisco
February 2015

Overview

- Theory:
  - A model for the evolution of production input linkages.
  - Network perspective: firms more likely to adopt inputs that are closer in their network neighborhood.
- Empirics:
  - sector-level: “network proximity” in any given year increases the likelihood of adoption in the subsequent years.
  - firm-level: firms are more likely to develop new input linkages with other firms in their suppliers’ network neighborhood.

Why Should We Care?

- The pattern of input-output linkages has first-order implications for
  - propagation of shocks: Barrot and Sauvagnat (2014), Carvalho et al. (2015), Acemoglu, Akcigit and Kerr (2015)
  - aggregate fluctuations: Acemoglu et al. (2012), Atalay (2014)
  - comovements: Shea (2002)
  - source of large productivity differences across countries: Ciccone (2002), Jones (2013)

- For example, Acemoglu et al. (2012) show that asymmetry in the role of firms as input-suppliers can translate idiosyncratic firm-level shocks to aggregate fluctuations.

Contributions

- Empirical:
    - first paper to document the evolution of input-output networks

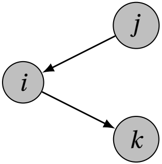
- Theoretical
    - the literature takes input-output relations as exogenously given.
        - exception: Oberfield (2013)
    - first paper to endogenize the formation input-output linkages
    - provides insights on the rise of General Purpose Technologies

This Discussion

- Stripped-down version of the model
- Interpretation of the results
- Relationship between the model and the empirical results

(Stripped Down Version of the) Model

- A dynamic model of input adoption (á la Jackson and Rogers, 2007)
- At step t, a new firm is introduced
- The firm draws m_k "*essential*" inputs uniformly at random
- It then searches among its suppliers' suppliers and draws m_n many new "*network*" varieties.



- In the paper: m_n and m_k are determined as a consequence of a trade-off between returns to the number of varieties and customization costs.

Firm-Level Results

Proposition

In the mean-field approximation of the model, the fraction of firms with fewer than d^{out} customers is

$$F(d^{out}) = 1 - \left(\frac{r(1+r)}{d^{out}/m_n + r(1+r)} \right)^{1+r},$$

where $r = m_k/m_n$.

- large heterogeneity in the role of firms as input-suppliers to the rest of the firms in the economy.
- Consistent with the evidence in the U.S. and other countries
  Atalay et al. (2011); Carvalho et al. (2015)

Sectoral Aggregation

- Aggregate firms into sectors depending on whether they use “similar” inputs.

Proposition

If the variety-level outdegree has a power law distribution, so does the the sectoral out-degree.

Proposition

If sector s is closer to sector s' than s'', then it is more likely that s adopts an input from s' than s''.

- Firm-level results are preserved even following sectoral aggregation.

Comment: Underlying Mechanism?

- This is really a paper about documenting an empirical regularity in the data:
    - closer initial network proximity raises the likelihood of subsequent input adoption.
- Natural question: why?
- Multiple plausible stories:
    - search and informational frictions?
    - anything about the nature of innovation?
    - ...
- Is there a way to tease out why this is happening?
  (or at least, more disaggregated, firm-level evidence may be useful)

Comment: Other Testable Implications

- The empirical analysis shows that input adoption is more likely across pairs that are initially closer in the input-output network.
- This observation is essentially hard-wired into the model:
  - each firm adopts inputs from the set of firms selling to its essential suppliers
- Important to test whether the model's other implications match the data.

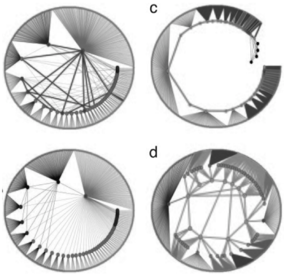
Comment: Other Testable Implications

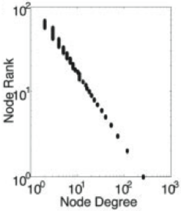
- The model predicts sector-level outdegrees (forward linkages) have a power law distribution.
- Matches the evidence in the U.S. and other countries
  Atalay et al. (2011); Acemoglu et al. (2012); Carvalho et al. (2015)

- But this is like matching just one moment in the dataset.
  - Many other models would deliver a similar distribution
  - Very different economies can exhibit the same distribution.

Comment: Other Testable Implications

- A very large class of networks have power law degree distributions, which can also be dramatically different from one another
- Example from Doyle et al. (2005):





- All have the same number of nodes, edges and degree distribution
- But very different structures

Comment: Other Testable Implications

- The model has specific predictions about other network "moments"
- One possibility is the distribution of the network's s-metric (Alderson et al., 2005):

$$s_{ij} = \begin{cases} d_i^{out} d_j^{out} & \text{if } i \text{ is a supplier to } j \\ 0 & \text{otherwise} \end{cases}$$

- Captures whether high-degree sectors are input-suppliers to other high-degree sectors, as is the case in the model

- Does the empirical distribution of s-metric (or some other "moments") in the data match the model's prediction?

Technical Comment: Technological Proximity

- The empirical analysis is not consistent with the structural model of network formation.

- A notion of technological/informational proximity: shortest path.

- Γ_{ij}: cost share of i in the intermediate input expenditure of j

$$d_{ij} = \min_{k \neq i} \left\{ \frac{1}{\Gamma_{ik}} + d_{kj} \right\}$$

with the convention $d_{jj} = 0$.

Technical Comment: Technological Proximity

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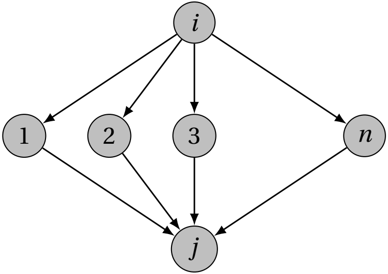

- network proximity measure: $d_{ij} = 1 + 1/n$.
- In the model, the likelihood of adopting i is independent of n.
- May want to utilize a measure that is consistent with the theoretical model

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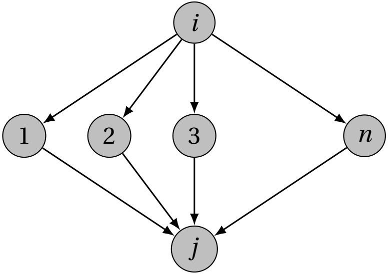

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Technical Comment: Technological Proximity

- A network proximity measure informed by the theoretical model:

$$d_{ij} = 1 + \sum_{k \neq i} \Gamma_{kj} d_{ik}$$

- "Harmonic distance": accounts for the intensity of connections as well as whether potential suppliers can be reached via multiple paths.

- $d_{ij} = 2$, regardless of the value of n

Summary

- Important question with implications for a better understanding the nature of input-output linkages, aggregate fluctuations, rise of GPTs
- Can anything be said about the actual underlying mechanism? (otherwise, the question of the reason behind the rise of GPTs remains open)
- More evidence on whether and how the model matches input-output data (beyond the outdegree distribution)
- Alternative notions of technological proximity (specially informed by the actual model)