Supply Chain Formation and Fragilities under Imperfect Information

Andrea Titton

CeNDEF, University of Amsterdam

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Hurricane Laura shuts 84% of US oil output in Gulf, one-third of SBR capacity

Al Greenwood

25-Aug-2020

Hurricane Ida Threatens Global Plastic Markets

Peter C. Earle – August 30, 2021 Reading Time: 7 minutes

AIER >> Daily Economy >> Government >> Financial Markets >> Crisis

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2. The supply chain is *opaque* (Williams et al., 2013).

Research Question

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1. How do production networks form under **opacity**?

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2. What are the implications for **endogenous fragility**?

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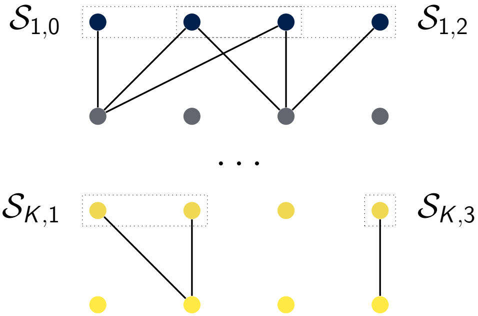
4. Firm contract with suppliers $\mathcal{S}_{k,i}$ at a marginal cost $c\, |\mathcal{S}_{k,i}|$
5. A firm is disrupted $(k, i) \in \mathcal{D}_k$ if all its suppliers are disrupted $\mathcal{S}_{k,i} \subset \mathcal{D}_k$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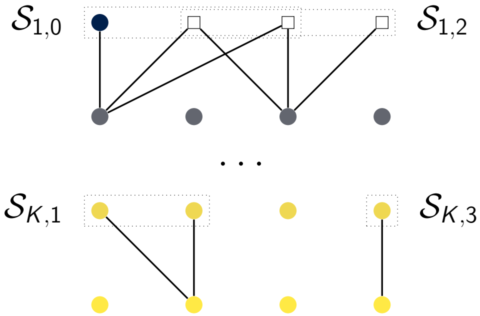
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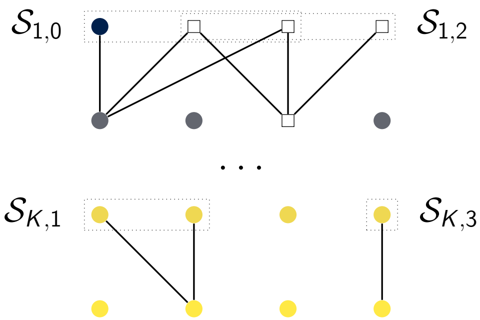
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Opacity

The upstream realisation of the production network $\mathcal{S}_{l,j}, l < k$ is not observable

Problem of the firm

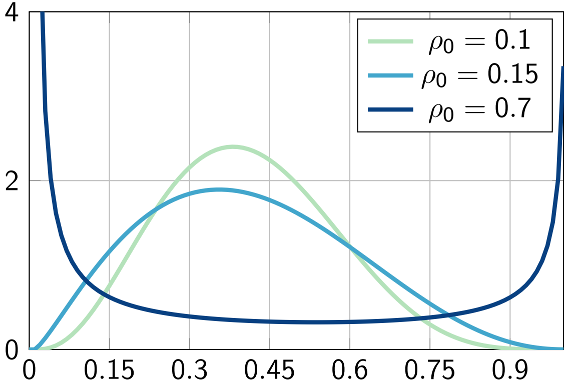
Choose a set of suppliers $\mathcal{S}_{k+1,i}$ to maximise expected profits

$$\Pi(\mathcal{S}_{k+1,i}) = \left(1 - \mathbb{P}\left(\mathcal{S}_{k+1,i} \subset \mathcal{D}_k\right)\right) \pi - \frac{c}{2}|\mathcal{S}_{k+1,i}|^2$$

Basal conditions

Assumption: The probability that a firm in the basal layer fails $p_{0,i}$ is sampled from a Beta with mean μ_0 and overdispersion ρ_0

Overdispersion parameter



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Opacity and *identical firms* $\implies$ exchangeability!

$\implies$ what matters is the **number** of disrupted firms, $D_k = |\mathcal{D}_{k,i}|$

$\implies$ optimise only on the **number** of suppliers, $s_{k+1} = |\mathcal{S}_{k+1,i}|$

Solution trick II

How do disruptions propagate from suppliers to firms, $D_k \to D_{k+1}$?

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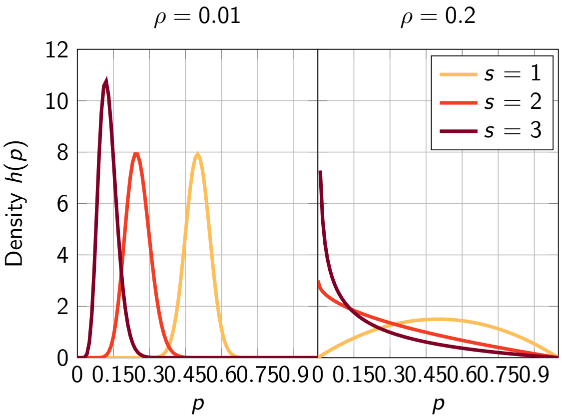
Borrow from Pólya's urns: if $D_k = D_0^{s_1 \; s_2 \dots s_k}$ with $D_0 \sim$ Beta, $D_{k+1} = D_0^{s_1 \; s_2 \dots s_k \mathbf{s_{k+1}}}$.

Solution trick II



Problem of the firm (revisited)

Choose the **number of sources** s_k to maximise expected profits

$$\Pi(s_{k+1}) = \Big(1 - p(s_{k+1}, D_k)\Big)\ \pi - \frac{c}{2} s_k^2$$

where $D_k = D_0^{s_1\ s_2 \ldots s_k}$, $D_0 \sim$ Beta.

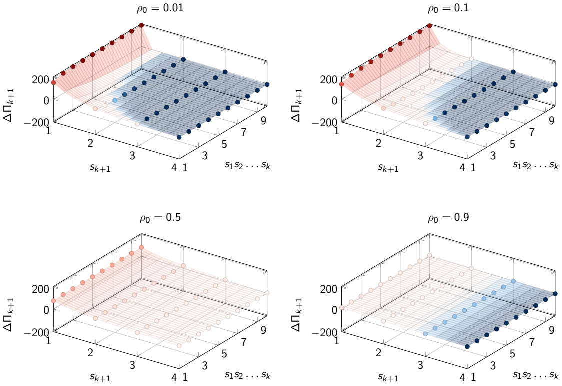
Optimal Number of Sources

Firms stop adding sources whenever doing so yields a negative marginal payoffs

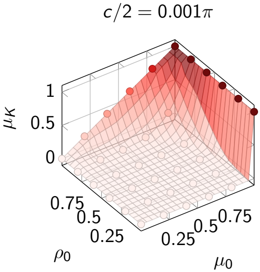
$$\Pi(s_{k+1}+1)-\Pi(s_{k+1}),$$

this depends crucially on μ_0 and ρ_0.

Optimal Number of Sources



Endogenous Fragility



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2. Common externalities are exacerbated
3. Self organised criticality: worse than we thought