How to Organize Crime

Mariagiovanna Baccara and Heski Bar-Isaac
(Stern, NYU)
Motivation

- Protecting information is an important concern of criminal organizations.
- Institutions facing these organizations need to understand their structures.
- Wide heterogeneity: Mafia centralized organizations vs. terrorist “cells”
- What determines the internal structure of criminal organizations? How do they react to investigation policies? How can one break their internal cohesion?
Key trade-off

- Criminal organizations benefit if the people who constitute them exchange information.
- Information sharing makes organization more vulnerable to external threat

Goal of this paper: building a model to study this trade-off and to rationalize different organization structures.
Sketch of the model

• Each player has a piece of private and verifiable information about himself

• Trade-off:
  – If A has information about B, then organization gets a fixed benefit W (examples)
  – If A has information about B, then if A is detected (probability $\alpha$), so is B. If an agent is detected organization pays $b>0$. More on detection…
Two detection models

- **Agent-based detection**
  - Detection probabilities of each agent \( (\alpha_i) \) are set by external authority, they do not depend on agent’s activity level
  - Examples: intelligence, list of potential members, etc.

- **Cooperation-based detection**
  - Probability of being detected is a function of cooperation level. Scrutiny of authority is ineffective if not criminal activity
  - Examples: monitoring territory, searching for illegal activities, constitutional limits, etc.
Information structure

B → A  Agent A has information on agent B

A ←→ B  Agents have information about each other

A,B,C → D  A,B and C all revealed information to D
Example: Agent-based detection

- A, B, C and D exchange information to create links
- Having an agent linked
  - benefit 1 to the organization, no additional benefits if linked to more than one
- Having an agent detected
  - cost 2 to the organization
- Probability of getting detected directly
  - A and B: probability $\frac{1}{4}$
  - C and D: probability $\beta \geq \frac{1}{4}$
Example (cont’d)

• Suppose $\beta=1/4$ (symmetric case)
Example (cont’d)

- Suppose $\beta = 1/4$ (symmetric case)
- Add first 3 links to minimize their cost: hierarchy (or binary cells)
Example (cont’d)

• Suppose $\beta = 1/4$ (symmetric case)
• Add first 3 links to minimize their cost: hierarchy (or binary cells)
• 4th link costly in hierarchy: binary cells dominates hierarchy
• Cost of each link in binary cells $2 \times (1 - \frac{1}{4})^{1/4} = 3/8 < 1$ → optimal structure
Example (cont’d)

- Suppose instead $\beta = 3/4$
Example (cont’d)

- Suppose instead $\beta = 3/4$
- For first 3 links hierarchy is optimal (top either agent A or agent B)
Example (cont’d)

• Suppose instead \( \beta = \frac{3}{4} \)

• For first 3 links hierarchy is optimal (top either agent A or agent B)

• Total cost with 4th link (A linked to B)
  – E.g., focus on C and see if it is better to link him to D only or to \{A,B\} together

  \[ \text{Hierarchy optimal since } \frac{1}{4} + \frac{1}{4} - \frac{1}{16} < 3/4 \]
Example: if $\beta \leq \frac{7}{16}$

- Binary cells is optimal structure
Example: if $\beta \geq 7/16$

- Centralized Hierarchy is optimal
- A/B as information hub
Preview of the results

• Agent-based detection
  – Full characterization of optimal organization structure for given probabilities of detection
    • “Binary cells”
    • Mixed centralized structures - properties
  – Full characterization of strategy for external agent

• Cooperation-based detection
  – Full characterization of optimal organization structure
    • More centralization, sometimes cells
  – Full characterization of strategy for external agent

• Comparison and discussion
• Extensions
Efficient structure in symmetric case: $\alpha_i = \alpha \ \forall i$

- If $W \geq b\alpha(1-\alpha)$, the most efficient information structure is a binary cell structure, otherwise it is an anarchy.
The general case

- Probabilities of detection \( \{\alpha_1, \ldots, \alpha_N\} \)
  w.l.o.g. increasing \( \alpha_1 \leq \alpha_2 \leq \ldots \leq \alpha_N \)
- Plan:
  - Fix the number of linked agents \( n \in \{1, \ldots, N\} \)
  - Optimal structure given \( n \) (cost minimizing)
  - Benefit of adding links
  - Characterization of optimal structure
**Optimal structure for given n**

- If \( n \leq N-1 \) the optimal organization structure is a hierarchy in which the \( n \) highest-probability players reveal their information to 1 (cheapest links)

```
1
```

```
N  N-1  ....  N-n+1  N-n  ....  2
```
Full cooperation: Optimal structure with $N$ links

where $i^*$ is lowest odd s.t.

$$\frac{2(1-\alpha_i)(1-\alpha_{i+1})}{(2-\alpha_i-\alpha_{i+1})} < (1-\alpha_1)(1-\alpha_2)$$
External agent

• Fixed budget $B$ to allocate to detect agents
• The induced cost of link of the symmetric allocation is $b(B/N)(1-B/N)$
• By previous result, given a symmetric allocation, the organization
  – Will stay in anarchy (no cooperation) if $W < b(B/N)(1-B/N)$
  – Will generate a binary cell structure (full cooperation) if $W > b(B/N)(1-B/N)$
• If $W < b(B/N)(1-B/N)$, the optimal allocation is symmetric ($\alpha_i=B/N$ for all $i$), since it achieves no cooperation.
External agent: Optimal strategy

- What if $W > b(B/N)(1-B/N)$? In this case, a symmetric allocation reaches full efficiency. Is there something better?

- Result: If $W > b(B/N)(1-B/N)$ the optimal strategy is $\alpha_1=0$ and $\alpha_i=B/(N-1)$ for all $i\neq1$. 
Cooperation-based Detection: Main Result

• First N-1 links’s cost is higher if the detection of these agents is high. Hierarchy is still optimal structure for 1,..N-1 links

• Differently from agent-based cooperation, agents that are less scrutinized are linked first. Top of the organization (most wanted agent) rarely cooperates.
Model comparisons

• If treatment of agents is symmetric we have:
  – Either anarchy or binary cells under agent-based cooperation model.
  – Either hierarchy or binary cells under cooperation-based
• Binary cell structure can emerge as optimal structure in both models
• Tendency to centralization in cooperation-based detection model.
• When are hierarchies optimal? Asymmetric treatment (in agent-based) or cooperation-based
Further comments

- Alternative organizations are optimal reaction to investigation policies.
- Detecting illegal activities on territory vs. monitoring agents directly lead to different organization structures.
- In turn, from authorities’ point of view, in different investigation environments resources should be allocated differently!
- In agent-based detection model, results suggest that external agent can do better than binary cells by imposing asymmetric treatment and induce hierarchy instead.
- In cooperation-based detection model we show that external agent better off by allocating some fixed budget (sufficient to discourage them to cooperate) on as many agents as possible.