Modeling civil violence: An agent-based computational approach

Epstein, J. M. (2002). Modeling civil violence: An agent-based computational approach. *Proceedings of the National Academy of Sciences*, *99*(suppl 3), 7243-7250.

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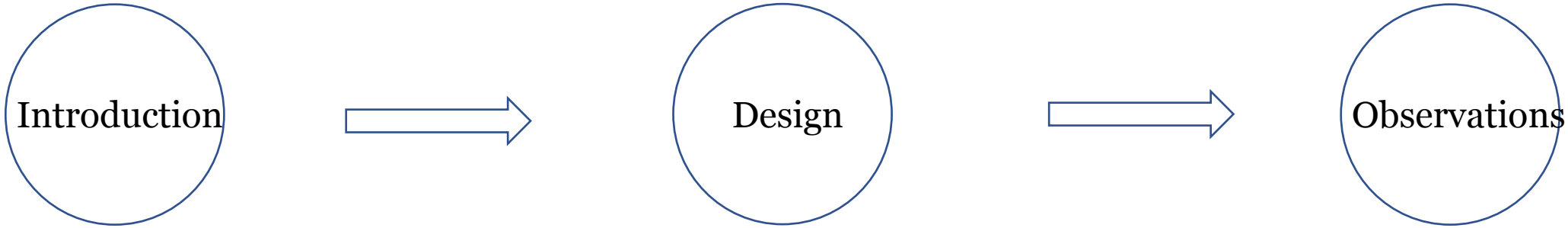
Outline

- Model 1: a central authority seeks to suppress decentralized rebellion
- Model 2: a central authority seeks to suppress communal violence between two warring ethnic groups.



Civil Violence Model I: Generalized Rebellion Against Central Authority

- Agents: members of the general population and may be actively rebellious or not
- “Cops” are the forces of the central authority, who seek out and arrest actively rebellious agents

Model 1 : Agent Specification
Representation of Political Grievance

H: the agent's perceived hardship (i.e., physical or economic privation)

- ❑ exogenous
- ❑ heterogeneous
- ❑ uniformly distributed on the interval (0,1)

L: the perceived legitimacy of the regime, or central authority

- ❑ exogenous
- ❑ equal across agents
- ❑ arbitrarily defined in range (0,1)

Level of grievance:

$$\boldsymbol{G = H(1 - L)}$$

Model 1: Agent Specification
Decision of Whether to Rebel

- Decision to rebel does not only depend on one's grievance but one's level of risk aversion.
- *R*: the agent's level of risk aversion
  - ❑ Heterogeneous across agents
  - ❑ Uniformly distributed
  - ❑ Fixed

Model 1: Agent Specification
Estimate the Likelihood of Arrest

- This estimate is assumed to increase with the ratio of cops to already rebellious agents.
- v: agent's vision, which is the number of lattice positions that the agent can inspect.
- $\left(\frac{C}{A}\right)_v$: the cop-to-active ratio within vision v (local deterrence)
- Agent's estimated arrest probability P to be given by:

$$P = 1 - exp(-k\left(\frac{C}{A}\right)_v)$$

  - ❑ The constant k is set to ensure a plausible estimate (of $P = 0.9$) when $C = 1$ and $A = 1$
  - ❑ A is always at least 1, because the agent always counts himself as active when computing probability.

Model 1: Agent Specification
State Transition Table

- N: the agent's net risk

$$N = RP$$

- Agent's expected utility: $G - N$ (local rationality)
- Binary action (active or quiet)
- Agent rule (Rule A): *If* $G - N > T$ *be active*; *otherwise*, *be quiet*.
  T is certain non-negative threshold, which could be zero

State	(G − N)	State transition
Q	>T	Q⇒A
Q	≤T	Q⇒Q
A	>T	A⇒A
A	≤T	A⇒Q

Agent state transition

Model 1: Cop Specification

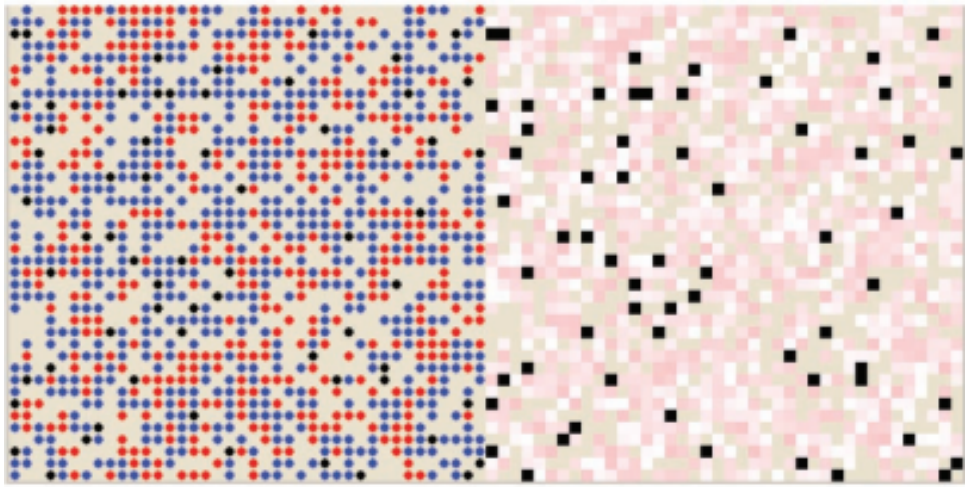
- v^*: the number of lattice positions that the cop can inspect (cop vision)
- Cop rule (rule C): Inspect all sites within v^* and arrest a random active agent.
- Cops never defect to the revolution in this model

❖Jail Terms:

J_{max}: maximum jail term

Arrested active is assigned a jail term randomly from U(0, J_{max})

Model 1: Graphical Strategy



- Events transpire on a lattice
- Agents and cops move around this space and interact
- In order to distinct between private grievance and public action:
  - ❖ On the right screen, agents are colored by their private level of grievance. The darker the red, the higher the level of grievance.
  - ❖ On the left screen, agents are colored by their public action: blue if quiescent; red if active.
  - ❖ Cops are colored black on both screens.

Model 1: Algorithm

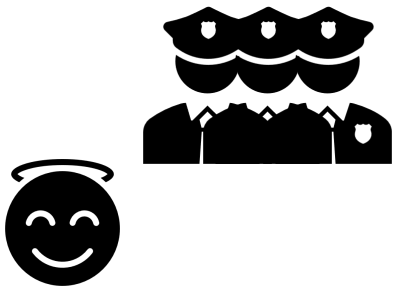
1. Sets $\boldsymbol{L}, \boldsymbol{J}, \boldsymbol{v}, \boldsymbol{v}*$ and the initial cop and agent densities
2. Agents are assigned random values for $\boldsymbol{H}$ and $\boldsymbol{R}$
3. Cops and (initially) quiescent agents are situated in random positions on the lattice
4. The model spins forward under the rule set: $\{\boldsymbol{A}, \boldsymbol{C}, \boldsymbol{M}\}$:

   An agent or cop is selected at random (asynchronous activation) and, under rule $\boldsymbol{M}$, moves to a random site within his vision, where he acts in accord with rule $\boldsymbol{C}$ (if a cop) or $\boldsymbol{A}$ (if an agent).
5. The model iterates this procedure until the user quits or some stipulated state is attained

	Model one			
	Run 1	Run 2	Runs 3 & 4	Run 5
Variable name				
Cop vision	1.7	7	7	7
Agent vision	1.7	7	7	7
Legitimacy	0.89	0.82	0.9	0.8
Max. jail term	15	30	Infinite	Infinite
Movement	None	Random site in vision	Random site in vision	Random site in vision
Initial cop density	0.04	0.04	0.074	0.074

Model 1: Individual Deceptive Behavior

I



cops near -> agent quiet

II

cops away -> agent active

Cop's departure:

1. C/A ratio reduces
2. Estimated arrest probability reduces
3. Net risk N reduces
4. State Transition

Model 1: Free Assembly Catalyzes Rebellious Outbursts

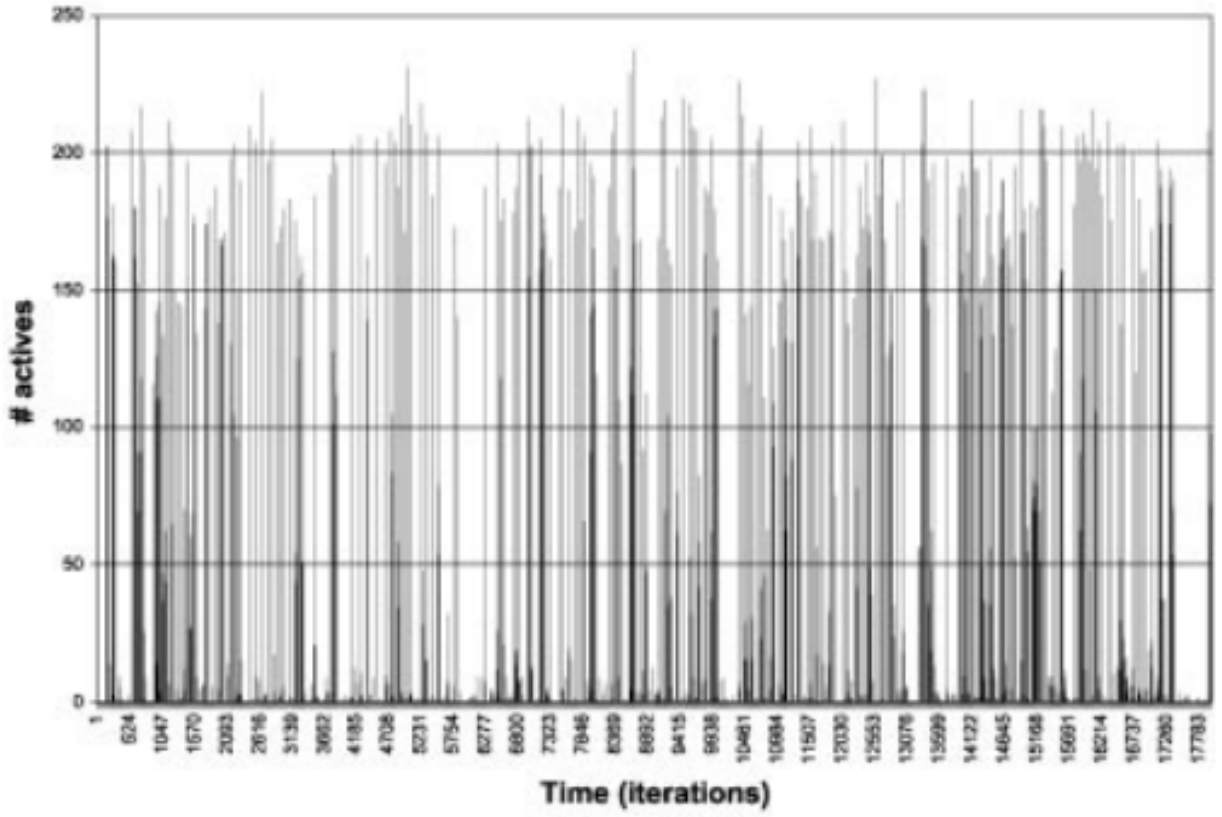
- Rational for why freedom of assembly is the first casualty of repressive regimes:

  local activist concentrations reduce local $\boldsymbol{C/A}$ (cop to active) ratios, reducing (via the equation for P above) the risk of joining the rebellion.

  To be the first rioter, one must be either very angry or very risk-neutral, or both.

Model 1: Punctuated Equilibrium

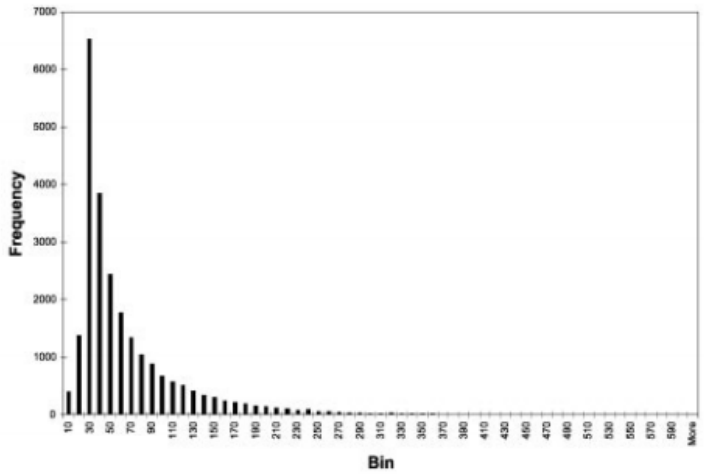
- Long periods of relative stability are punctuated by outbursts of rebellious activity
- In reality, many major revolutions are episodic



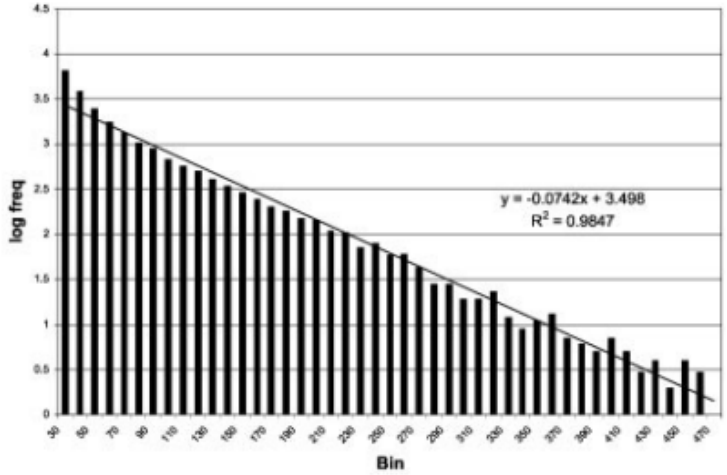
data over some 20,000 iterations of the model

Model 1: Waiting Time Distribution

- Distribution of waiting times between outbursts above some threshold (50 actives)

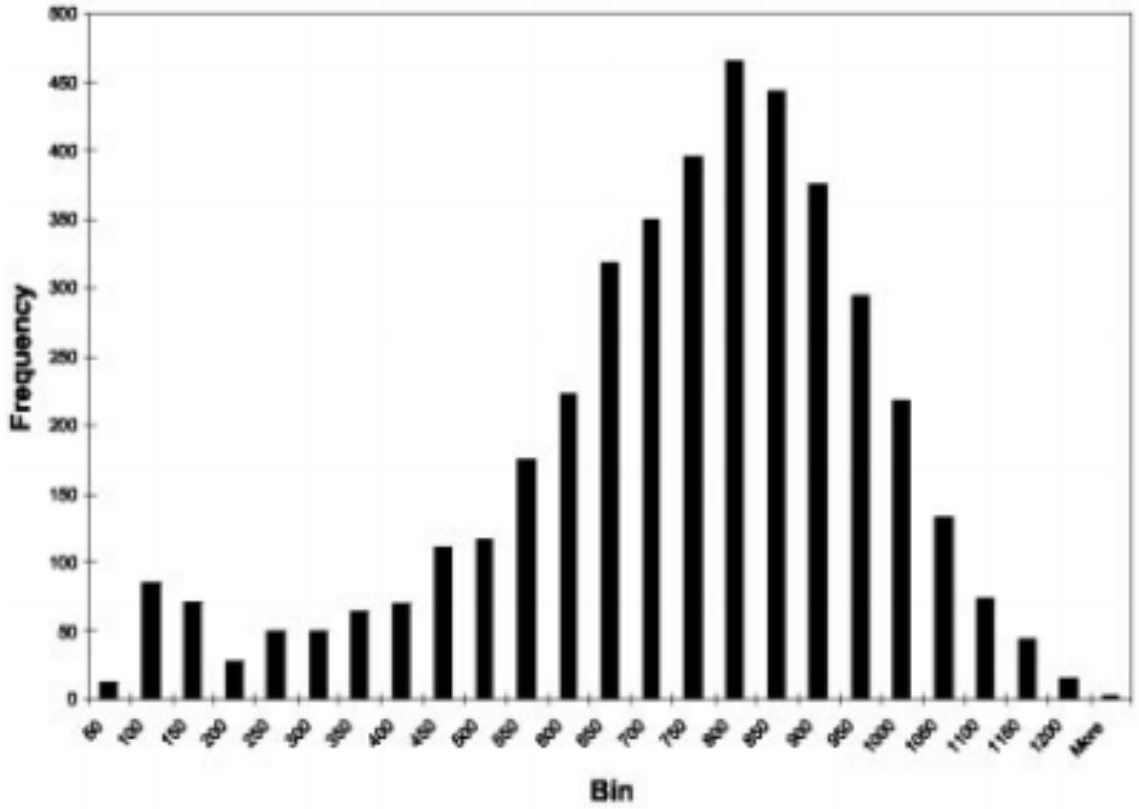


Waiting time distribution



Truncated distribution
(cut those of waiting time less than 30 cycles)

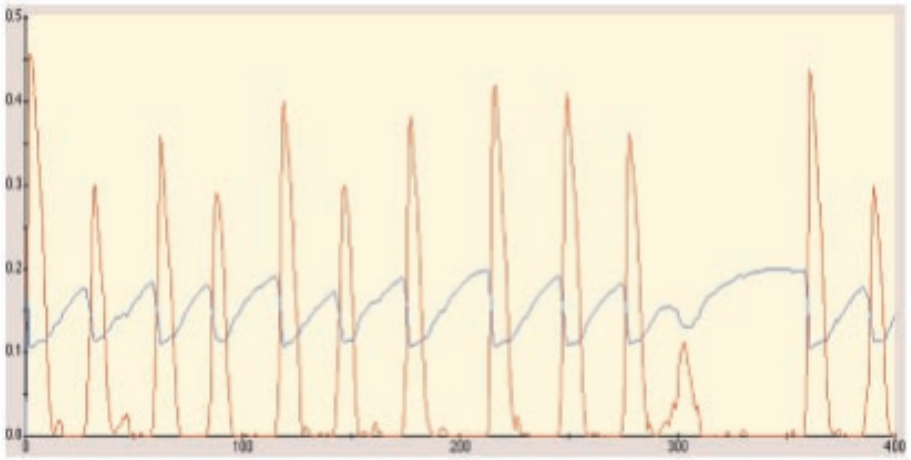
Model 1: Outburst size distribution



Mean: 708
Std: 230

Model 1: Ripeness Index

- Ripeness: high level of tension or private frustration
- Ripeness express in graph: dark red on the right screen while being entirely blue on the left
- Ripeness index = $\bar{G}\ \bar{B} / \bar{R}$



Tension (blue) and actives (red)

Model 1: Reductions in Legitimacy

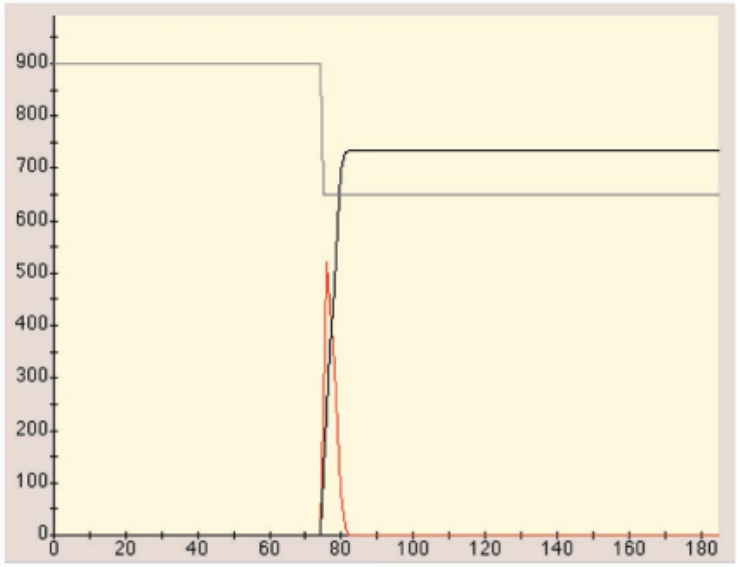
Scenario 1. A large absolute reduction (from $L = 0.9$ to $L = 0.2$) in legitimacy, but in small increments

Large legitimacy reduction in small increments

- Downward sloping upper curve plots the steady incremental decline in legitimacy over time
- The horizontal red curve just above the time axis shows the number of actives in each time period (no red spike)
- middle curve , representing the total jailed population, rises smoothly over time

Model 1: Reductions in Legitimacy

Scenario in leg2. A large absolute reduction of legitimacy in one jump



Small legitimacy reduction in one jump, t=77

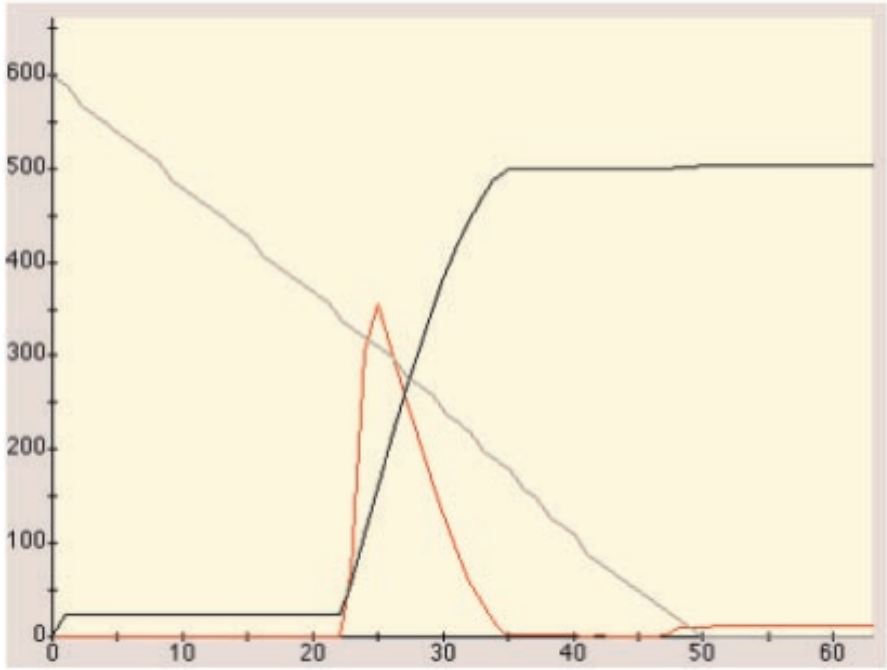
- Hold legitimacy at its initially high level (of 0.90) for 77 periods in one jump (t=77), reduce it to 0.70, making upper legitimacy curve is a step function
- There is an explosion of actives, shown by the red spike, even the absolute legitimacy reduction (of 0.30) is far smaller than before
- there is a sharp rise in the jailed population

Model 1: Reductions in Legitimacy

- Reason for such difference?
  - ❑In the first scenario, the potentially catalytic agents at the tail of the grievance distribution are being picked off in isolation, before they can stimulate a local contagion.
  - ❑In the second scenario, even though the absolute legitimacy decline is far smaller, multiple highly aggrieved agents go active at once. A result, local C/A ratios are depressed enough so that less aggrieved agents jump in.
- It is the rate of change—the derivative—of legitimacy that emerges as critical

Model 1: Cop Reductions

- There comes a point at which a marginal reduction in central authority does “tip” society into rebellion
- The dynamics of legitimacy reduction and cop reduction are fundamentally different.



Cop Reductions

Model 2: Inter-Group Violence

- two ethnic groups: blue and green
- "going active": killing an agent of the other ethnic group
- Legitimacy (L): each group's assessment of the other's right to exist (exogenous and the same for each group)

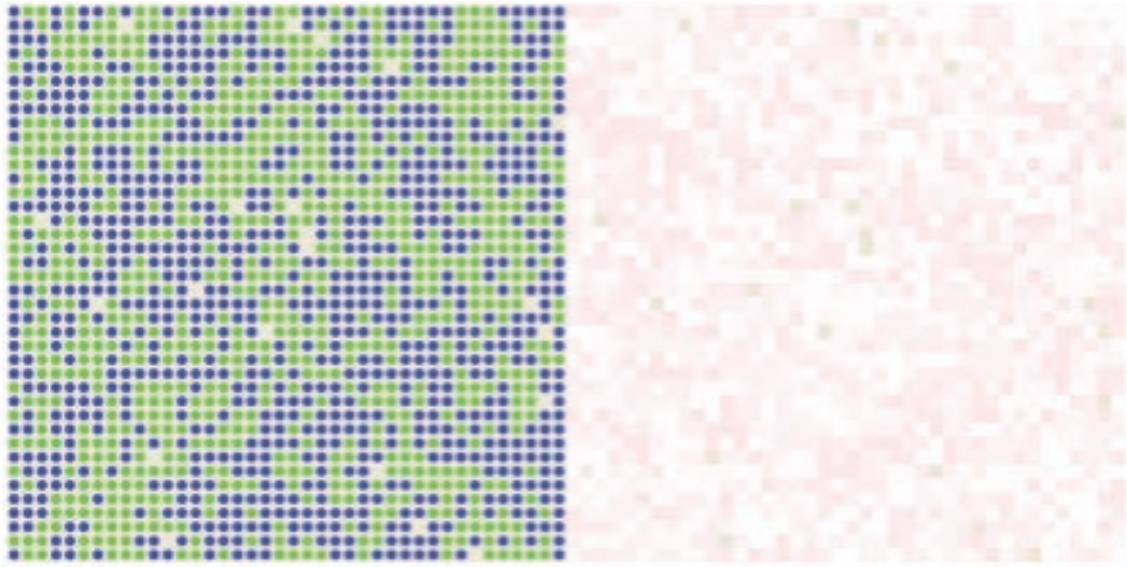
Model 2: Specification

Population Dynamics

- $\boldsymbol{p}$ is the probability of agent cloning offspring onto unoccupied neighboring sites each period. (can be taken as birth)
- Offspring inherit the parent's ethnic identity and grievance
- agents are assigned a random death age form $U(0, maxage)$ where $maxage = 200$.
- Cops have similar behavior to model I- arrest active agents within their vision.

Model 2: Peaceful Coexistence

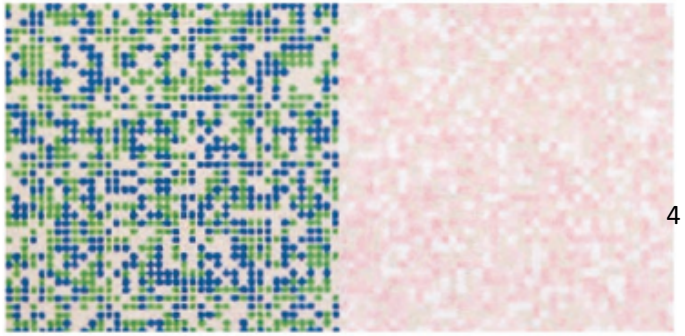
- When legitimacy is set to a high number, peaceful coexistence prevails with no cops
- Left screen: spatial heterogeneity and peaceful mixing of groups with no red agents
- Right screen: only the palest of pink shades, indicating low levels of grievance



Model 2: Ethnic Cleansing

- When legitimacy is low $L < 0.8$
- The sequence of five figures clearly shows local episodes of ethnic cleansing.
- Over a large number of runs (n > 30), genocide is always observed
- The victor is random

1



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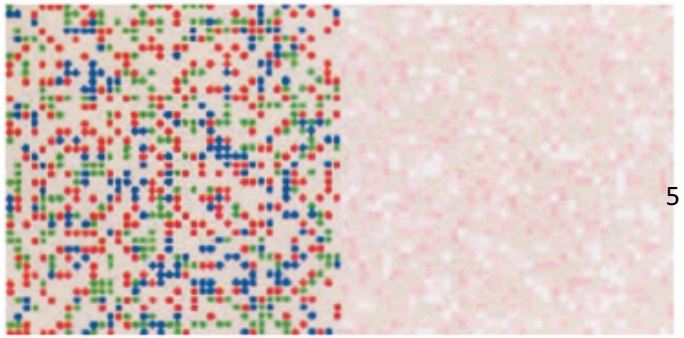

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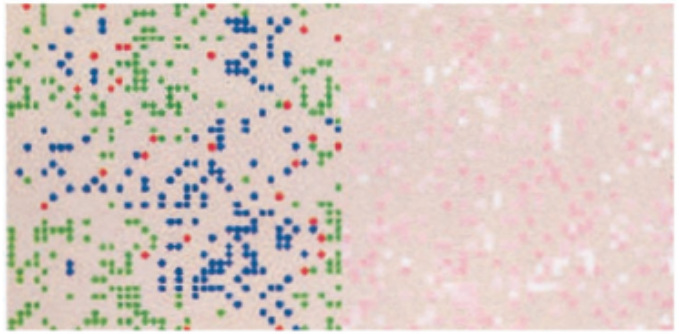

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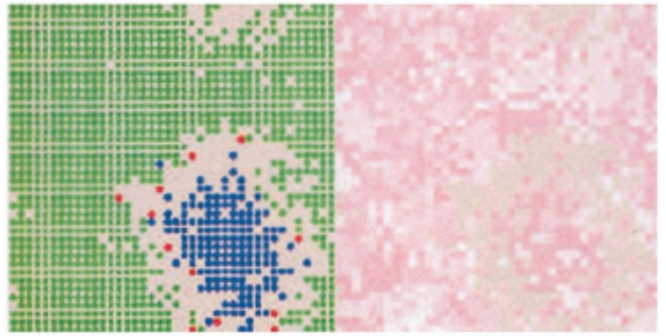

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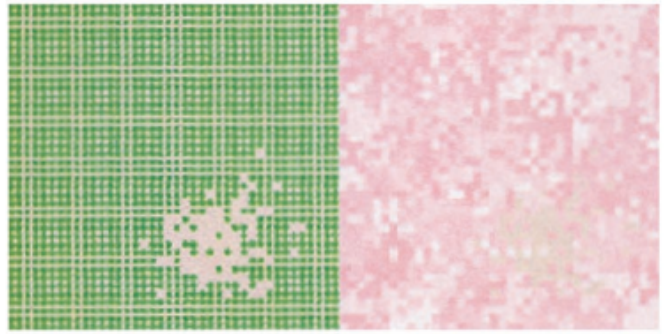
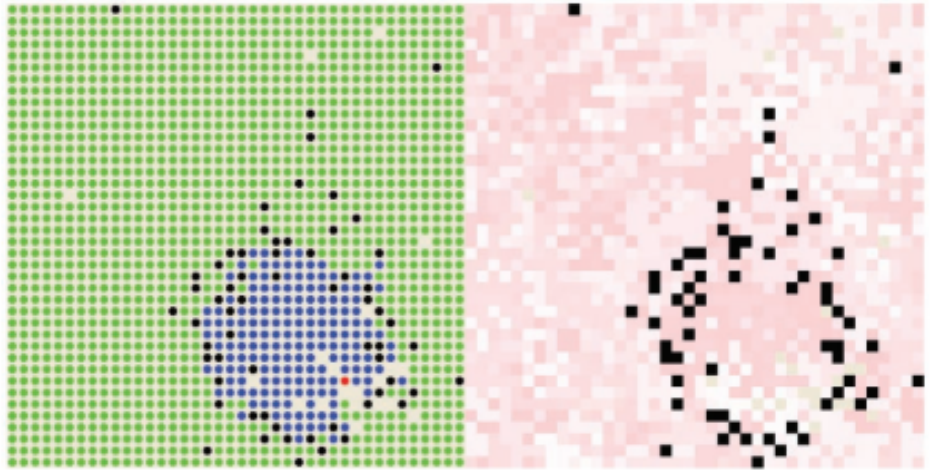


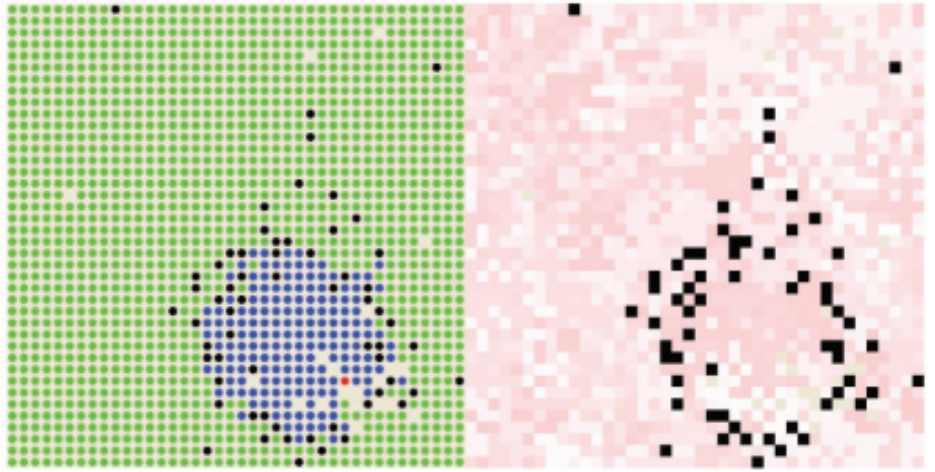
Model 2: Safe Havens

- If the inter-species competition is regulated by a predator that feeds evenhandedly on the competitors, then both can survive. (peacekeeper)
- the run begins exactly as in the previous genocide case
- But, at t=50, deploy a force of peacekeepers.
- Peacekeepers go to random unoccupied sites on the lattice



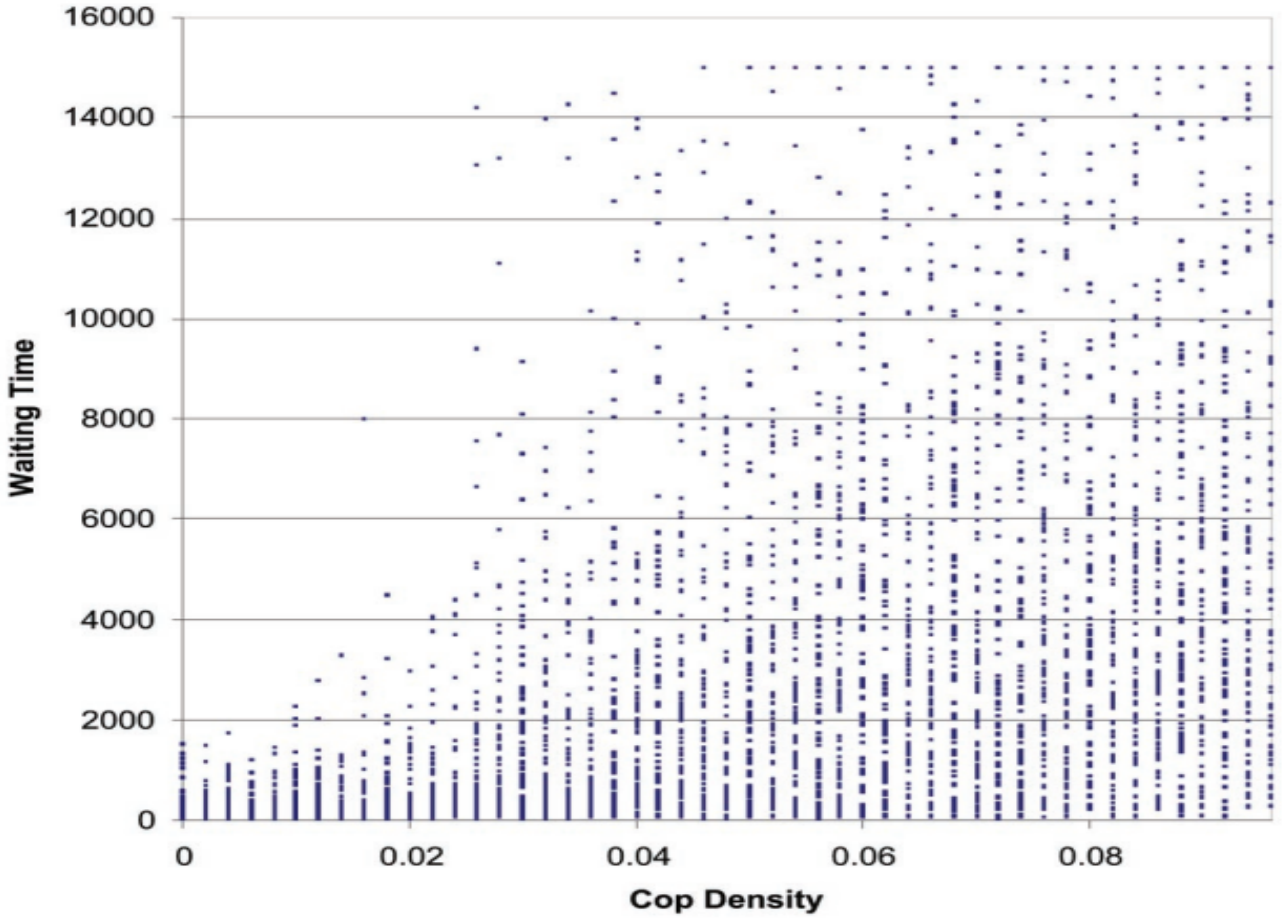
Model 2: Safe Havens

- A case with high initial cop density was also examined.
- The presence of cops prevents either side from wiping the other out, but their coexistence is not peaceful
- Clearly, peacekeeping forces can avert genocide. But what is the overall relationship between the size of a peacekeeping presence and the incidence of genocide?



Model 2: Cop Density and Extinction Times

- Cops are randomly placed in their initial position and in their subsequent movement
- Initial cop densities are systematically varied from 0.0 up to 0.1, in increments of 0.002
- For each such value, the model run 50 times until the monochrome genocide state was reached (or terminated after 15000 cycles)

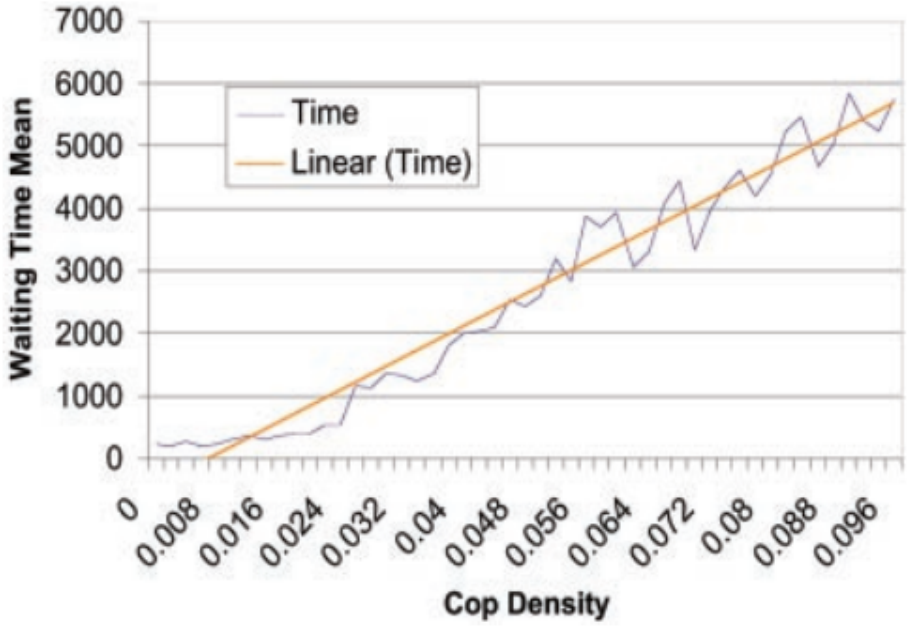


Model 2: Cop Density and Extinction Times

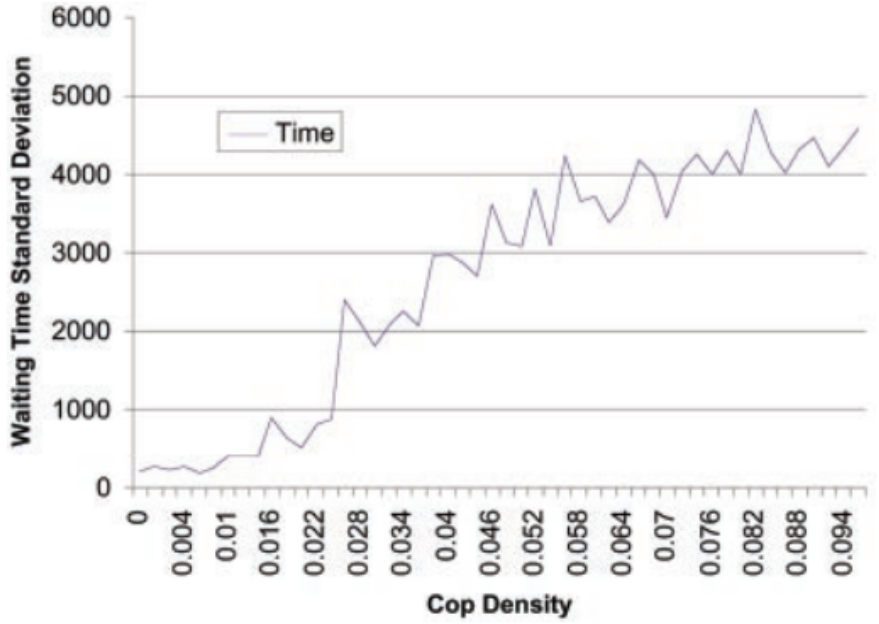
- Observations:
  1. at low force densities (0 to 0.02), convergence to genocide is rapid
  2. at high force densities (0.08 and above), there is high variance

     one can have high effectiveness (delays of over 15,000 cycles) or extremely low effectiveness (convergence in tens of cycles)

Model 2: Distribution of Waiting Times



Waiting time mean and initial cop density



Waiting time standard deviation and initial cop density

Summary

Model 1

- Deceptive behavior of the agents
  - This behavior would not have been detected without spatial visualization.
- Random spatial correlation
  - Catalyze local outburst
- Distribution of waiting time of outburst
  - The outburst are episodic, but these episodes are not uniformly distributed
- Dynamics of legitimacy reduction and cop reduction
  - It is interesting that it often happens that when people that has put up with an oppressive rule over long period without protest suddenly finds the government relaxing its pressure, it takes up arms against it.

Summary

Model 2

- If legitimacy above 0.8:
  Peaceful coexistence exists

- If legitimacy below 0.8:
  1. Local episodes of ethnic cleansing happens
  2. Early intervention on a sufficient scale, this process can be stopped
  3. Although the mean relationship was positive, quick convergence to genocide at extremely high force levels is not precluded

Relation with what we learned in class

- The agent risk behavior in Model 1 was important factor for agents to decide whether to go active or remain inactive:
  - A risk neutral doesn't care about the risks but only on the grievance
  - A more risk averse agent would be more cautious before being active
  - A risk-taking agent could go active even with the low grievance
- Agent exploring the environment leading to the deceptive individual behavior
  - Agent figure out that it's better to be inactive when cops are within their vision and become active when cops are far
- Emergent behavior of model 2 leading to ethnic cleansing

Conclusion

We conclude:

- Agents based modeling makes it easy to figure out the complex behavior which can’t be identified otherwise or are hard to explain.
  - The episodic behavior unrest which is not uniformly distributed
  - Deceptive individual behavior

Future modification

- Sharing of knowledge, i.e. hardship and perceived legitimacy among people
- Increasing jail time could help flatten the curve of episodic outbreaks
- Cops communicating could have great impact in preventing ethnic cleansing in Model 2.
- Individual L for each member of ethnic group in second model.

Compare to Our Project

	Paper	Our Project
Agent	Individual people	District region
Model	Grievance based Model	Contact based Model
State	Active Inactive	Susceptible Infected Recovered