Computational Models of Civil War

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Epstein (PNAS, 2002)[1]

[1] Available in NetLogo Models Library. See Social Science/Rebellion

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- Agents: may be actively rebellious or not.
- Cops: work for central authority to find and arrest rebellious agents.

Agent Characteristics

- Hardship (H), where $H \sim \mathrm{U}(0, 1)$.
- Perceived legitimacy of the central authority (L), which is constant across agents.
- Political grievance $G = H(1 - L)$.

Agent Characteristics

- R is an agent's level of risk aversion, where $R \sim \mathrm{U}(0,1)$.
- Agent's estimate risk of arrest before joining a rebellion.
- Risk estimate increases with ratio of cops to rebellious agent's within prospective rebel's vision (v), which is constant across agents.

Agent Characteristics

- Agent's arrest probability $P = 1 - \exp[-k(C/A)_v]$.
- Sets $k = 0.9$ to ensure plausible estimate of P when $C = A = 1$.
- For a fixed number of cops, the agent's estimated arrest probability decreases the more rebellious agent's there are.
- Net risk $N = RP$.

Table 1. Agent state transition

State	(G – N)	State transition
Q	>T	Q⇛A
Q	≤T	Q⇛Q
A	>T	A⇛A
A	≤T	A⇛Q

- Agent rule: If $G - N > T$ be active; otherwise be quiet.

Cops

- Cop vision (v^*) is constant across all cops.
- Cop rule: Inspect all sites within v^* and arrest a random active agent.

Movement and Jail Terms

- Movement Rule: move to a random site within your vision (same for both agent's and cops).
- Any arrested agent is assigned a jail term drawn from $\mathrm{U}(0, J_{max})$.
- J_{max} removes actives for various durations.
- Agents level of G is the same before and after jail.

Simulations

- The model proceeds under the rule set: $\{A, C, M\}$.
- An agent or cop is selected at random and moves to a random site (M), where it acts in accord with rule C or A.
- The model ends exogenously or when some specified state is reached.

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- Can this highly stylized model generate macro-level revolutionary dynamics of interest?

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Results: Rebellious Outbursts

- Movement rule can lead to high concentrations of actives in areas with few cops.
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- Why? The risk of arrest is lower.

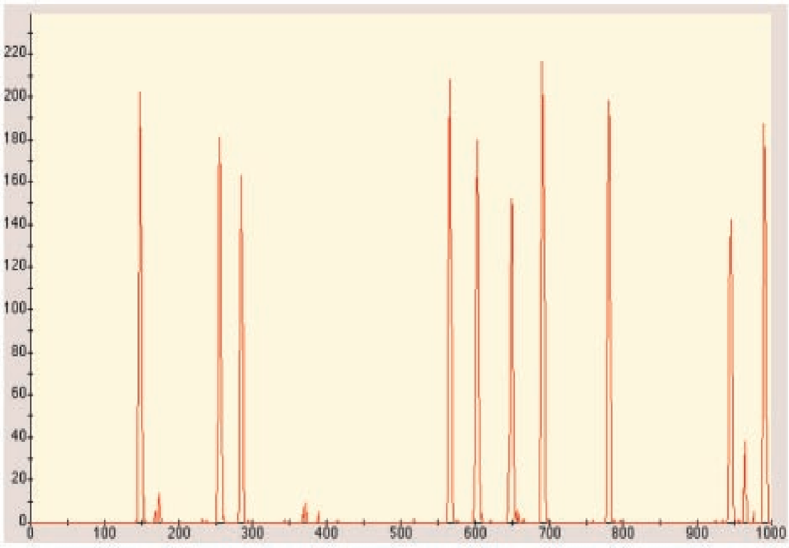

Fig. 3. Punctuated equilibrium.

Results: Varying Legitimacy

1. In small increments
2. In one jump

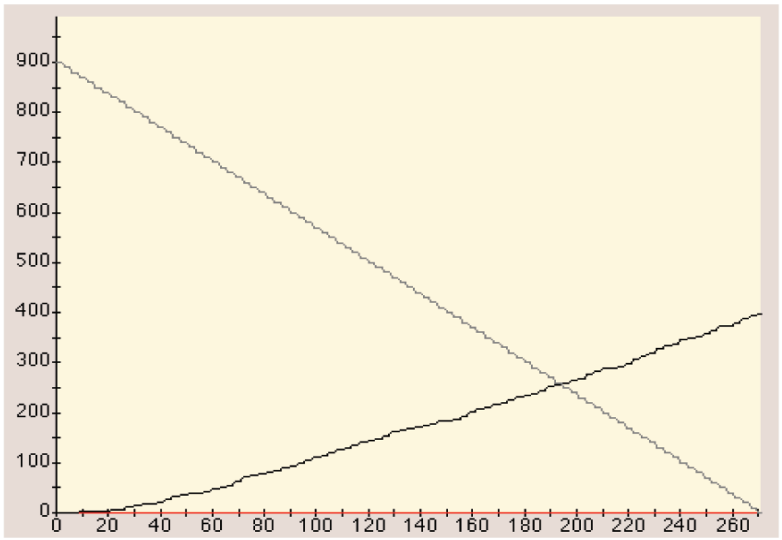

Fig. 9. Large legitimacy reduction in small increments.

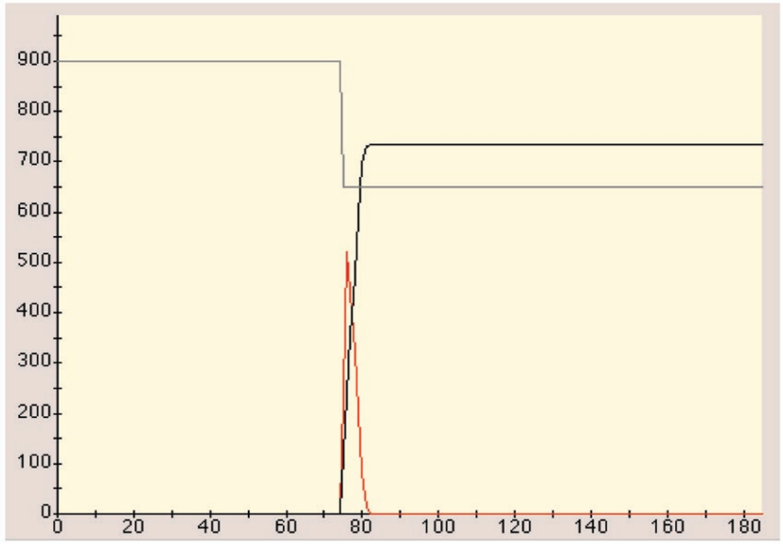

Fig. 10. Small legitimacy reduction in one jump, $t = 77$.

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- The rate of change of legitimacy is important in predicting rebellious outbursts.

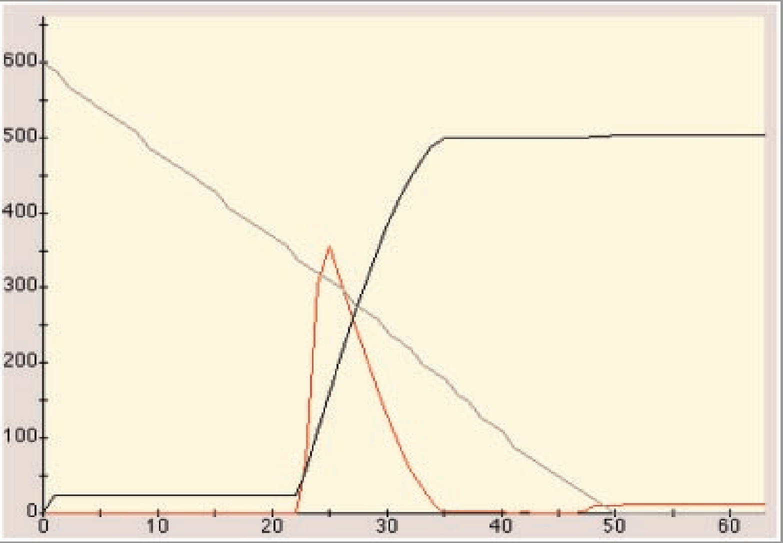


Fig. 11. Cop reductions.

Results: Varying Number of Cops

- A marginal reduction in cops does lead to rebellion.

Conclusions

- The model explains standard repressive tactics used to restrict freedom of assembly to prevent the spatial clustering of highly aggrieved individuals, which reduces the cop-to-active ratio, which leads other less aggrieved individuals to join the rebellion.
- A steady drop in perceived legitimacy does not lead to rebellion but a sudden (smaller) drop does.
- Incremental reductions in repressive personnel (e.g., cops) can lead to rebellion.
- One reason these results are interesting is because leadership is not modeled.

Take-Away Points

- Very general model, no specific empirical target.
- Non-empirical distributions used for agent characteristics.
- Simple rules
- Can we test this model empirically?

Bennett (JASSS, 2008)

- Why do some insurgencies become well established but others fail?
- Is there a trade-off between increasing accuracy (avoiding civilian casualties) and effectiveness (capturing insurgents) in terms of stopping an insurgency?

- Two types of agents: civilians (population) and soldiers (government)

Soldier Characteristics

- Physical location.
- Level of effectiveness: probability of capturing or killing an insurgent after the insurgent attacks.
- Level of accuracy: probability that they avoid collateral damage to civilians near the insurgent.

Civilian Characteristics

- Anger at the government: ranges from 0 (not angry at all) to 1 (maximum anger).
- Fear of the government: ranges from 0 (not fearful of government response) to 1 (maximum fear).
- Violence threshold: ranges from 0 (low threshold to commit violence) to 1 (very reluctant to turn to violence).

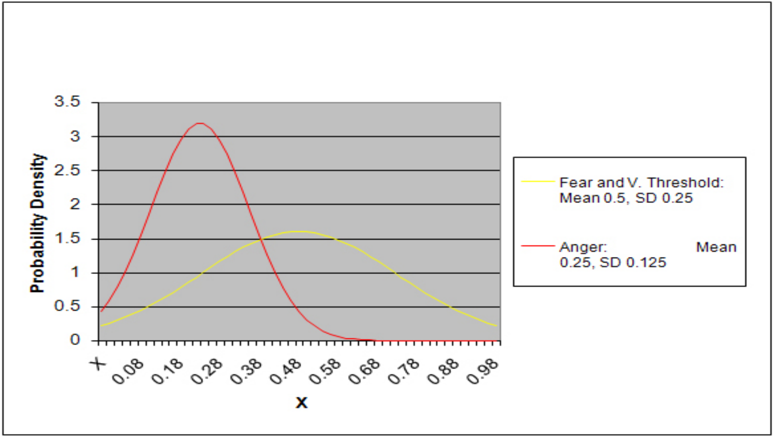


Figure 1. Default Probability Distributions of Fear, Anger, and Violence Threshold

- Only a small percentage of civilians initially meet the criteria for becoming latent insurgents.

Insurgents

- If a civilian is more angry than afraid and their anger passes a threshold propensity to use violence, they become an latent insurgent.
- If a latent insurgent is within range of a soldier (Moore neighborhood) and is given an opportunity, it will attack and become an active insurgent.
- Note: individual soldiers are not killed if attacked.

Soldier Counterattacks

- Attacking exposes latent insurgents.
- After an attack, soldiers can target the insurgent in an attempt to remove it from the population.
- These counterattacks may also deter civilians from becoming insurgents by increasing their level of fear.
- The government would like to remove all insurgents, thereby defeating the insurgency.

Civilian Response to Counterattacks

- Insurgents often remain after counterattacks because of soldier accuracy and effectiveness.
- Collateral damage (civilian injuries) increases both fear and anger.
- $\mathrm{Fear}_{t+1} = \mathrm{Fear}_t + 0.10 \times (1 - \mathrm{Fear}_t)$.
- $\mathrm{Anger}_{t+1} = \mathrm{Anger}_t + 0.05 \times (\mathrm{Number\ of\ Civilians\ Hurt}) \times (1 - \mathrm{Anger}_t)$.
- Counterattacks by soldiers can only remove insurgents, civilians are not removed when injured.

Simulation Sequence

1. Soldiers and civilians randomly distributed on the grid.
2. Civilians level of anger, fear, and violence threshold drawn from distributions.
3. Latent insurgents are identified.
4. One latent or active insurgent is randomly selected and if within range of a soldier attacks.
5. The soldier counterattacks: a) with probability=effectiveness, the insurgent is killed; b) with probability=1-accuracy, each nearby civilian is injured in the counterattack. If injured, a civilian increases their anger and fear.
6. Simulations end if: a) no latent insurgent remains, b) latent insurgents remain, but none are within the interaction range of any soldier, or c) exogenously.

Simulations

- Vary soldier effectiveness (from 0.1-1) and accuracy (from 0-1).
- 25 runs for each combination.
- The durations of each insurgency under each condition were then averaged.

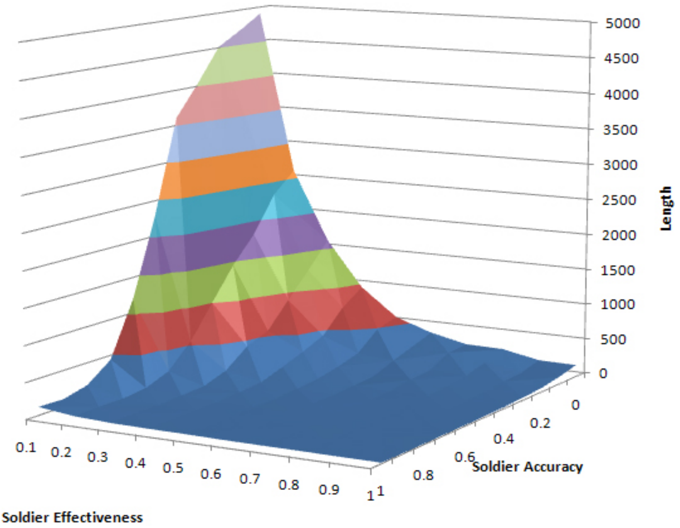


Figure 7. Average Time to Simulation Termination, Varying Accuracy and Effectiveness, 25 Runs per Combination

Results

- Need both low accuracy and low effectiveness to get a long insurgency.
- However, the average length of insurgency is more sensitive to a decrease in accuracy than a decrease in effectiveness.
- This results appears to be robust to changes in some of the parameters.

Add Replacement

- Replace killed insurgents with new civilians.
- New civilians are randomly placed on the grid.
- New civilian characteristics are: 1) drawn from the same distributions as above, or 2) average of values drawn from same distributions as above and average of civilians in their neighborhood.

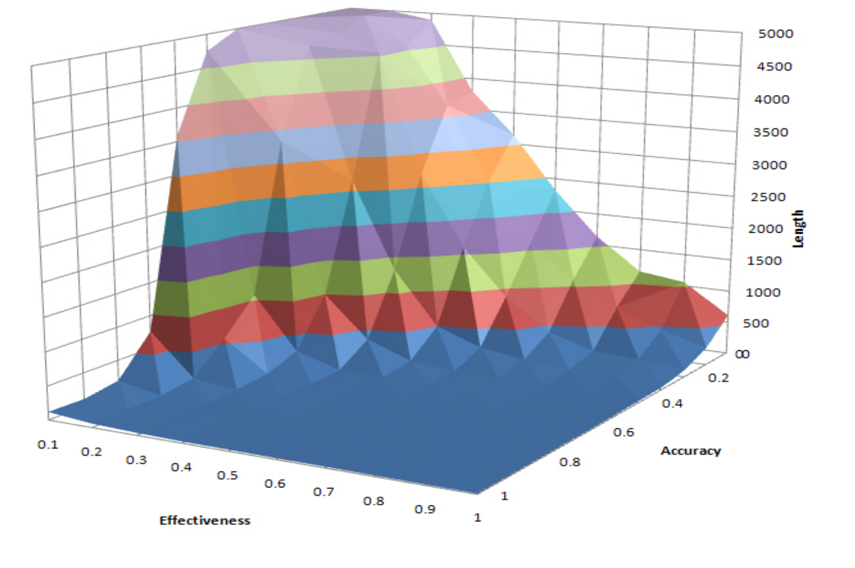
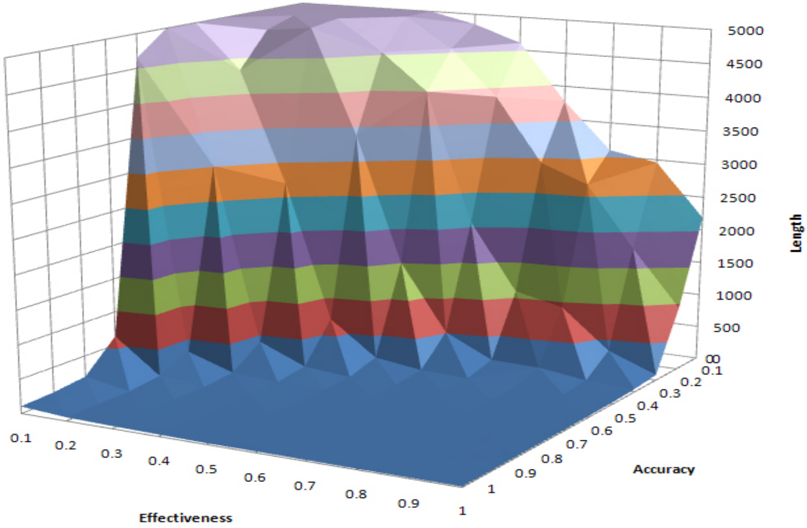


Figure 9. Time to Simulation Termination, Varying Accuracy and Effectiveness, Simulations with Replacement and No Neighborhood Influence, Average of 25 Runs per Combination



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Results With Replacement

- Overall, there are more combinations of accuracy and effectiveness that lead to longer insurgencies.
- In contrast to the result above, even very high effectiveness may be inadequate to counter the negative effects of low accuracy.
- Even if effectiveness is low, there is some high enough level of accuracy that will lead to very short insurgencies.
- Still confirm that accuracy is more important than effectiveness in terms of insurgency duration.

Conclusion

- Accuracy is critical to the long-term defeat of an insurgency.

Take-Away Points

- Build a model one piece at a time.
- Can we test this model empirically?