Computational Models of Civil War

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Findley & Young (Civil Wars, 2007)

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- Hearts & Minds: focus on providing benefits to government supporters.
- Attrition: focus on raising the costs of supporting an insurgency.
- Argue that how civilians respond to costs or benefits depends on their commitment to the insurgency.

Agents

- Insurgents: i^{λ} (5%)
- Counterinsurgents: i^{κ} (10%)
- Civilians: i^{π} (85%)

Level of Commitment to Insurgency

- Insurgents: $\chi_i^{\lambda} \in \mathrm{U}[0.8, 1]$ (Highly)
- Counterinsurgents: $\chi_i^{\kappa} \in \mathrm{U}[0, 0.2]$ (Not)
- Civilians: $\chi_i^{\pi} \in \mathrm{N}[0, 1]$ (Varies)
- χ_i varies over time

Interaction

- Agents reside on grid and move randomly in their neighborhood (Von Neumann).
- Insurgent vision (ϕ_i^{λ}, 2 cells out).
- Counterinsurgent vision (ϕ_i^{κ}, 1 cell out).

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- When an insurgent is neutralized, it returns to the civilian population and is assigned a new level of commitment (based on the initial distribution).

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- If $\chi_i > \chi_j$ then $\chi_{i,t+1} = \chi_i - ((\chi_i - \chi_j) \times R_i)$.
- If $\chi_i = \chi_j$ then no updating occurs.
- R represents an agent's level of responsiveness, where $R \in \mathrm{U}[0, 0.33]$ (a low level).

Interaction

- When civilians commitment exceeds a threshold ($\chi_i^{\pi} \geq \theta$), civilians become insurgents.
- Set $\theta = 0.8$.

Simulations

- Vary two parameters: 1) provision of benefits and costs to civilians, 2) initial distribution of commitment to civilians.
- Run model for 1,000 time steps.
- 30 runs for each experimental condition.

TABLE 2
SUMMARY OF INPUTS AND RESULTS FOR THE EXPERIMENTS

Run	Commitment	Benefits/Costs	Outcome
	χ	B, C	$\%\Delta$in λ
1	Low	Benefits	-93%
2	Low	Costs	+42%
3	Normal	Benefits	−92%
4	Normal	Costs	+140%
5	High	Benefits	+38%
6	High	Costs	+200%

Number of Agents (425); Vision ($\phi^{\lambda} = 2, \phi^{\kappa} = 1$).
Agent Distribution ($\lambda \approx 5\%, \pi \approx 85\%, \kappa \approx 10\%$).
Threshold ($\theta = 0.8$); Death occurs with $p < 0.001$.
Responsiveness ($R \in [0, 0.33]$).

FIGURE 1
NUMBERS OF INSURGENTS GIVEN *LOW* INITIAL COMMITMENT

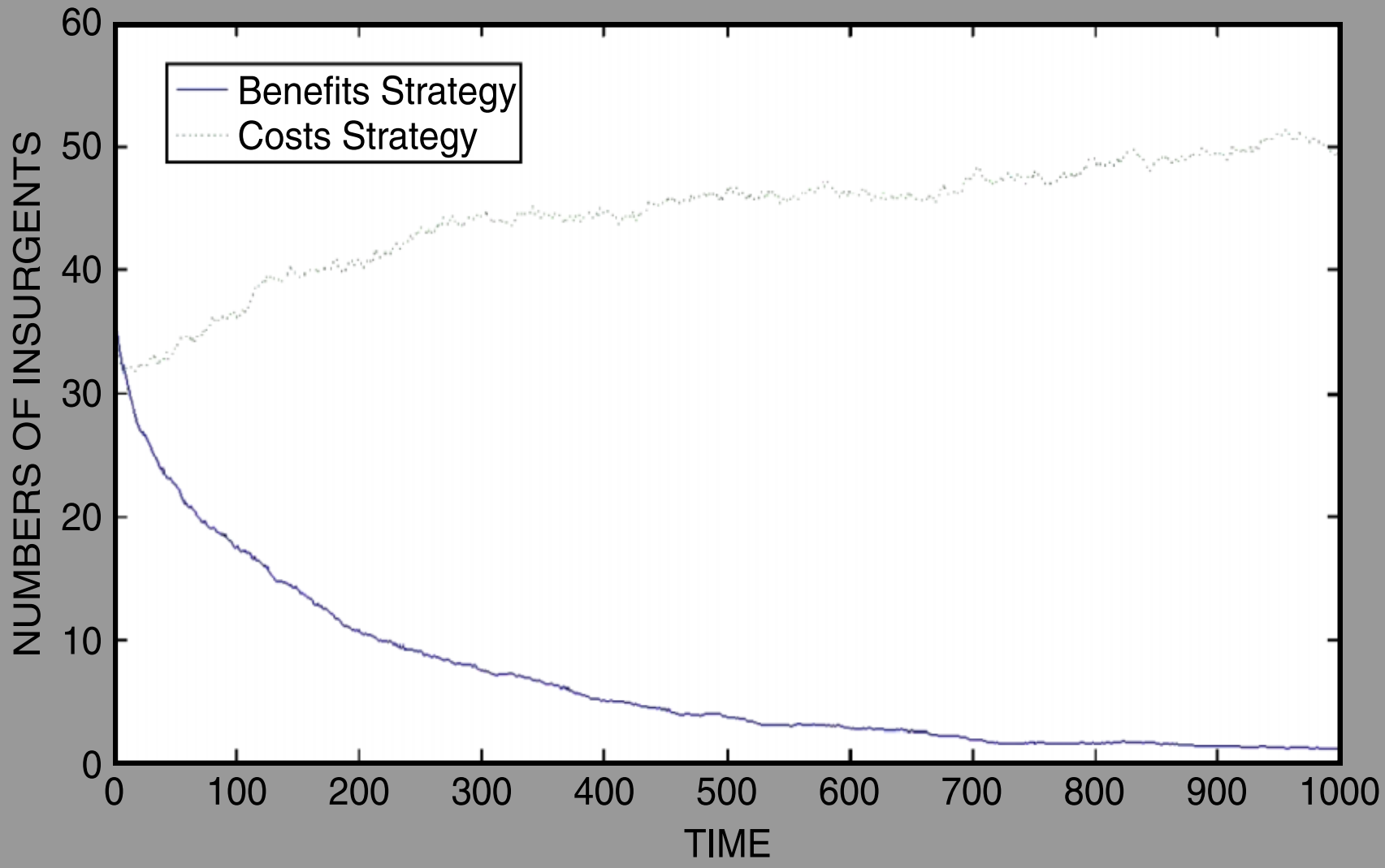


FIGURE 2
NUMBERS OF INSURGENTS GIVEN *NORMAL* INITIAL COMMITMENT

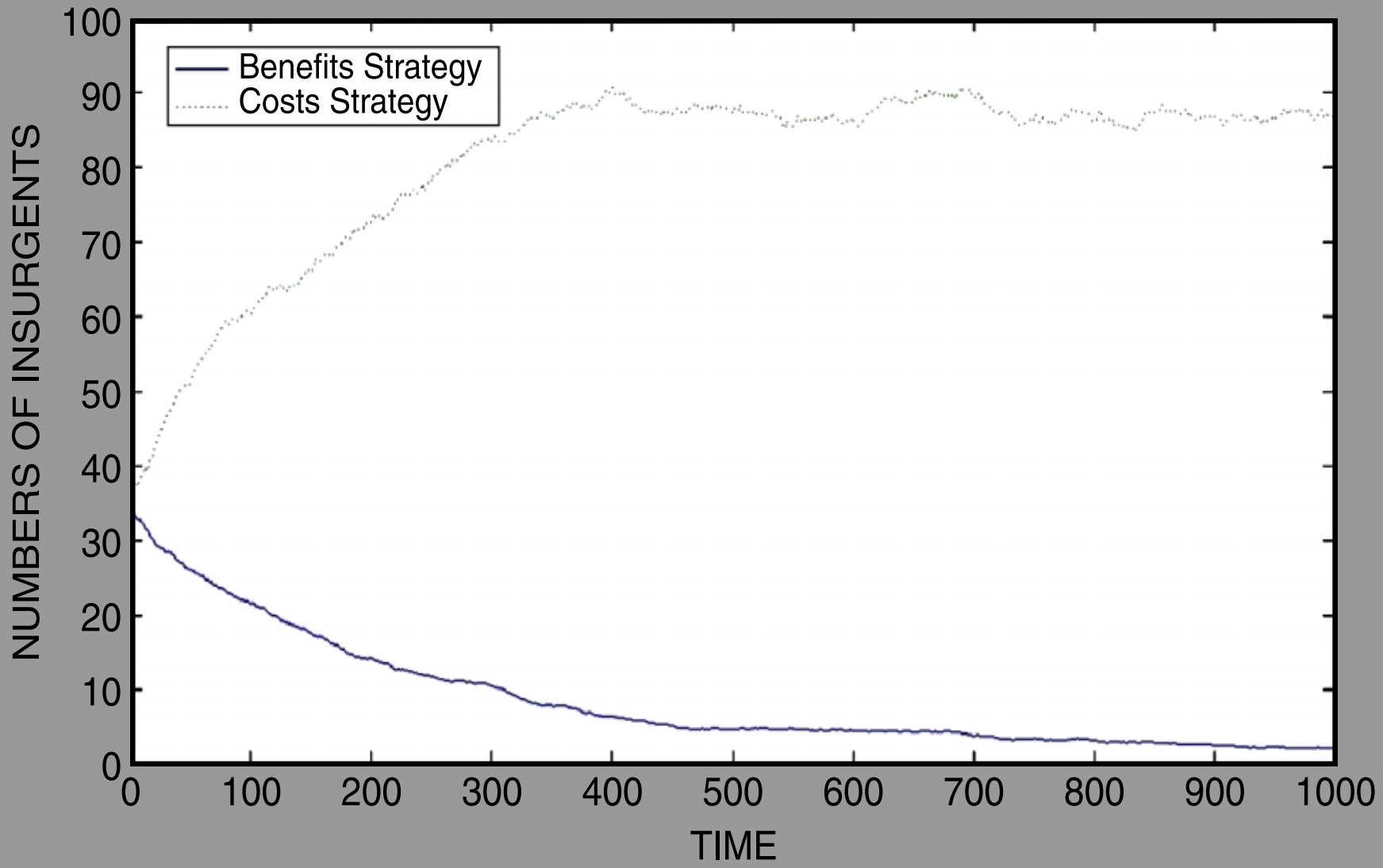
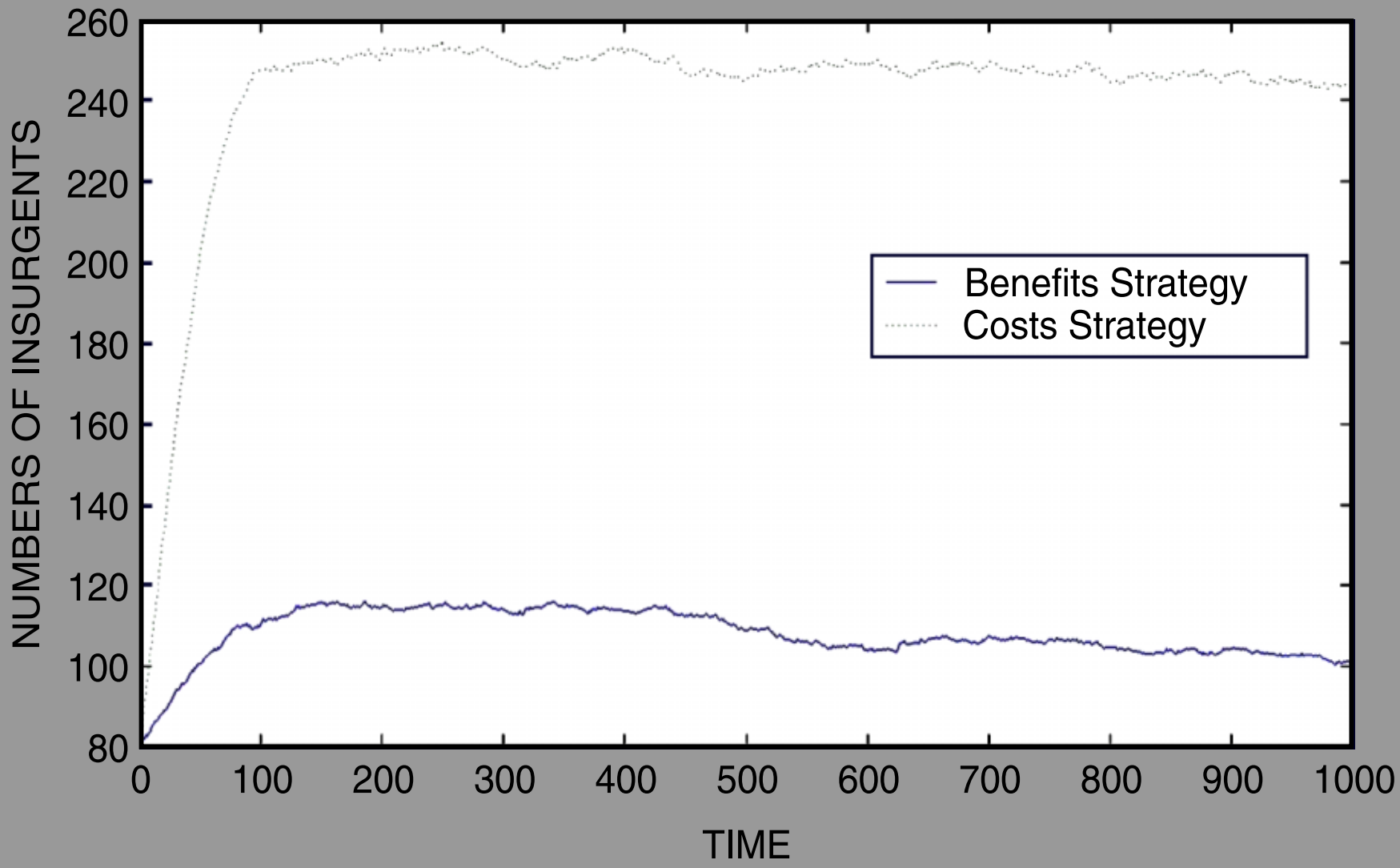


FIGURE 3
NUMBERS OF INSURGENTS GIVEN *HIGH* INITIAL COMMITMENT



Conclusions

- Hearts & Mind approach outperforms Attrition approach.
- Impact of Hearts & Mind approach depends on the population's commitment to the insurgency.

Take-Away Points

- Models used to generate hypotheses or test them?
- Case study to evaluate model.

Weidmann & Salehyan (ISQ, 2013)

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- Violence shifted from attacks against the US-led coalition to sectarian killings.
- Bombing of Shia mosque in 2006 precipitated a spiral of violence.
- By 2007, the violence looked to be out of control leading many to call for a US withdrawal.

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- At the same time, Baghdad changed from mixed ethnic neighborhoods to homogeneous ethnic neighborhoods.

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- There was a significant decline in violence in 2008 and 2009, particularly in Baghdad.

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- What is the relationship between inter-ethnic violence and forced migration?
- What are the most important measures needed to prevent mass killing and ethnic segregation?

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2. The "Surge" was irrelevant": ethnic unmixing and the establishment of relatively homogenous neighborhoods reduced the level of violence by reducing inter-ethnic contact.

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- Solution: re-run history?
- Develop an agent-based model of Baghdad that takes into account levels of violence, ethnic settlement patterns, and counter-insurgency effectiveness, to try to determine which process lead to the decline in violence.

Model Space

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- Locations differ with respect to the Sunni/Shia balance.
- The initial ethnic balance is based on an ethnic map of Baghdad neighborhoods.

Agents

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- A certain proportion of agents in a neighborhood are randomly chosen to be insurgents (π, equal across neighborhoods).

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- The probability of success depends on the ethnic configuration of the location measured by the proportion of the insurgent's co-ethnics in the respective location ($p_{i,j,t}$).

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- Second, attacks against a group could increase as the proportion of co-ethnics decreases if insurgents try to kill as many of the other group as possible (e.g., bombing a marketplace).

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- In this case, attacks occur with a constant rate of success across all neighborhoods.

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- Once all agents have attempted an attack they move to a randomly selected location.

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- 2 possible effects of violence.
- First, attacks in a neighborhood influence the level of fear experienced by members of the targeted group.
- In this case, experienced violence ($a_{i,j,t}$) influences an agent's decision.

Migration

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- Second, violence can have effects beyond the borders of a single neighborhood.
- In this case, violence in one neighborhood could instill fear in nearby neighborhoods (i.e., spillover).

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- Probability of migration:
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- β_0, β_1, and β_2 are selected at the beginning of a simulation run.
- If $\beta_1 > 0$ and $\beta_2 > 0$ then there is evidence that violence leads to migration.

Migration

- If a civilian choses to migrate, she chooses a location that appears to be safer than her current location ($a_{z,j,t} < a_{i,j,t}$).

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- Note: migration decisions are driven by safety concerns, not ethnic attachments.

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- The ethnic composition of neighborhoods is based on high-resolution ethnic maps.
- Period of observation: Samarra bombings to onset of Surge.

(a) Pre-surge Period

Figure 1: Empirical data used for seeding and validation of the model. Ethnic maps show Shia (grey), Sunni (black) and mixed neighborhoods (striped). The level of violence by neighborhood is displayed in different grey shades (center map).

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  4. Examine the distribution of the parameter values in Θ' to determine if a parameter is necessary to generate empirically plausible model outcomes, and if so, whether it has the expected sign.

Results: Model Initialization and Dynamics

- Each neighborhood contains 100 agents with a 50/50 split for mixed neighborhoods and a 70/30 split for an ethnically dominated neighborhood.

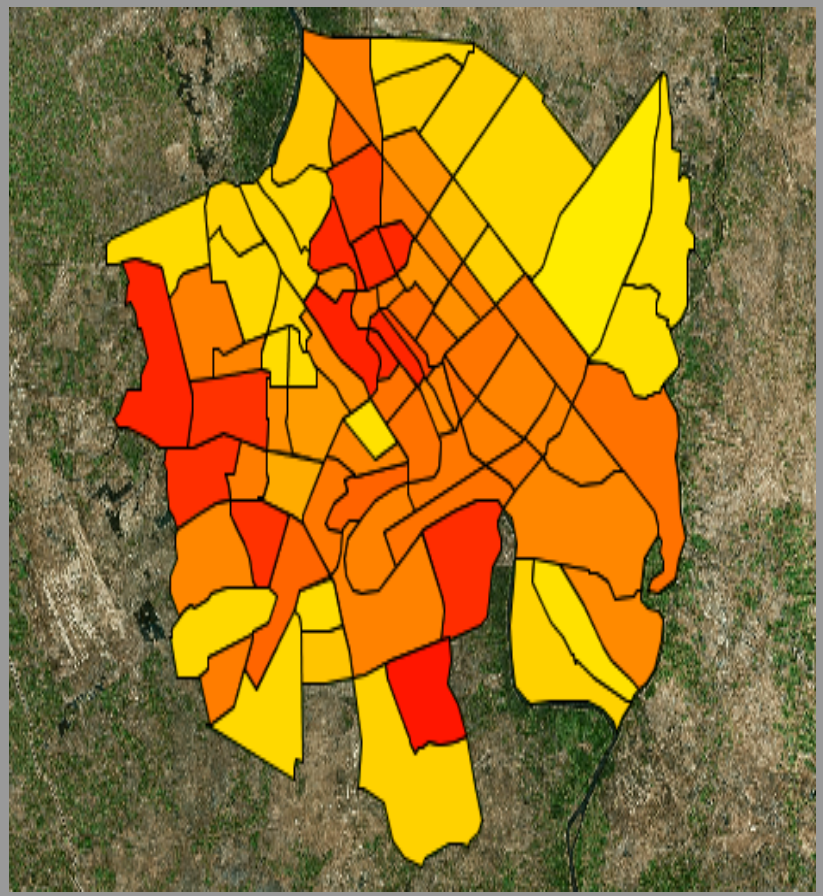

Figure 2: Screenshot of the computational model, initialized using the 2006 ethnic map. The shading indicates the group distribution (bright: Shia, dark: Sunni).

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- Each simulation is run 500 time steps.

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- A plausible run 1) produces a simulated ethnic map that approximates the observed one, 2) produces a spatial distribution of violence similar to the observed one, and 3) does so at the same time during the run.

Results: Model Initialization and Dynamics

- There are 533 plausible parameter vectors (Θ').

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- Only 3% of all parameter vectors capture dynamics that are similar to Baghdad.

Results: Proportion of Co-ethnics and Insurgent Attacks

- What is the relationship between the proportion of co-ethnics and the likelihood of attacks?

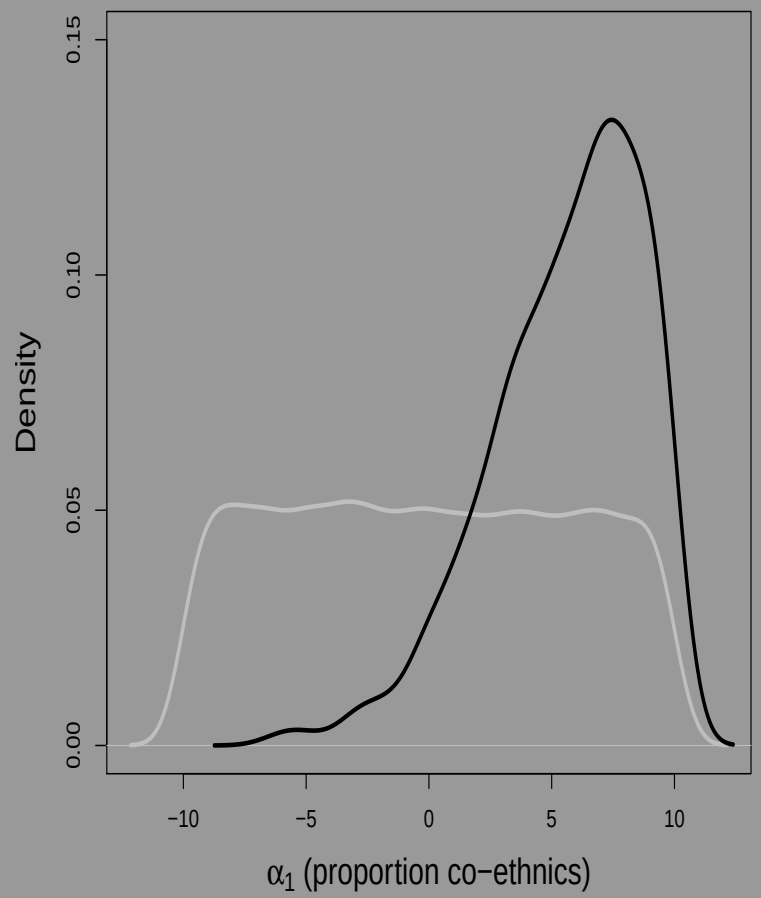

Figure 3: Density of α_1 in Θ' (solid line). The full sampling range in Θ is shown as a grey line.

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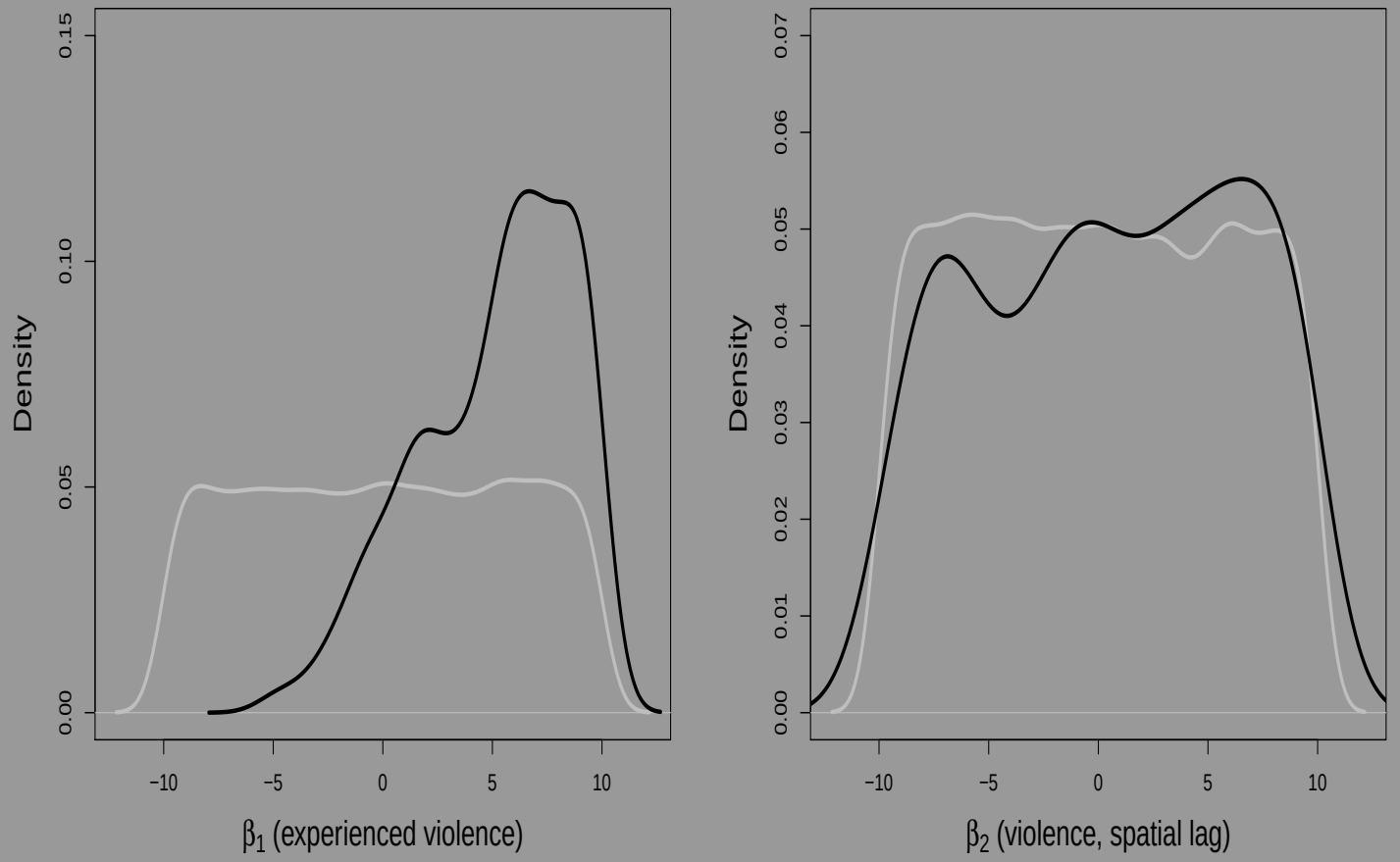
- Violence is of an ethnic cleansing type; a higher proportion of co-ethnics encourage insurgents to attack civilians in minority groups.
- Attacks are motivated by a desire to create ethnically homogenous enclaves.

Results: Experienced Violence and Migration

- What is the effect of violence on migration?



(a) Experienced Violence (b) Experienced Violence (spatial lag)

Figure 4: Density of β_1 (left panel) and β_2 (right panel) in Θ' (solid lines).

Results: Experienced Violence and Migration

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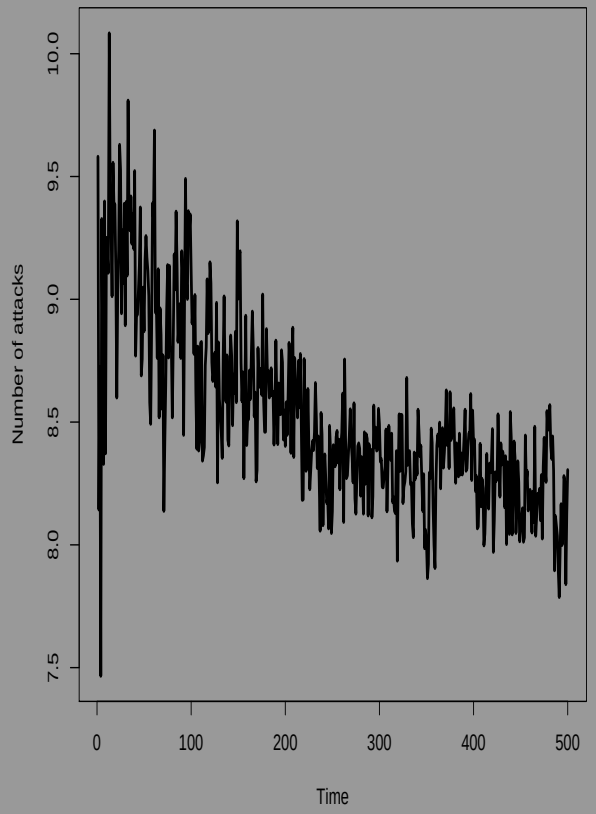
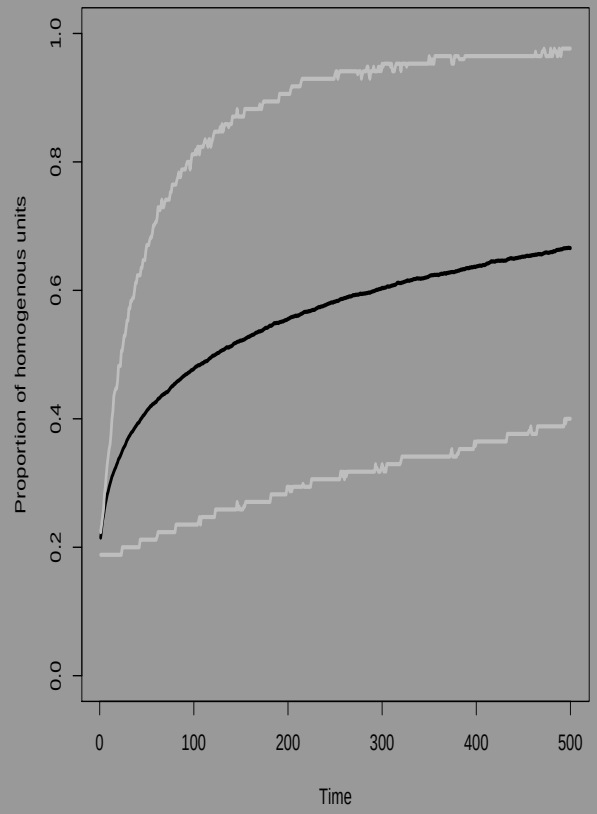
- What is the effect of violence on migration?
- Fear created by insurgent attacks in a neighborhood strongly influences migration.
- Insurgent attacks in other neighborhoods does not influence migration.

Results: Violence and Segregation over Time

- Is there a relationship between violence and segregation over time?



(a) Violence over time



(b) Segregation over time

Figure 5: Evolution of violence (left) and segregation (right) over time, averaged over 533 models runs with parameters from Θ'.

Results: Violence and Segregation over Time

- Is there a relationship between violence and segregation over time?
- Increased segregation is associated with lower levels of violence.
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- Increased segregation is associated with lower levels of violence.
- As mixed neighborhoods move towards homogeneity, attacks against the minority increase.
- However, the migration of minorities reduces the number of potential targets, decreasing the risk of violence in homogeneous neighborhoods.
- This suggests a curvilinear relationship between segregation and violence (low violence for homogeneous neighborhoods; high violence in mixed neighborhoods).

Table 1: Notes: Regression of violence on segregation. Number of observations: 266,500. Adjusted R-squared: 0.83. Coefficients for the model run dummies not shown. Standard errors in parentheses, * indicates significance at $p < 0.05$.

	Model 1
Prop. homogeneous	3.73*
	(0.03)
Prop. homogeneous (squared)	−3.21*
	(0.03)
(Intercept)	0.45*
	(0.02)

Results: Policing to Reduce Ethnic Violence

- To what extent can policing by outside actors be successful in limiting violence?

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- Does it matter if policing is implemented early or late during an insurgency?

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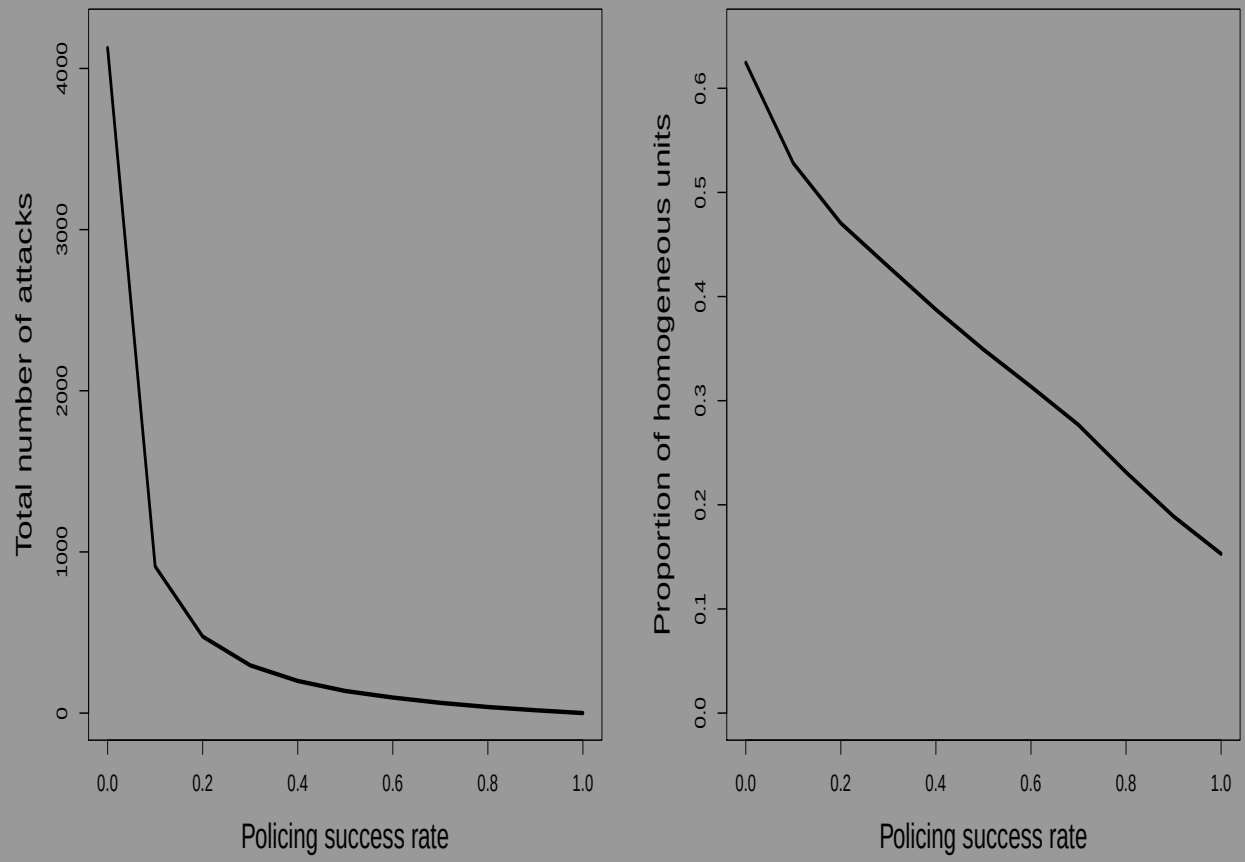
- Assume the probability of successful policing is constant across neighborhoods.
- Assume that punished attacks do not generate fear among civilians, only unpunished attacks.

Results: Policing to Reduce Ethnic Violence

- How does policing success influence violence and segregation?



(a) Violence

(b) Segregation

Figure 6: Effect of policing on the reduction of violence (left) and segregation (right).

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- Even small levels of policing are highly effective in reducing violence.

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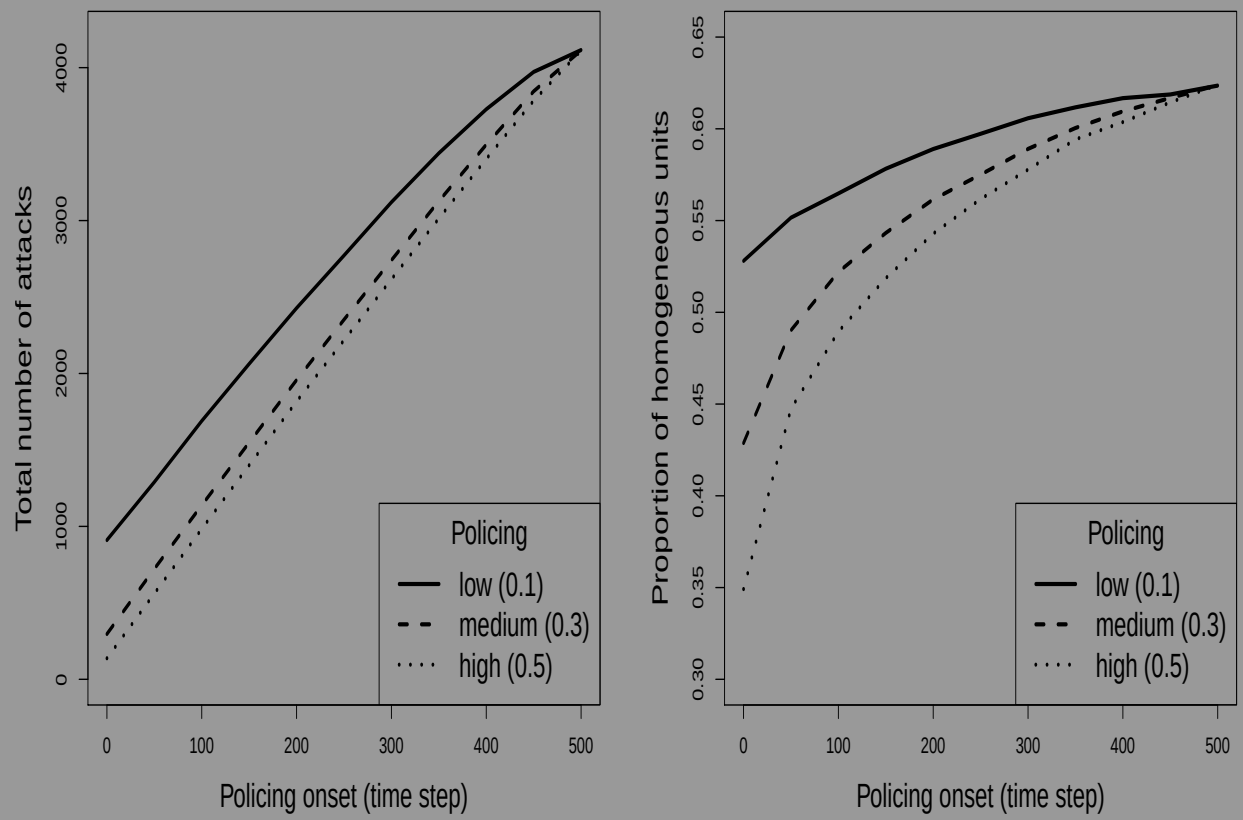
- How does policing success influence violence and segregation?
- Even small levels of policing are highly effective in reducing violence.
- There is a continuous decline in segregation as policing success increases, but with limited success.

Results: Policing to Reduce Ethnic Violence

- How does the timing of policing influence violence and segregation?



(a) Violence

(b) Segregation

Figure 7: Effect of the onset of policing on the reduction of violence (left) and segregation (right).

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- In order to compensate for a delay of 100 time steps before policing begins, you have to triple policing efforts to obtain a comparable reduction in violence.

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- There is a reciprocal relationship between ethnic segregation and violence.
- Even small increases in policing effectiveness can dramatically decrease the level of violence, but only if policing is implemented early on during an insurgency.

Take-Away Points

- Use GIS data.
- Validating the output of simulations.