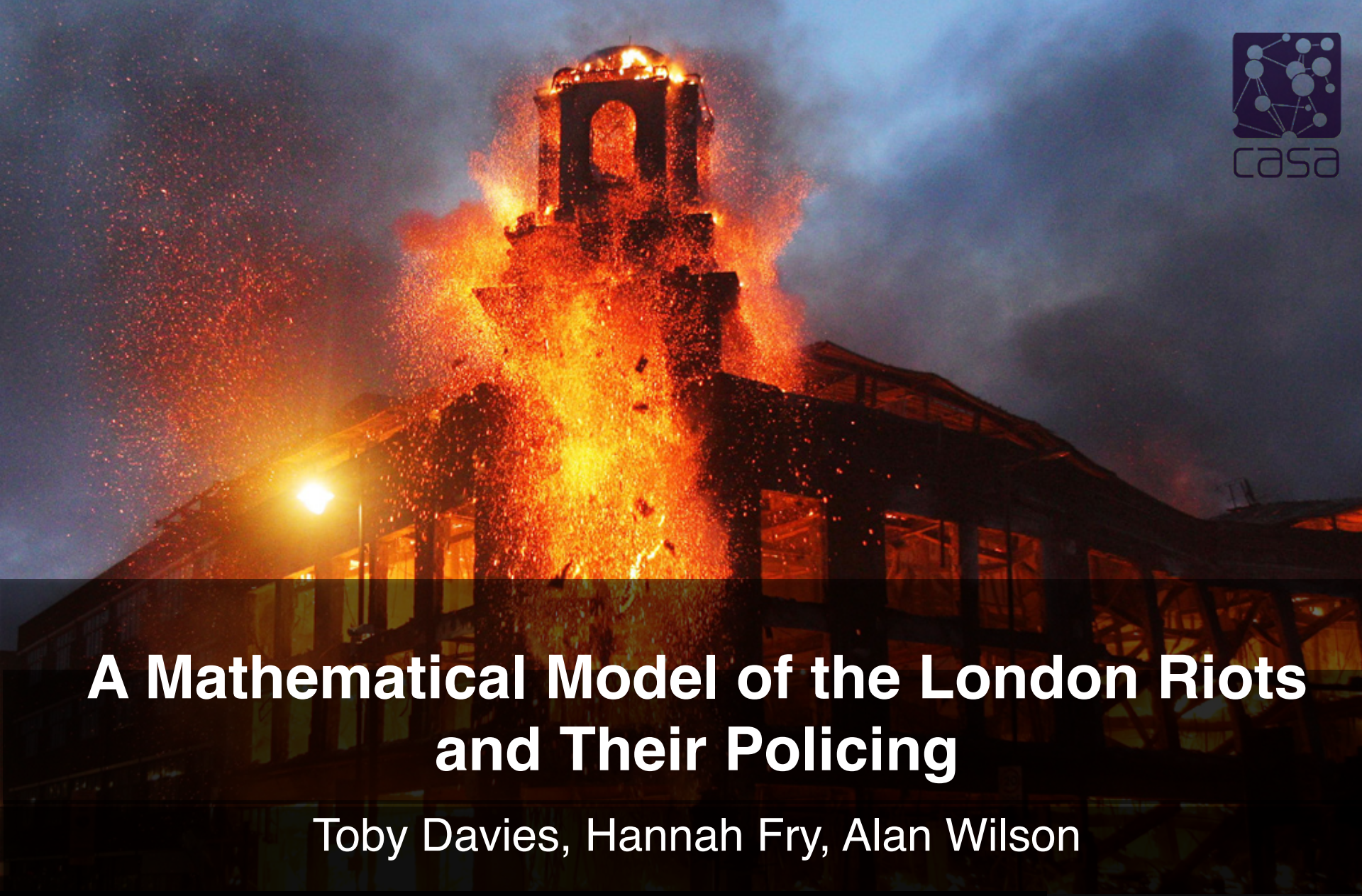
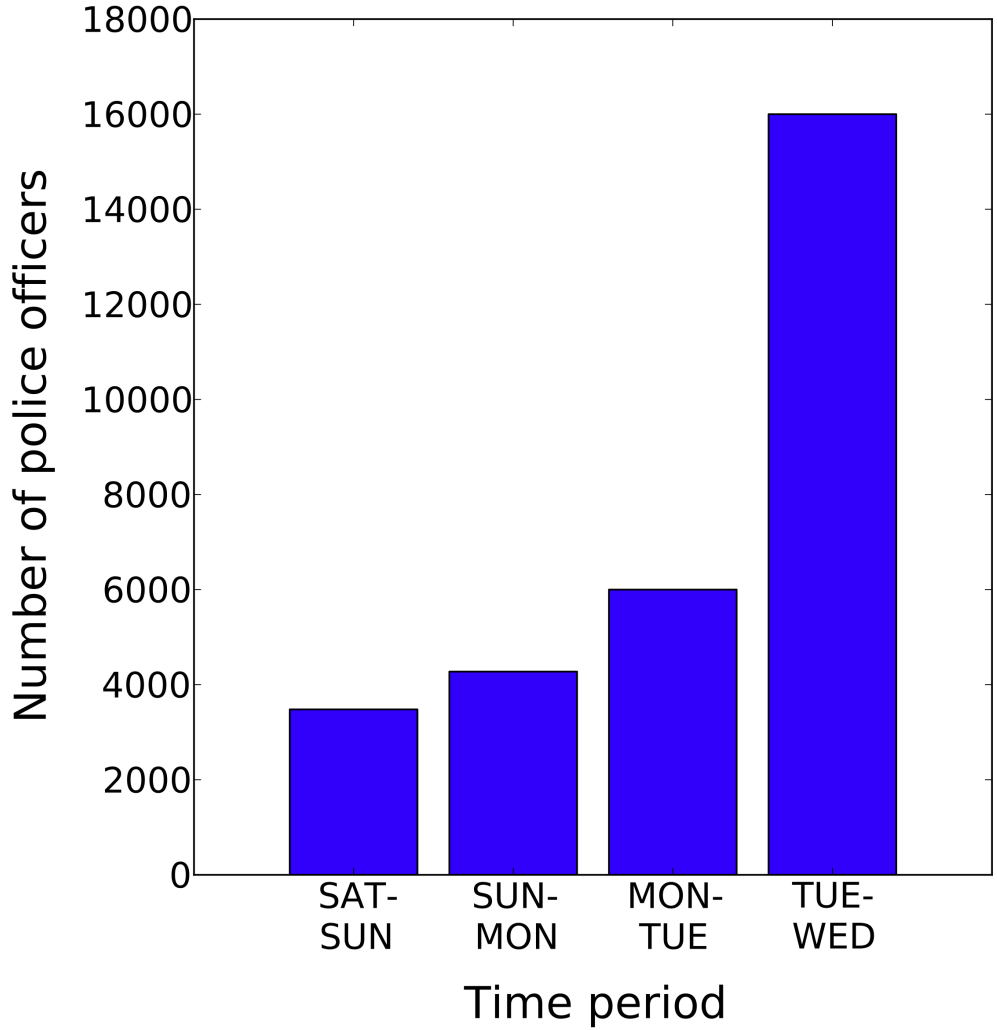


A Mathematical Model of the London Riots and Their Policing

Toby Davies, Hannah Fry, Alan Wilson

- Between the 6th and 10th of August 2011
- At least 4000 crimes recorded across London
- 5 fatalities, 16 injured
- £250 million cost to the tax payer at most recent estimate
- Police numbers increased from 3,480 to 16,000 over the course of the events



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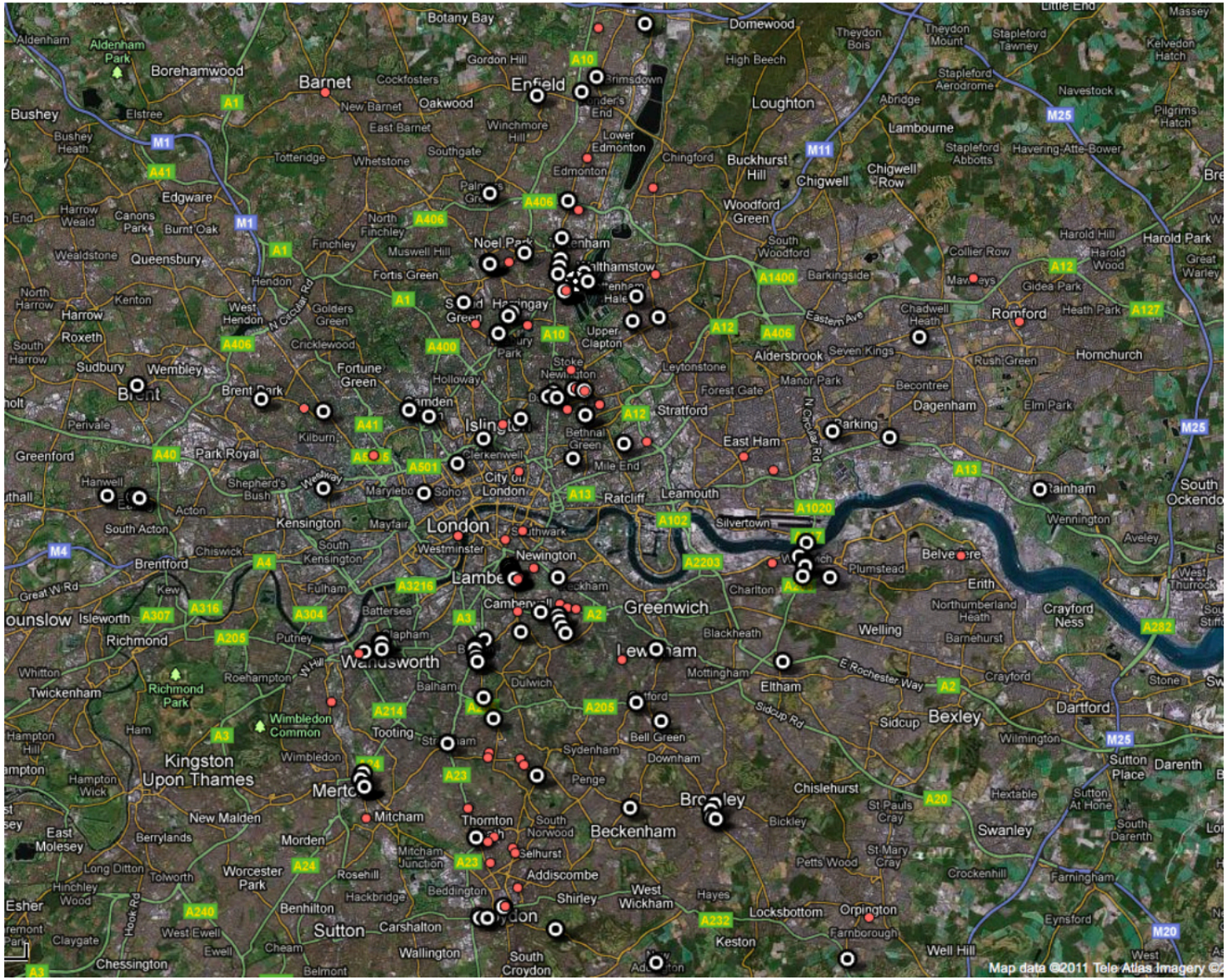
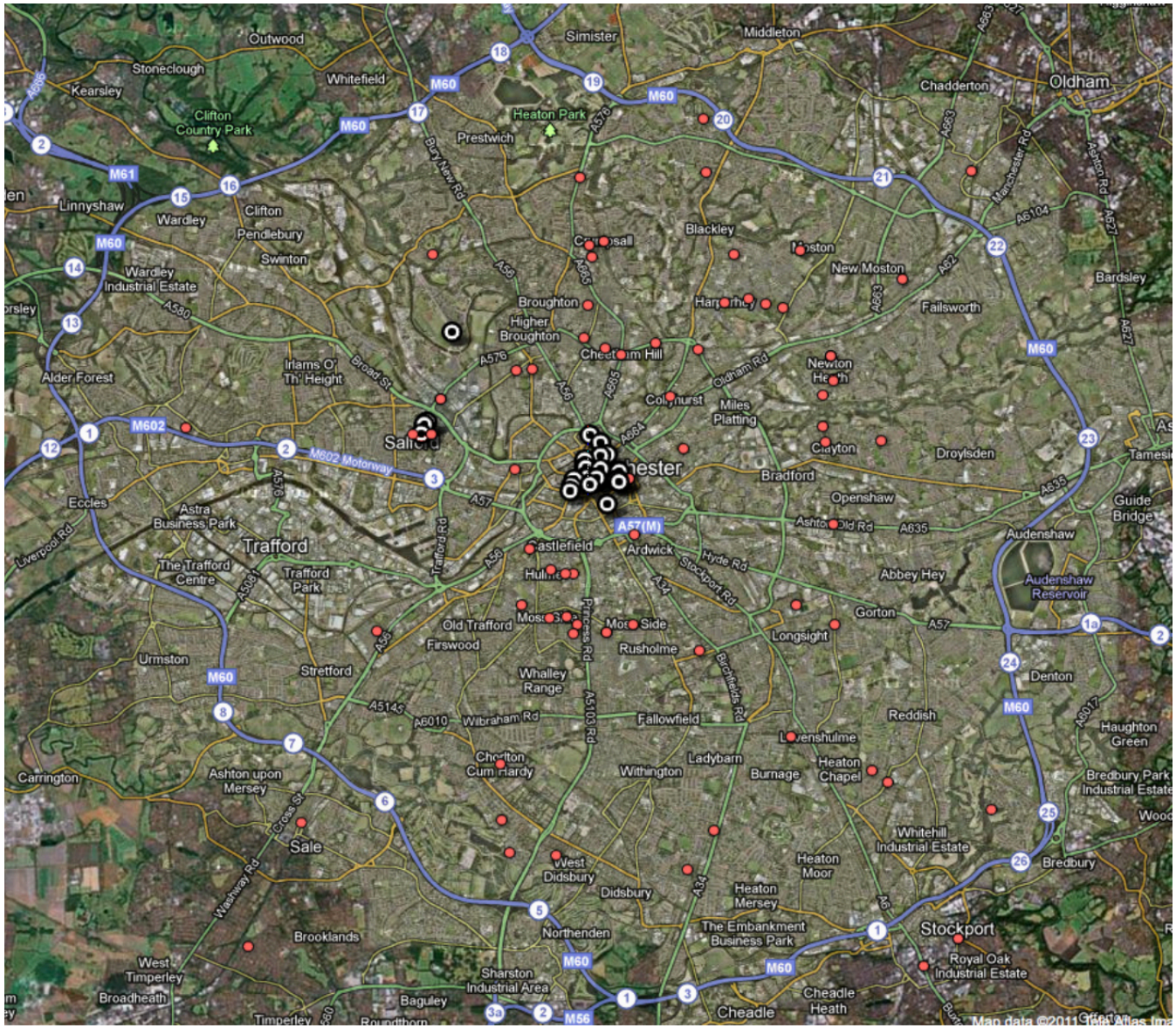
London



Source: http://www.guardian.co.uk/news/datablog/interactive/2011/aug/09/uk-riots-incident-map

Manchester



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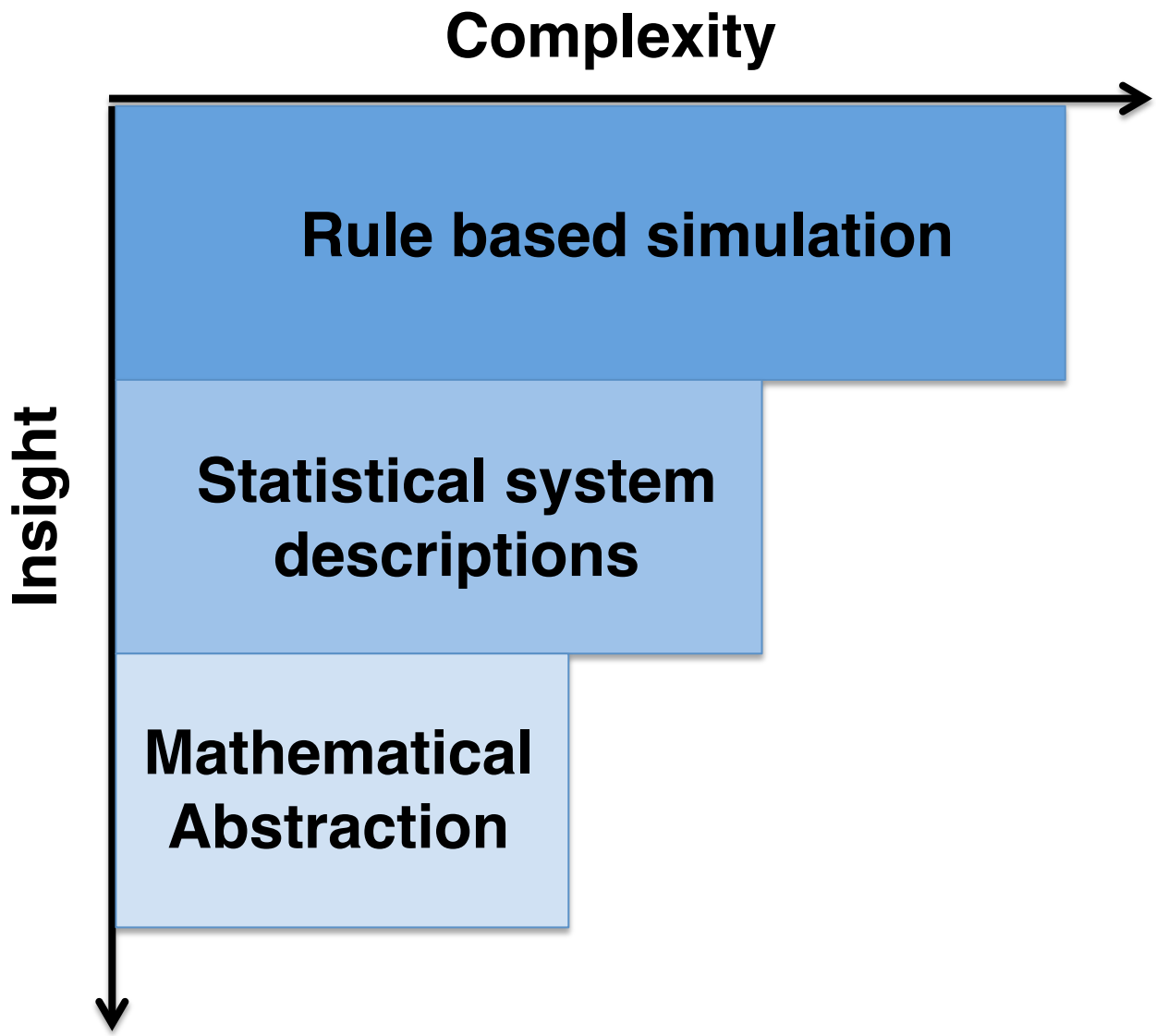
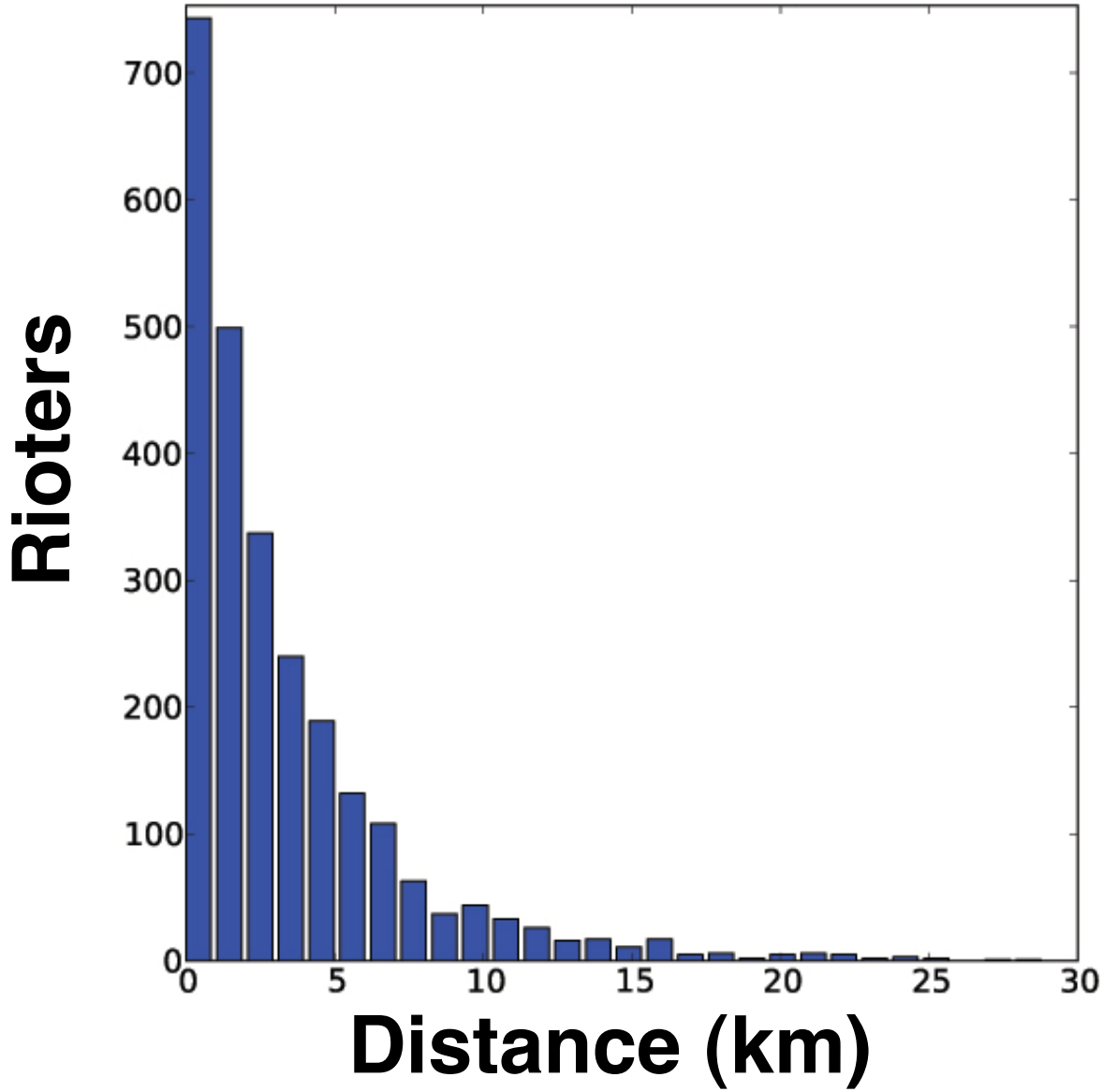
6th August 2012 - 12:01

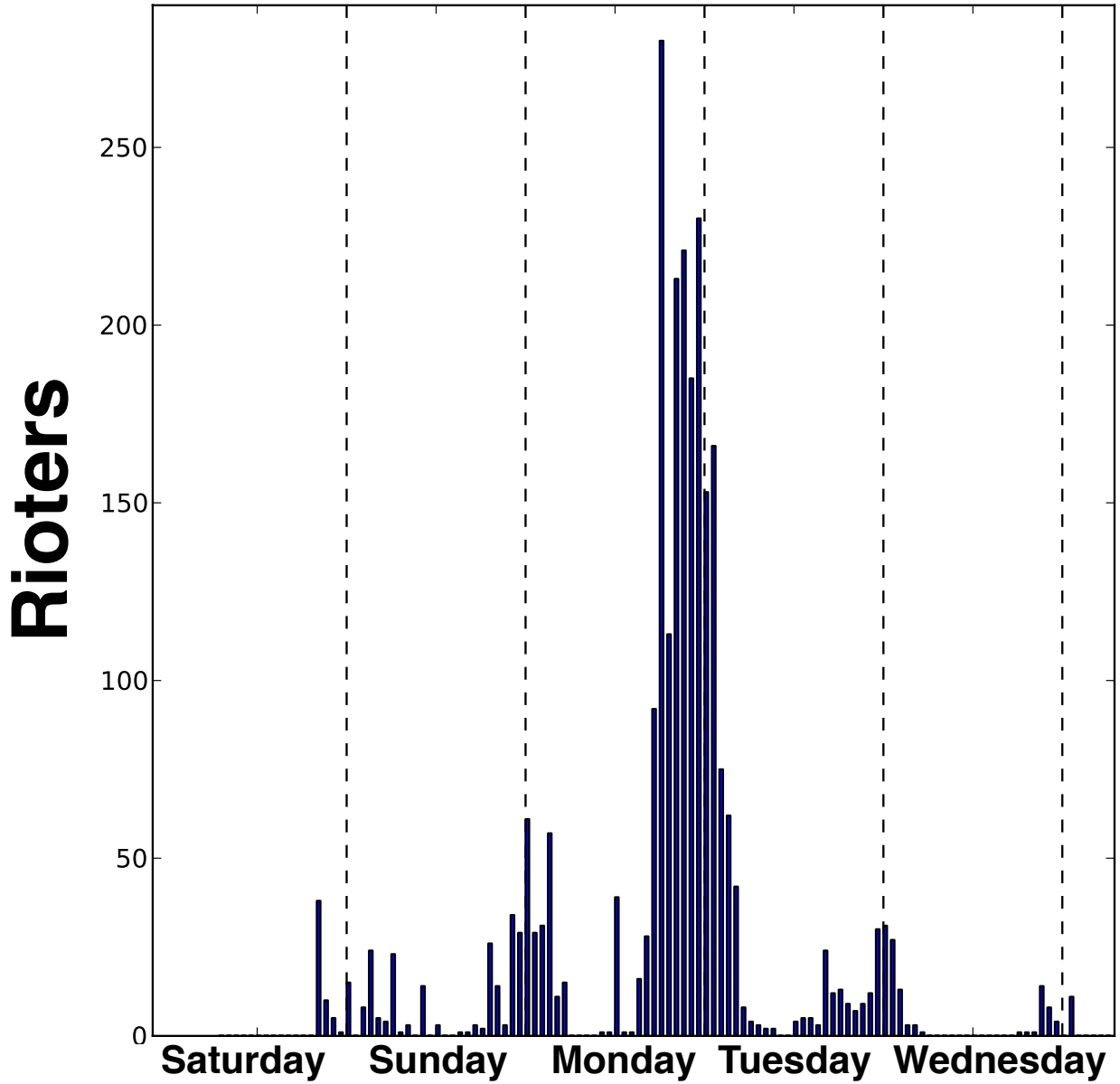
How to model?


Complexity
Insight
Rule based simulation
Statistical system descriptions
Mathematical Abstraction

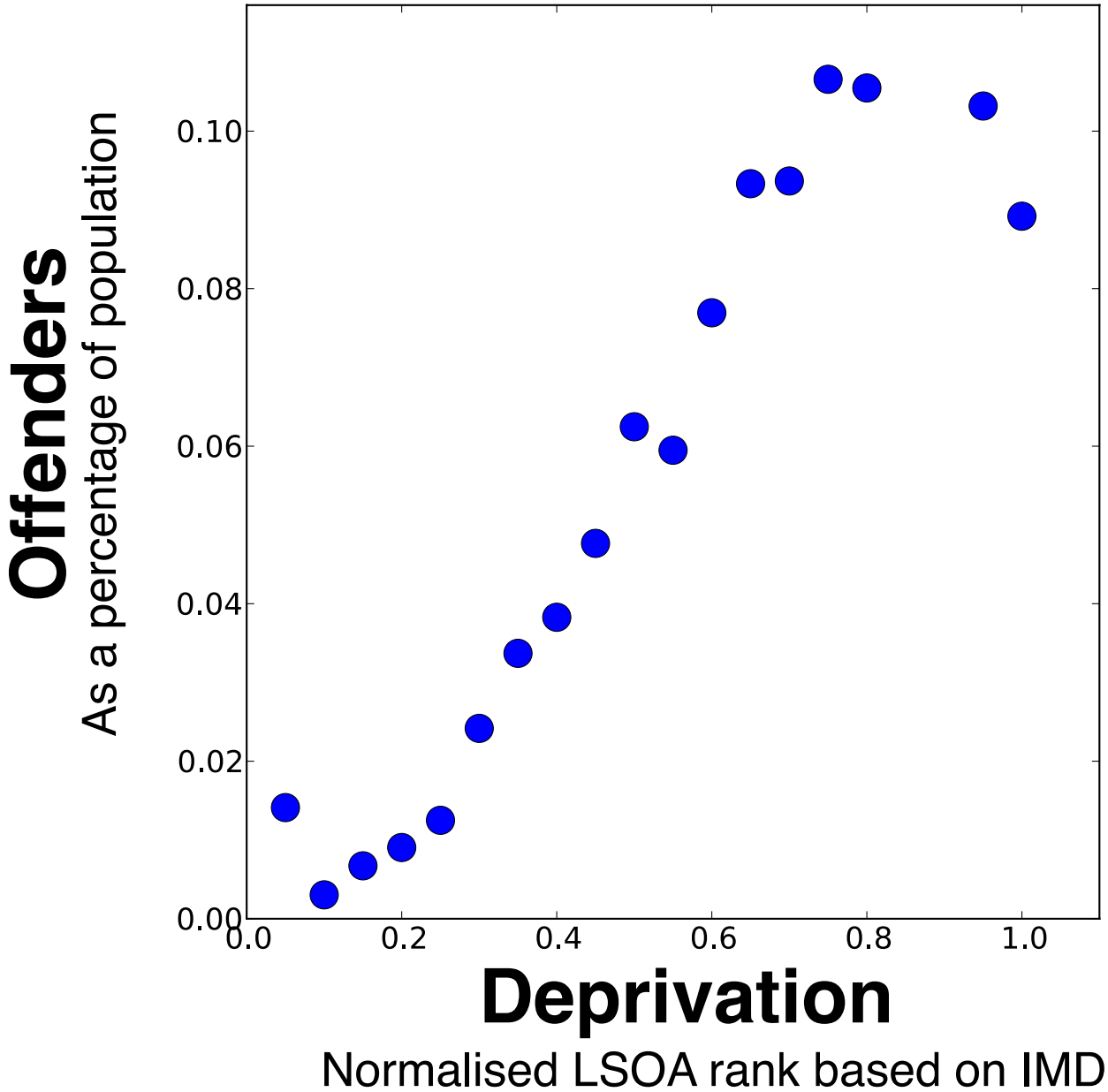
Key observations from data



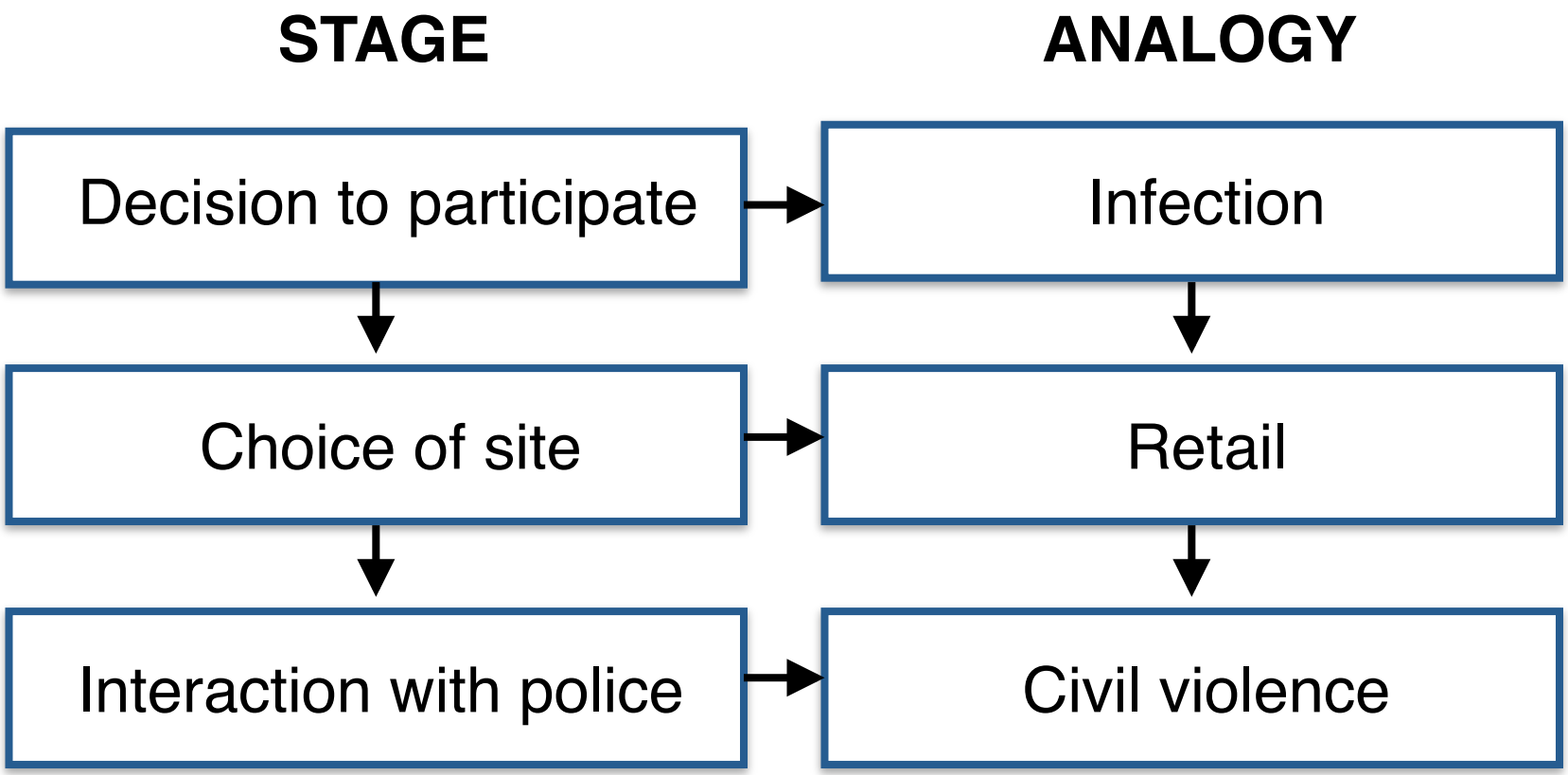
Key observations from data



Key observations from data



Proposed model

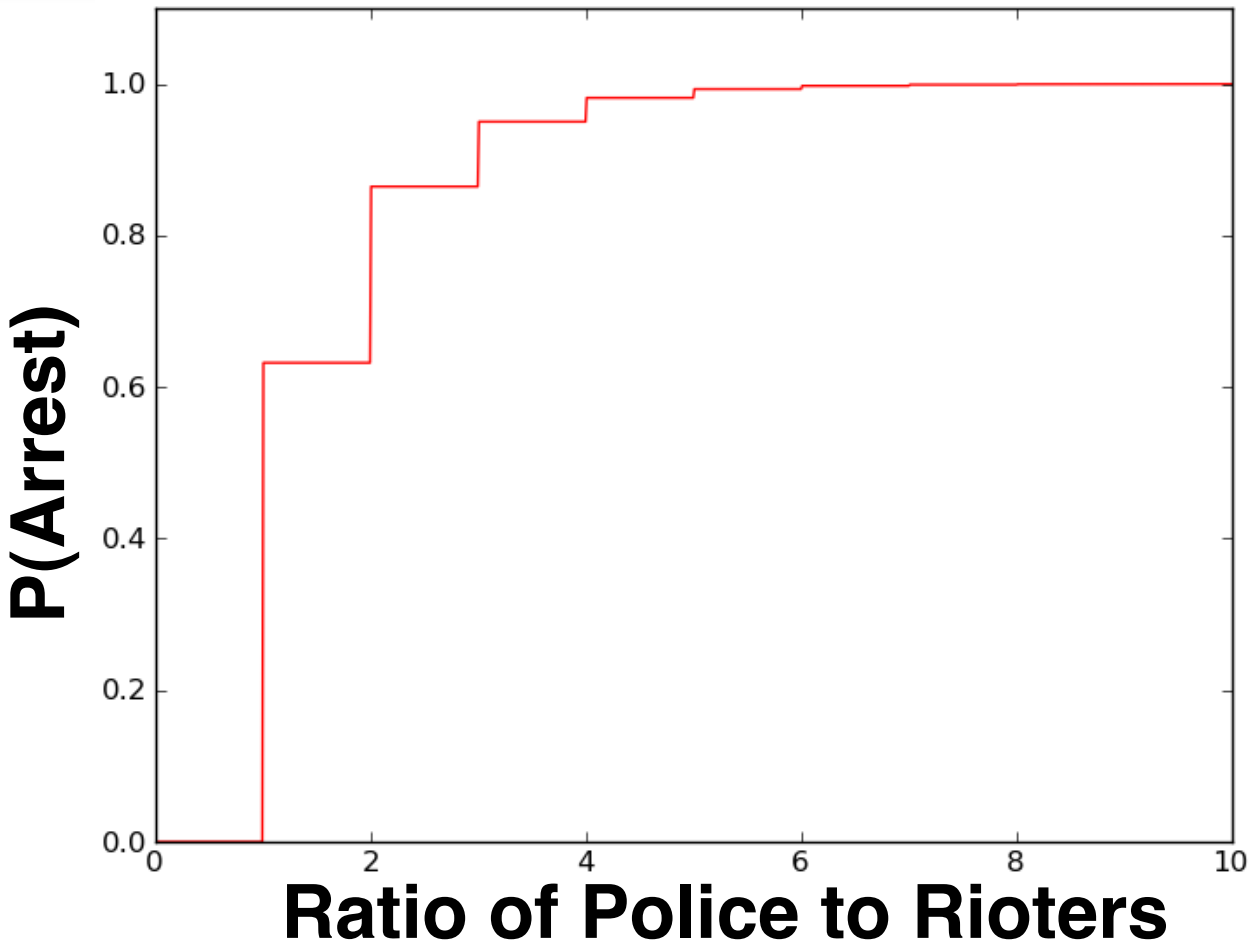


Probability of arrest

$$\mathbf{P}(\text{arrest in } j \text{ in one time unit}) = 1 - \exp\left(-\left\lfloor \frac{Q_j}{aD_j} \right\rfloor\right)$$

Number of Police

Number of Rioters



Utility and Attractiveness

Utility

Floorspace

Distance

Deterrent effect

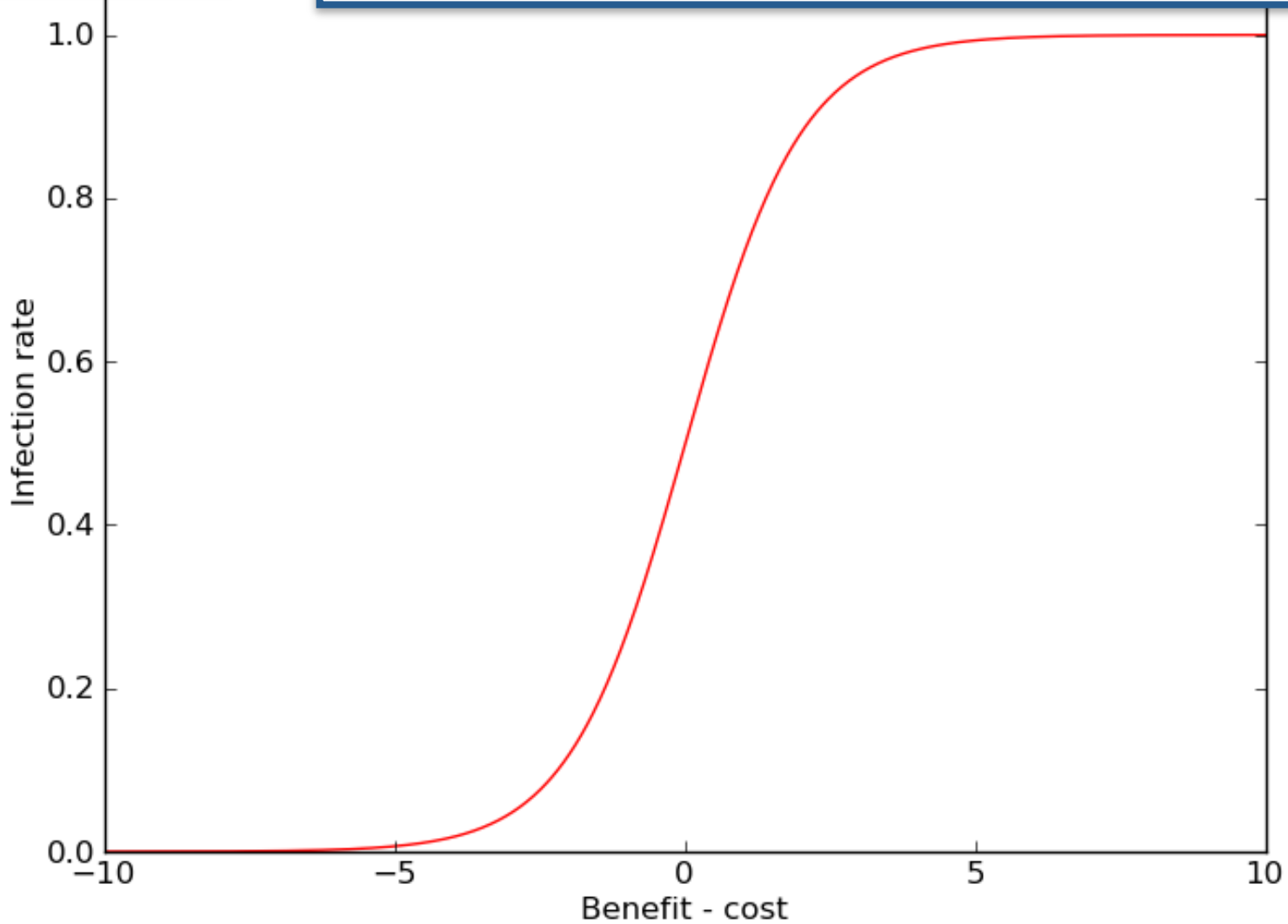
$$U_{ij} = w_1 \log Z_j - w_2 d_{ij} - w_3 \left\lfloor \frac{Q_j}{aD_j} \right\rfloor$$

Attractiveness

$$W_{ij} = Z_j^{\alpha_r} \exp(-\beta_r d_{ij}) \exp\left(-\left\lfloor \frac{\gamma_r Q_j}{D_j} \right\rfloor\right)$$

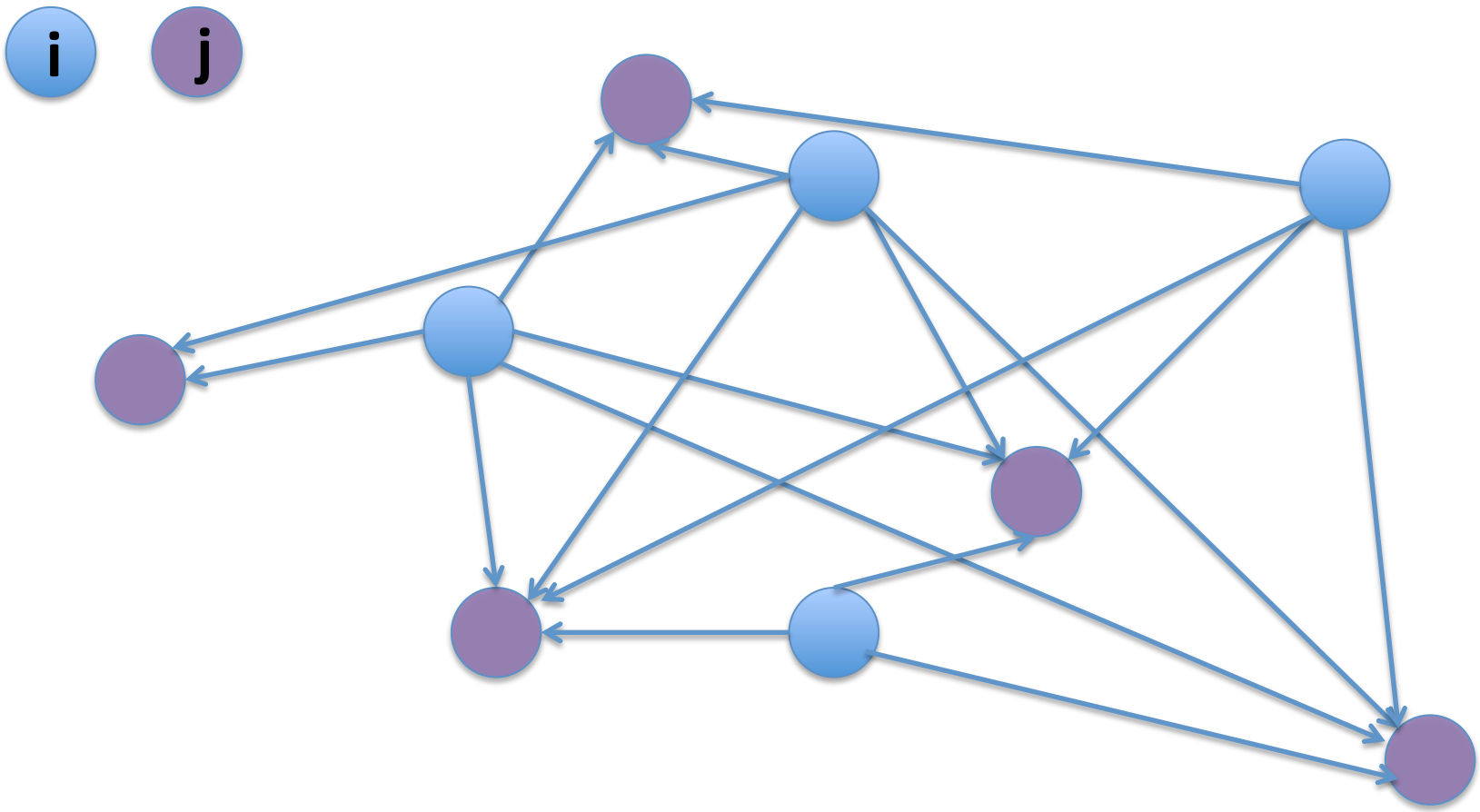
Infection

$$\mathbf{P}(\text{individual in } i \text{ chooses to offend}) = \rho_i \frac{\sum_j W_{ij}}{1 + \sum_j W_{ij}}$$

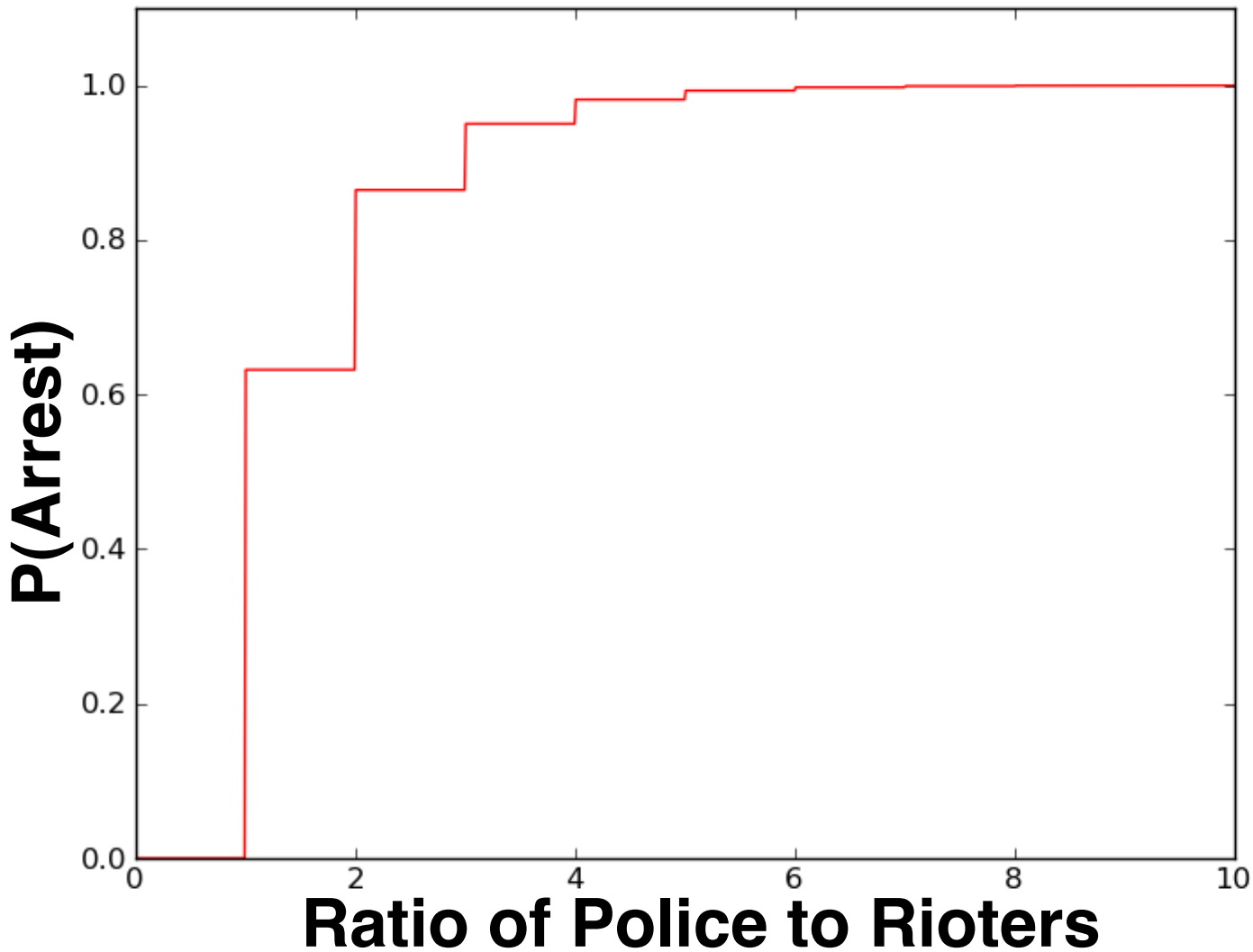


Retail

$$D_j(t) = \sum_i \frac{R_i(t) W_{ij}(t)}{\sum_{j'} W_{ij'}(t)}$$



Civil Violence → $\mathbf{P}(\text{arrest in } j \text{ in one time unit}) = 1 - \exp\left(-\left\lfloor \frac{Q_j}{aD_j} \right\rfloor\right)$



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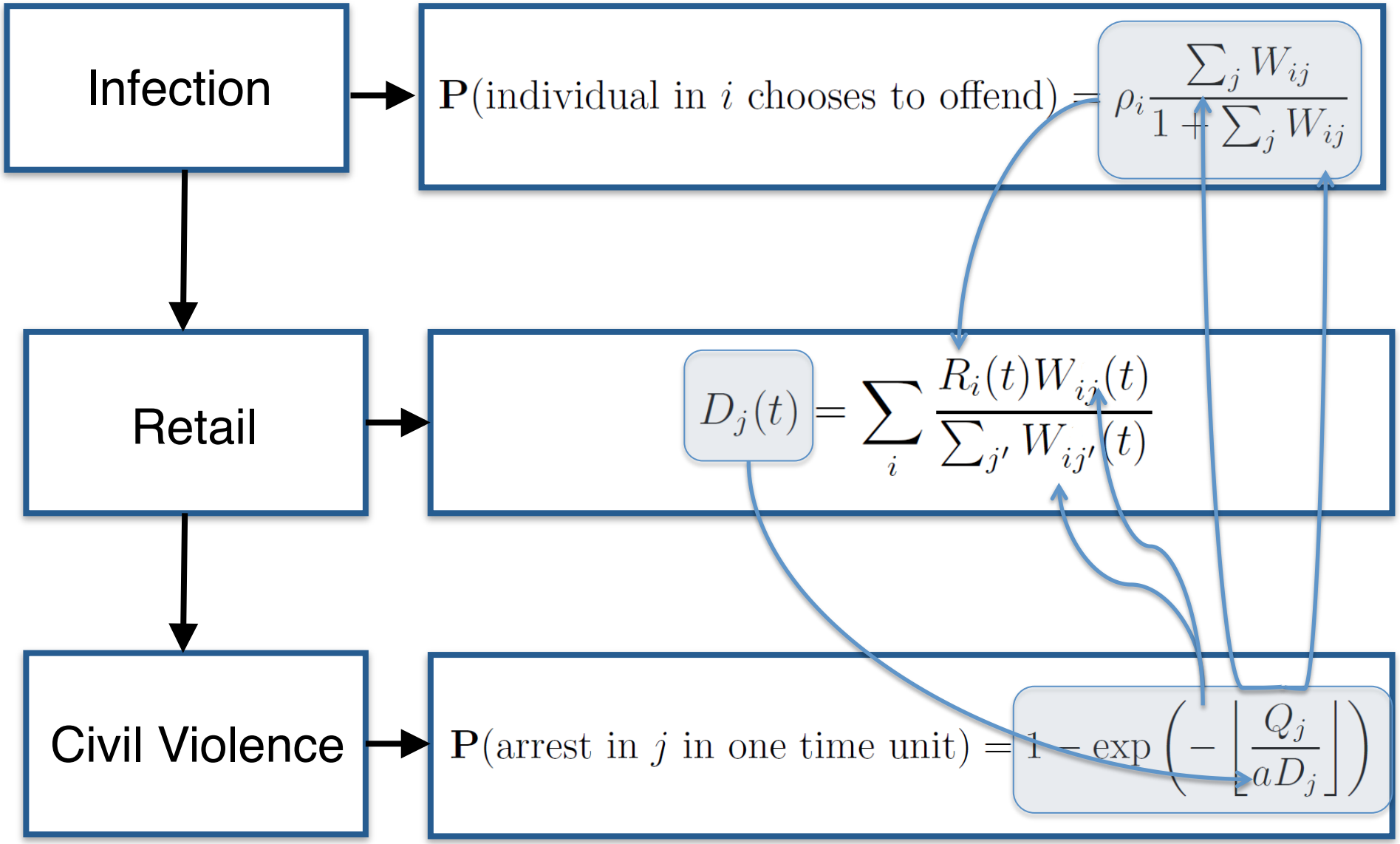
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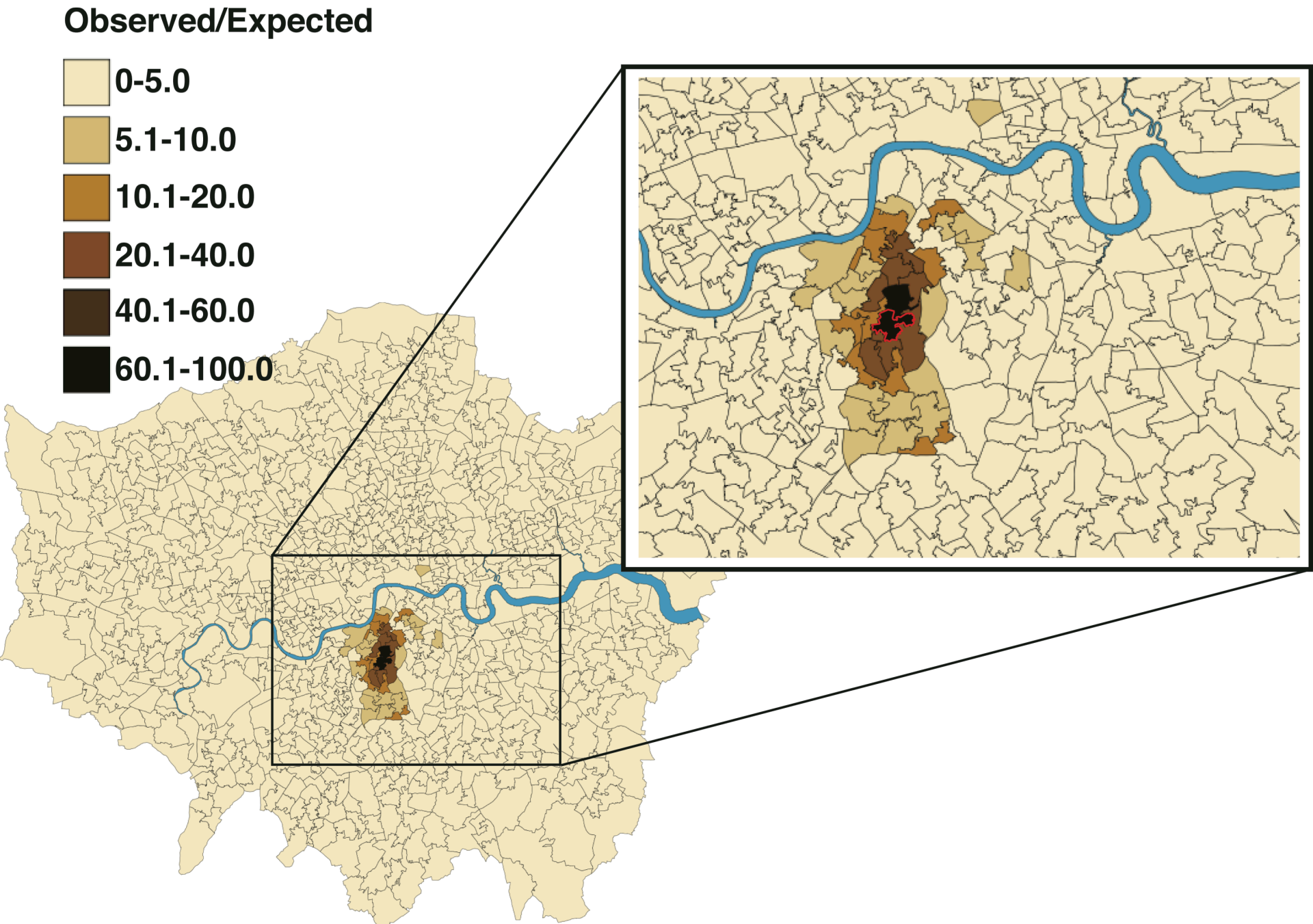
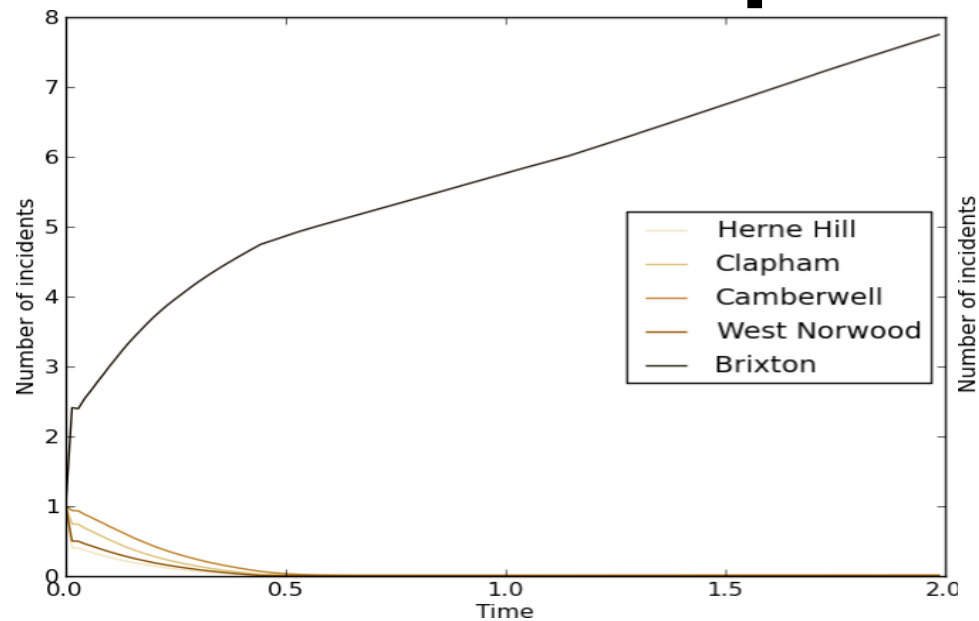
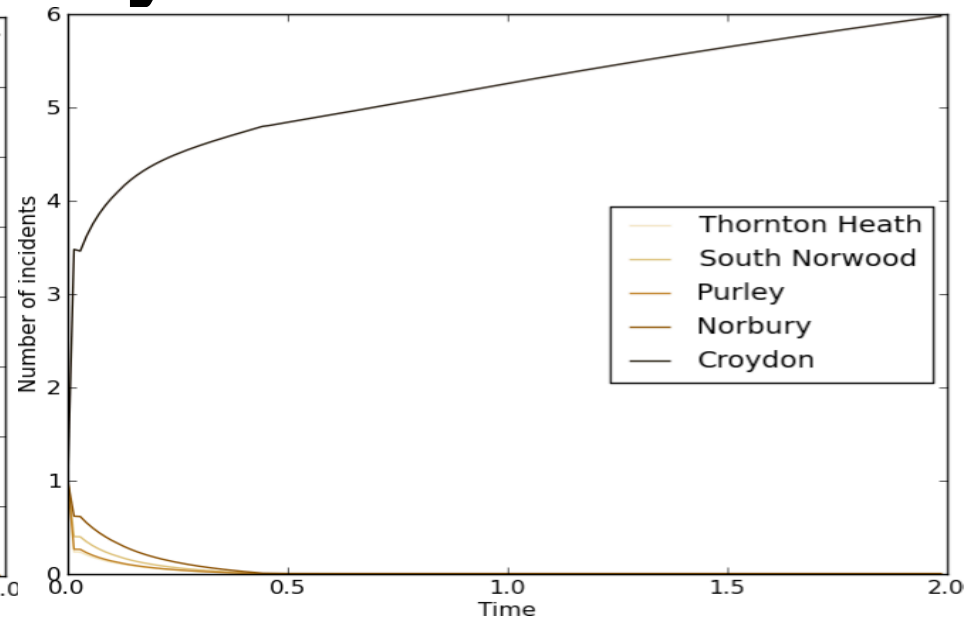
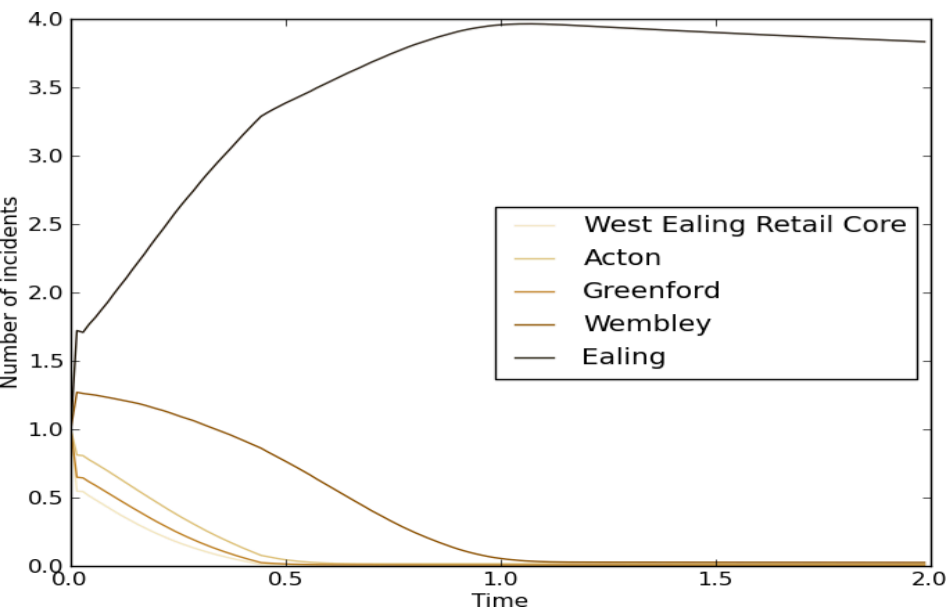
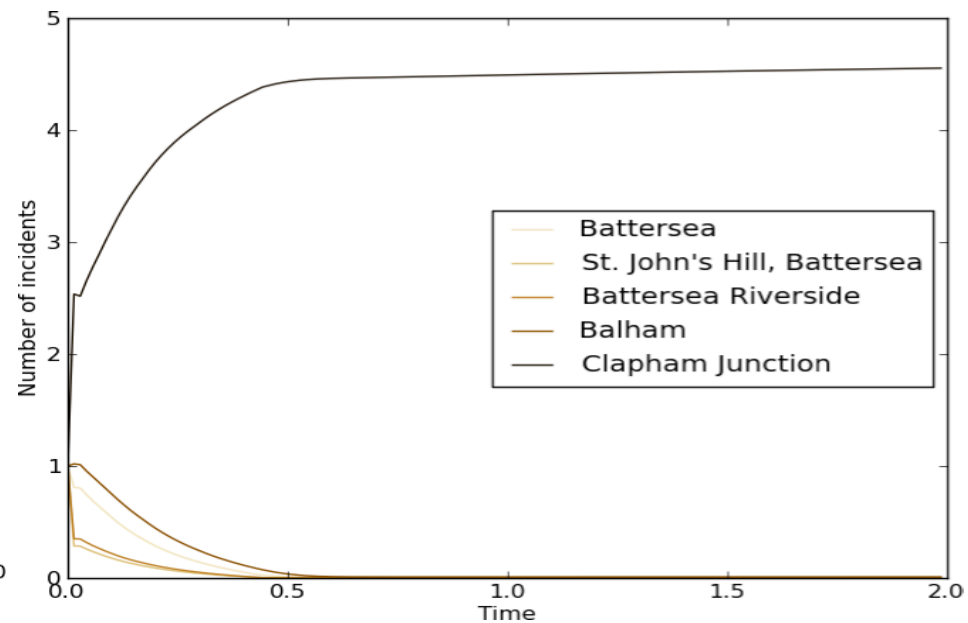

Observed/Expected
0-5.0
5.1-10.0
10.1-20.0
20.1-40.0
40.1-60.0
60.1-100.0

Susceptibility of sites

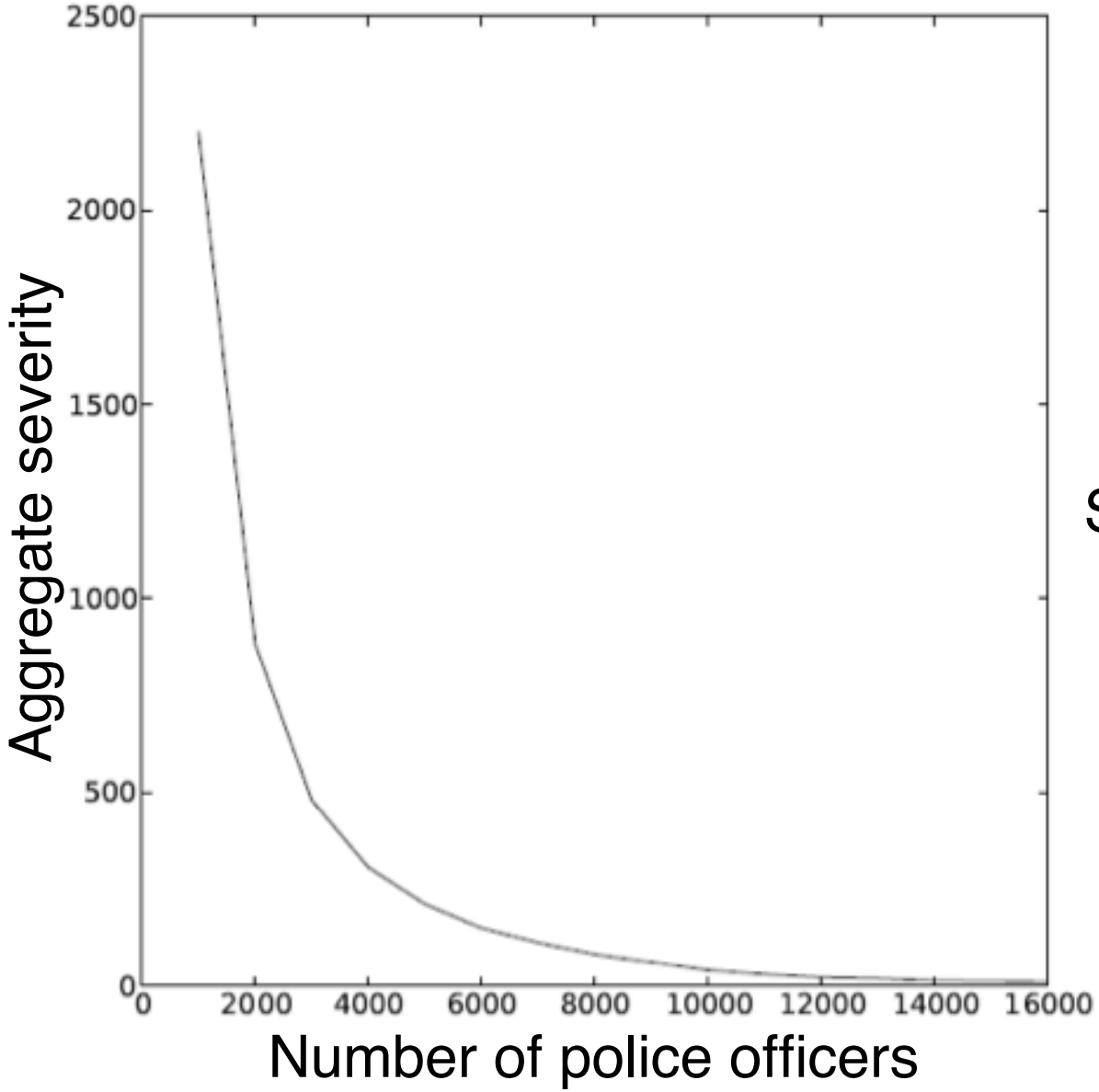








Police numbers & response delay



$$\text{Severity} = \sum_{zones} \sum_{t} \frac{\#\ \text{rioters}}{\#\ \text{police}}$$

Concluding Comments & Further Work

- Extension to full 5 days
- More sophisticated policing strategies
- Integration of transport network
- Communication between rioters
- PDE description of system