NSW Bureau of Crime Statistics and Research

AN EPIDEMIC MODEL OF DELINQUENCY

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Outline of presentation

- Background
- Description of the model
- Implications
- Simulations to illustrate features
- Limitations
- Further development

Background

Economic stress (unemployment, low income)

→ increases likelihood of parental neglect / abuse

(reduced with social supports e.g. strong family/neighbourhood ties, increased with social stresses e.g. large family, family conflict)

→ increases likelihood of peer influence on child

→ increases likelihood of child's involvement in crime, to the extent that peers are involved in crime.

Epidemic process

This is an epidemic process because:

the rate at which *susceptible* juveniles

become *delinquent* ('infected')

depends on the number of delinquent peers.

Develop an epidemic model for offender population growth

Adapt epidemic model of disease transmission using elements from criminal career theory.

Criminal career theory

Aggregate amount of crime:

– number of active offenders

– frequency of offending.

Number of active offenders:

– rate of initiation into crime

– length of criminal career.

Epidemic model of disease transmission ('mass-action' model)

$$C_{t+1} = r\,C_t S_t$$
$$S_{t+1} = S_t - C_{t+1} + B_t$$

where

C_t = no. cases of disease at time t

S_t = no. individuals susceptible to infection at time t

r = proportion of all possible contacts which lead to new infections

B_t = no. new susceptibles at time t

Problems with this model if applied to offenders

- The period of infection is assumed to be short – the number of cases is just the number of newly infected persons.
- Persons remain susceptible to infection.
- There is an assumption of ‘homogenous mixing’.

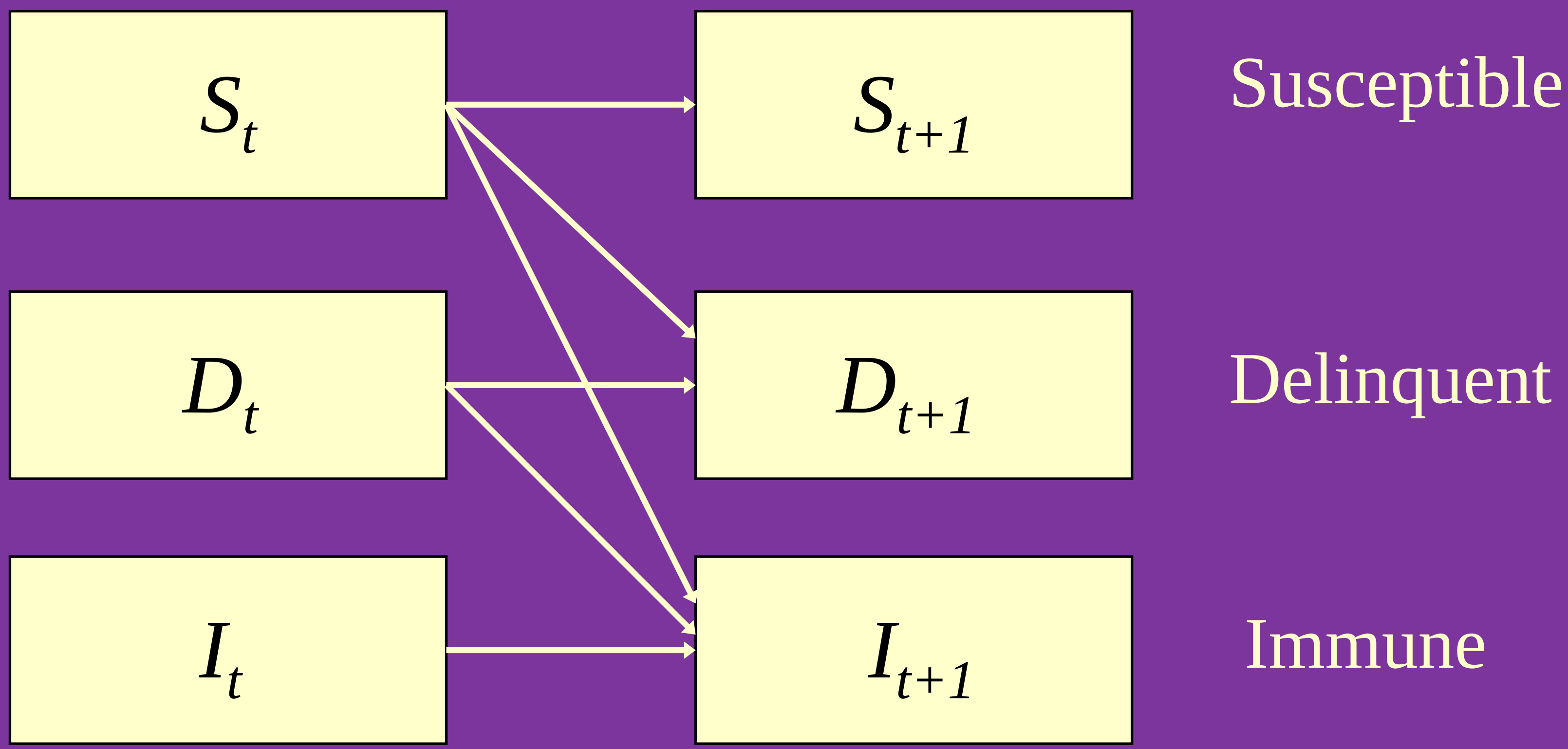
Changes to the disease model

- Assume that delinquents are active offenders for some time (the length of their ‘criminal career’).
- Assume that there is a limit to a person’s period of susceptibility to ‘infection’.
- Assume that only a proportion p of all possible contacts between delinquents and susceptibles actually occur and that only a proportion r of those contacts result in ‘infection’. In practice we need only one parameter $k=pr$.

Definitions

- A delinquent is an active offender.
- A susceptible juvenile is one who has been neglected / abused by parents and is susceptible to peer influence.
- An immune juvenile is one who is not susceptible to peer influence OR who has quit crime (i.e. whose criminal career is over).

Possible state transitions



Variable and parameter definitions

S_t = no. susceptibles at time t

D_t = no. delinquents at time t

I_t = no. immunes at time t

B_t = no. new susceptibles at time t

q = probability a delinquent becomes immune

k = probability a susceptible comes in contact with a delinquent and becomes delinquent

m = probability a susceptible becomes immune

Model equations

$$D_{t+1} = D_t + k S_t D_t - q D_t$$

$$S_{t+1} = S_t - k S_t D_t + B_t - m S_t$$

$$I_{t+1} = I_t + q D_t + m S_t$$

Conditions for stability

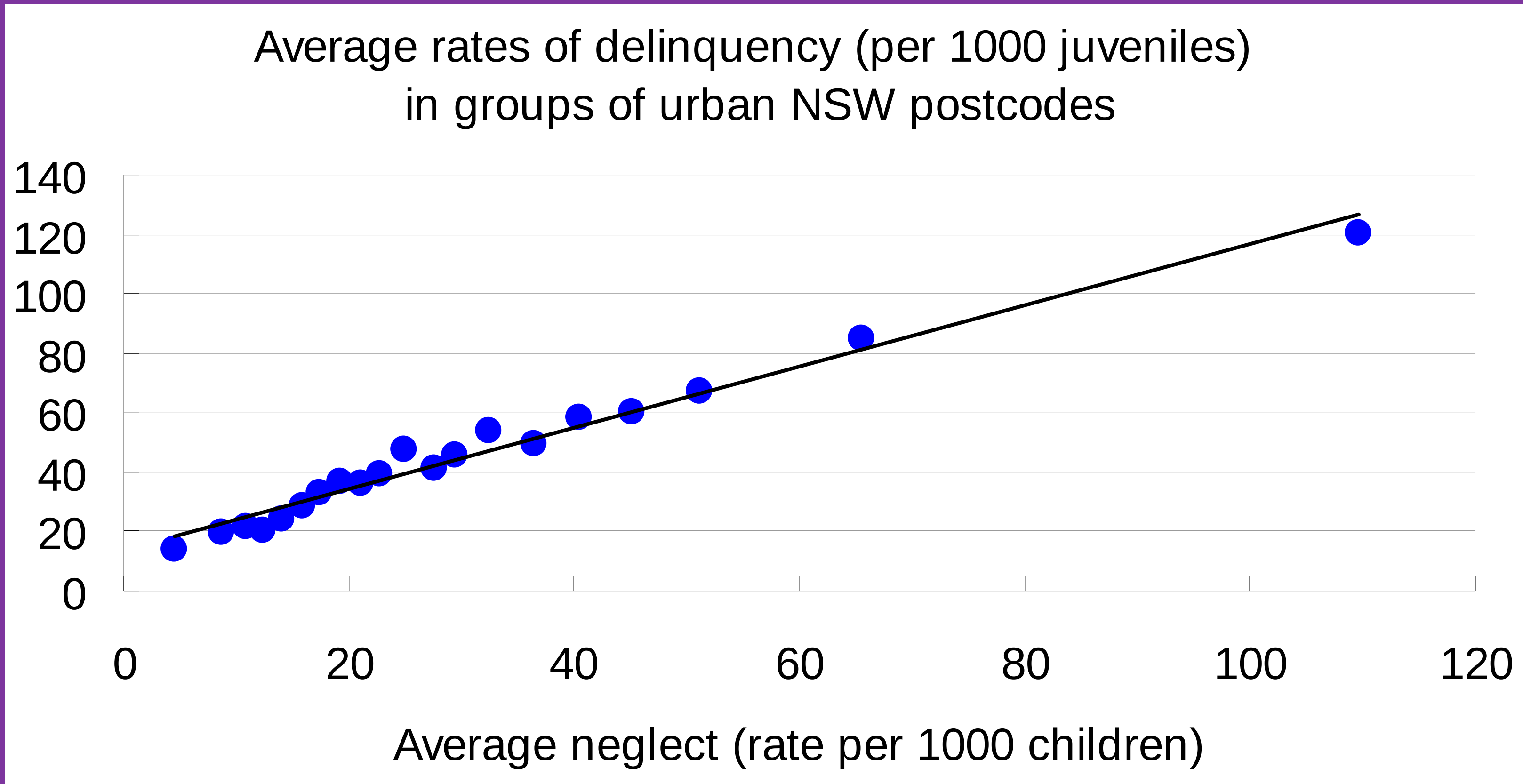
Can show that $D_{t+1} = D_t$ if $S_t = q/k$

and that $S_{t+1} = S_t$ if $D_t = B_t/q - m/k$

Implication of $D_t = B_t/q - m/k$

Across a group of stable communities there should be a linear relationship between delinquents and new susceptibles.

Relationship between rates of delinquency and rates of neglect in different communities



Implications of $D_t = B_t / q - m/k$

Implications for 'stable' communities are:

- delinquent population higher if more new susceptibles (B_t bigger)
- delinquent population lower if delinquents more likely to quit crime (bigger q)
- delinquent population lower if susceptibles more likely to become immune (bigger m)
- delinquent population higher if susceptibles more likely to become delinquent (bigger k)

Population growth threshold

$$D_{t+1} = D_t + k\,S_t\,D_t - q\,D_t$$

Therefore $D_{t+1} > D_t$ only if $S_t > q/k$.

Implies that the delinquent population only grows when susceptibles exceed a threshold number.

Some illustrative simulations

For the purposes of illustration, make the following assumptions:

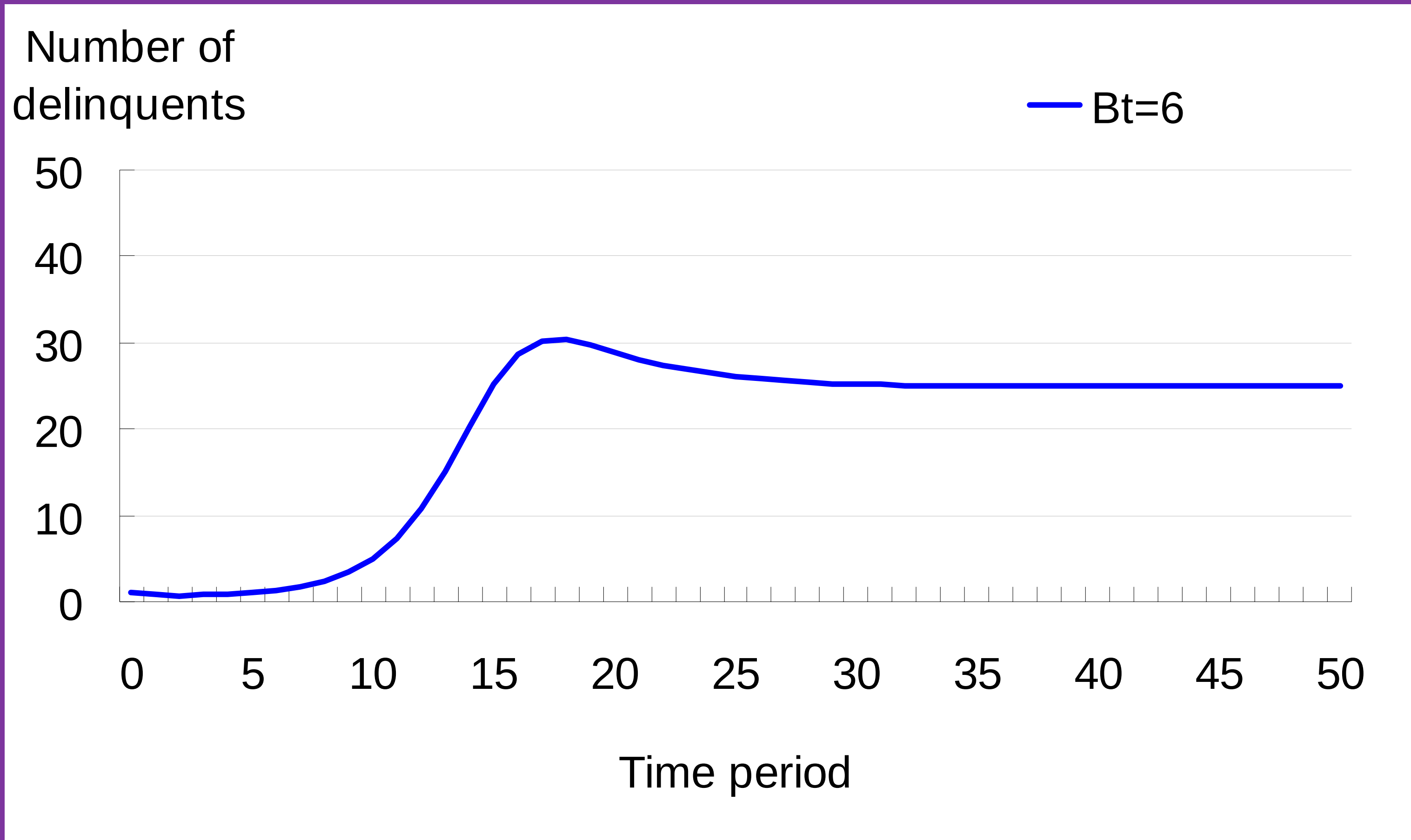
$q = 0.20$ average time in crime is 5 years

$m = 0.10$ juveniles susceptible about 10 years

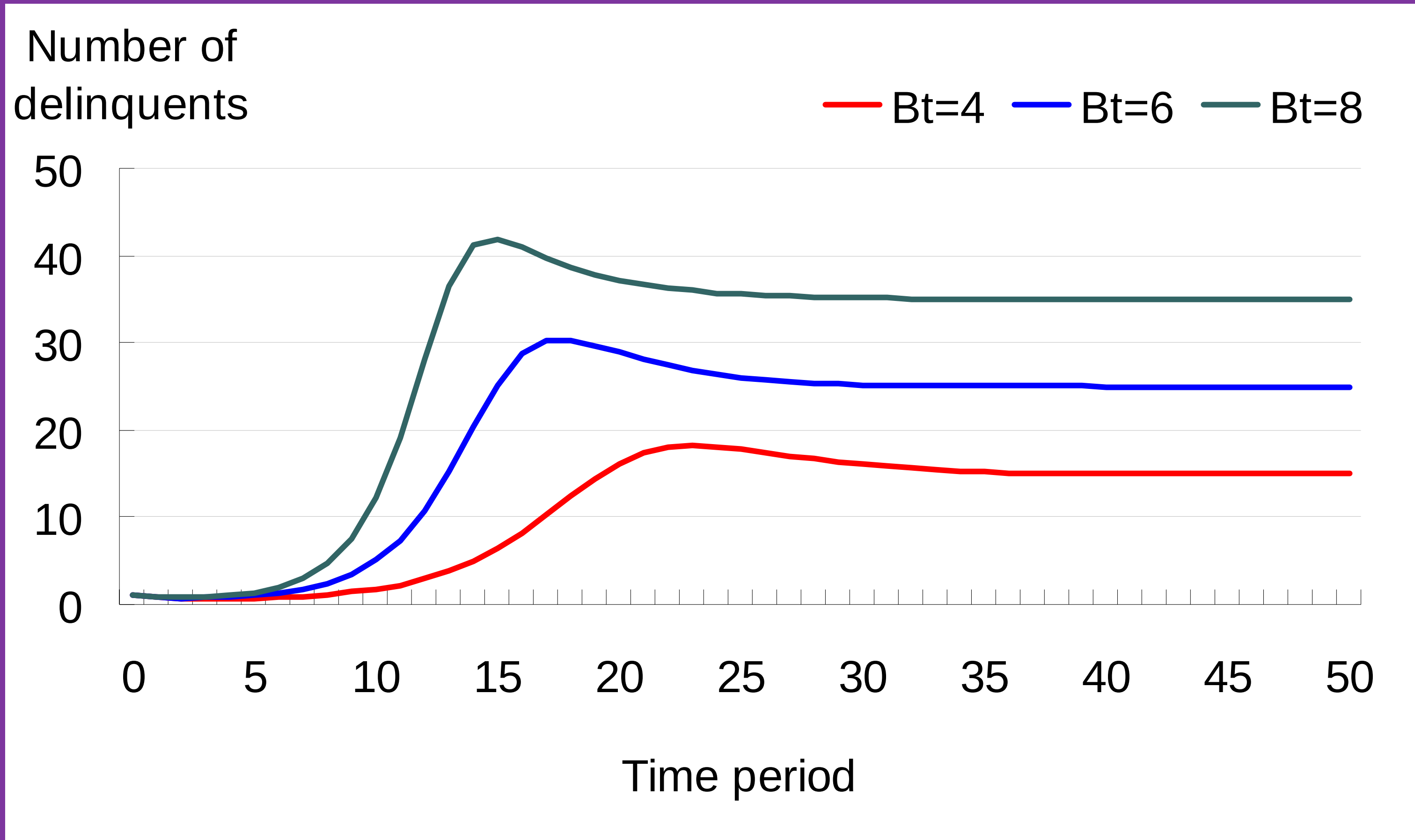
$k = 0.02$ arbitrary choice

Note the threshold value is $S_t > q/k = 10$.

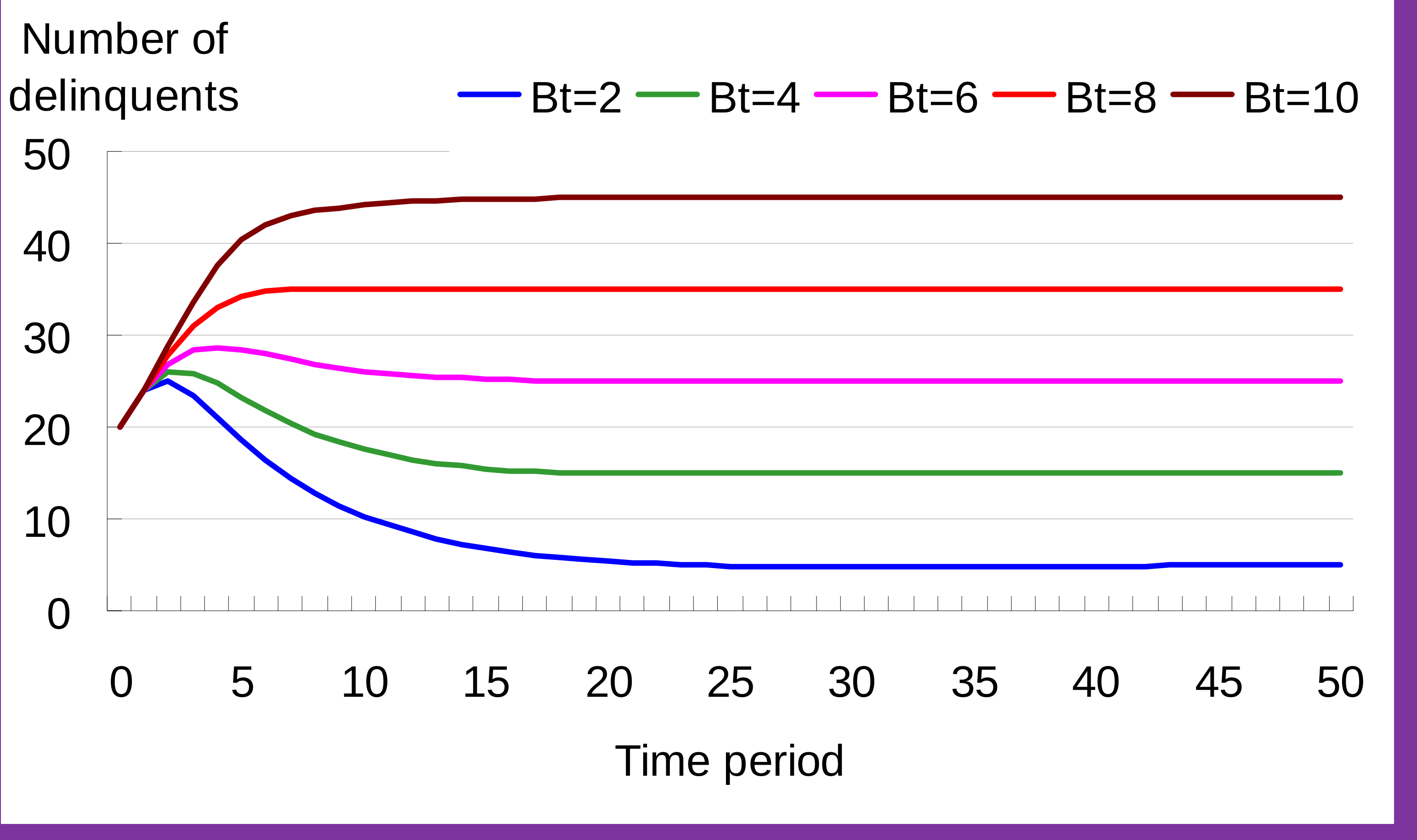
Start with ONE delinquent and NO susceptibles – add 6 new susceptibles each time period



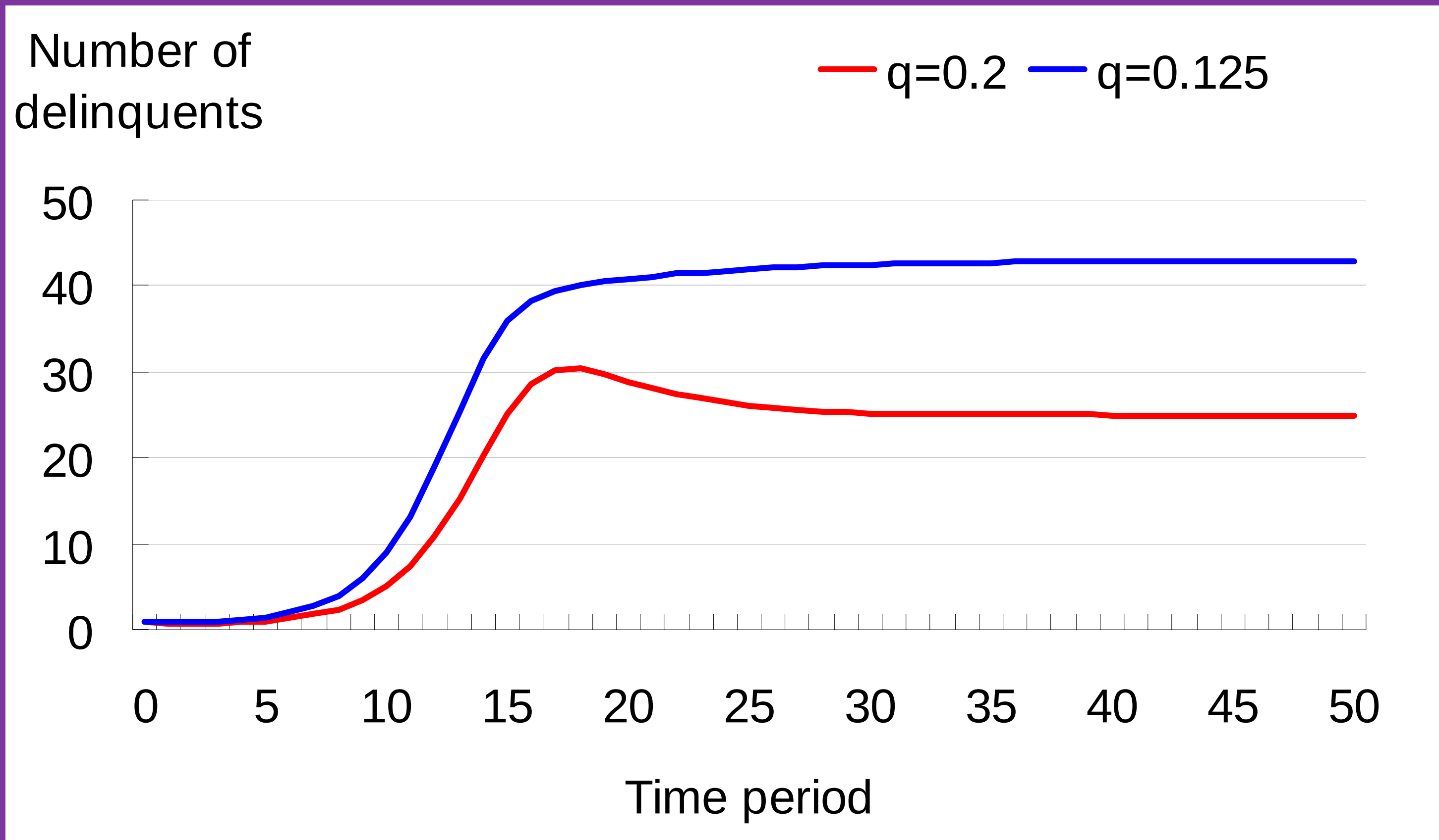
Different numbers of new susceptibles – $D_0 = 1,\ S_0 = 0$



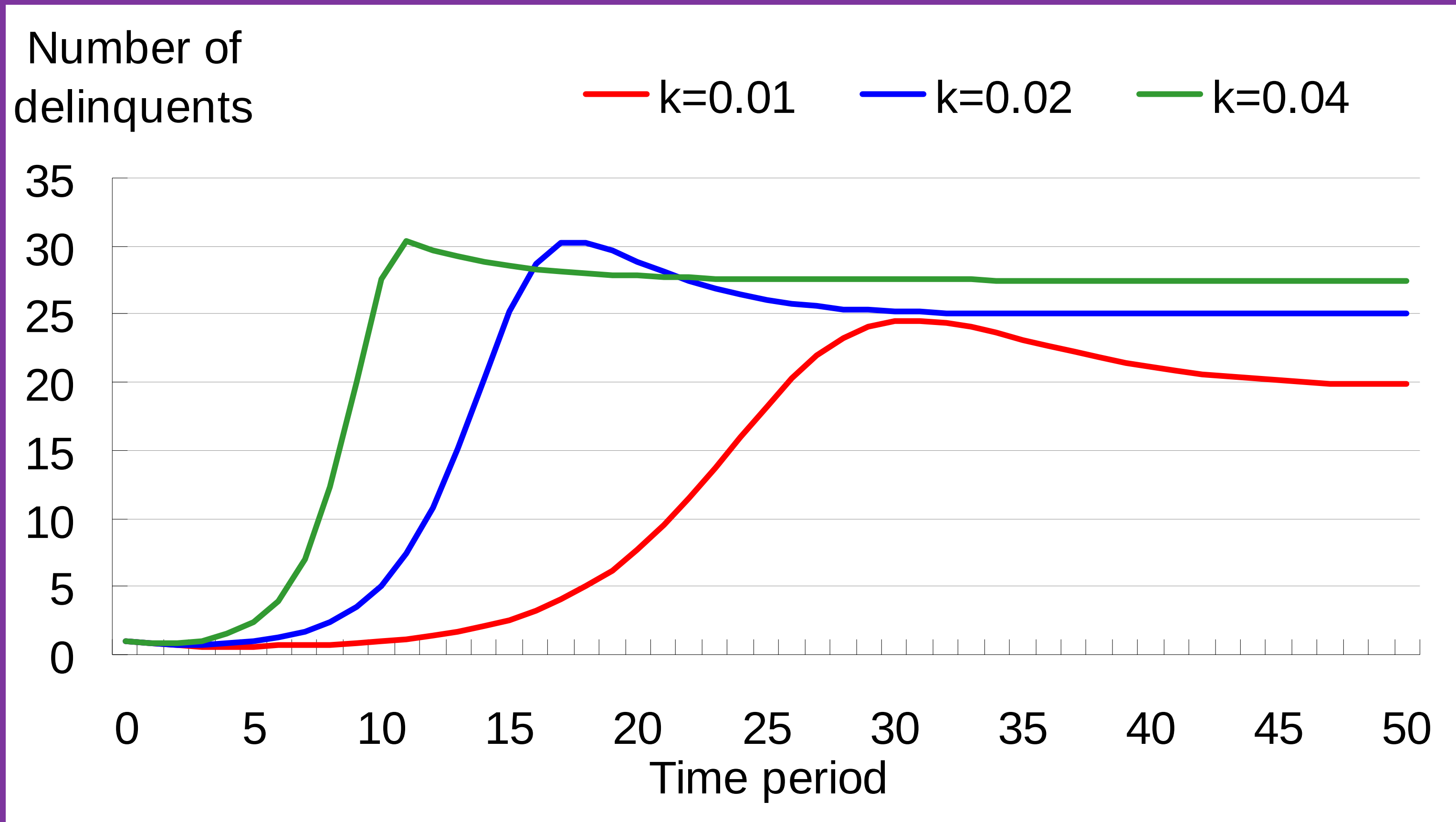
Different numbers of new susceptibles – $D_0 = 20, \; S_0 = 20$



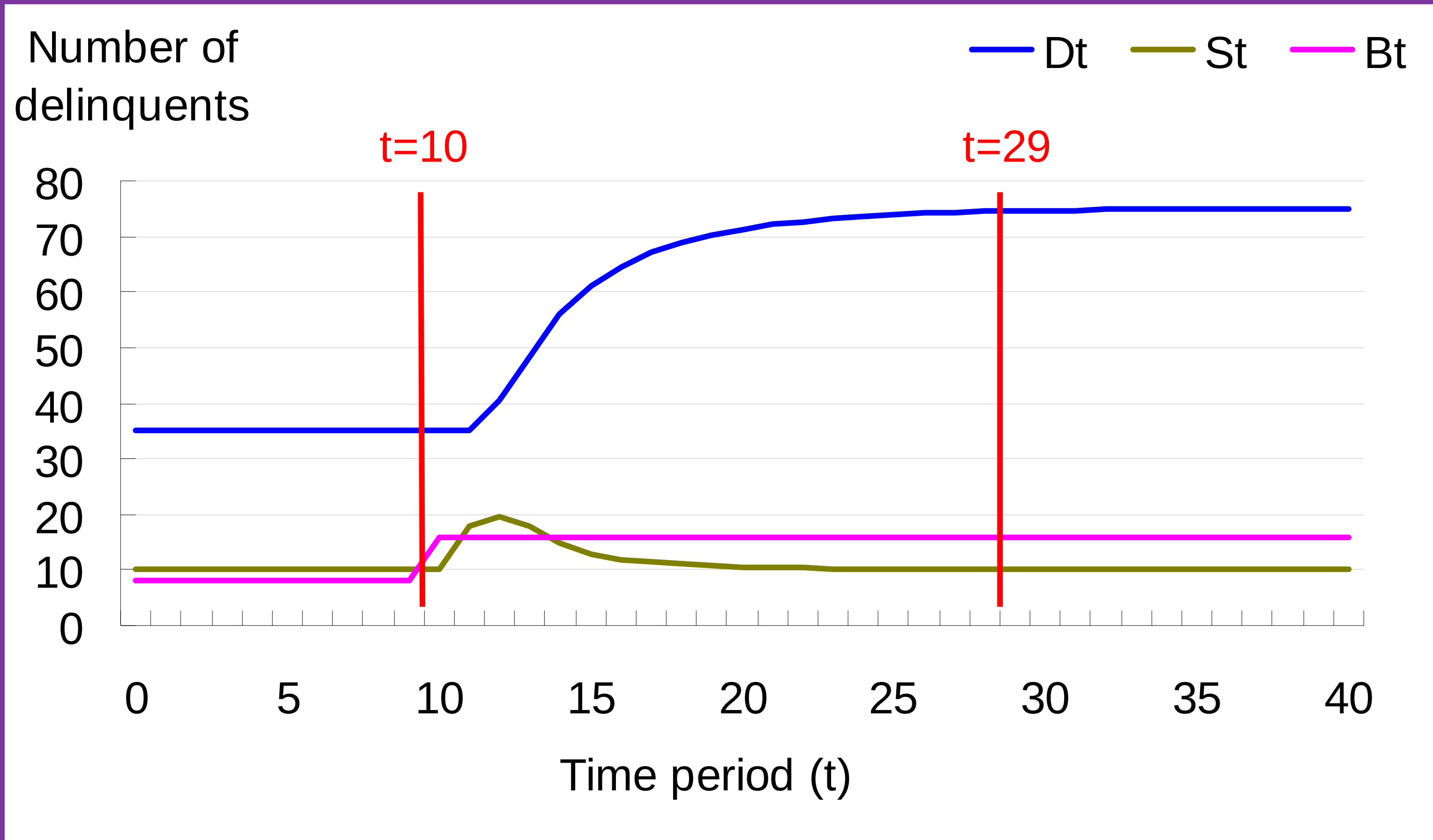
Criminal careers of different lengths: 5 years (q = 0.2) and 8 years (q = 0.125)



Different values for the contact parameter



Start with a stable community (D_0=35, S_0=10) then double B_t from 8 to 16 at time t =10



Summary of features (1)

- Offender populations do not grow until the number of susceptibles exceeds a threshold value (important for policy).
- Once they start to grow offender populations can increase very rapidly – consistent with observed ‘tipping points’ – abrupt increases or decreases in crime.
- There is both a more rapid rise and a higher stabilisation level of offenders in response to a higher number of new susceptibles.

Summary of features (2)

- Offender populations don’t always grow in response to changes in the numbers of new susceptibles i.e. changes in the economic and social conditions.
- It can take a considerable time for the effects of increased social disadvantage to take full effect.
- The population can peak at a higher level than the stable population level – consistent with the inconclusive times series evidence.

Limitations

- Difficult to test – need longitudinal studies of communities from which to estimate parameters.
- Not a general model of crime – takes no account of frequency of offending.
- Needs at least one delinquent to start the process.
- It models ‘persisters’ not ‘desisters’.
- Offenders are not generated in any other way –not realistic.
- The model behaves erratically with some parameter values.

Potential further development

- Caulkins' drug user model – positive effect of light users, negative effect of heavy users
- Stochastic approach
- Innovators and imitators (model of consumers)
  - innovators unaffected by social contagion
  - imitators driven only by social contagion
  - prob'y of purchase depends on no. previous buyers