Simulation of Experimentation in Networks

Undergraduate Research Week

Shiyu Ma 23'
Math/Econ+Statistics
Mentored by Professor Moritz Meyer-ter-Vehn

How Innovations Diffuse?

- Innovations: key drivers of long-term economic growth
- Two ways of gathering information:
  - individual experimentation vs. social learning
- Individual only: time-consuming, slow development
- Social only: crowds out new information generation

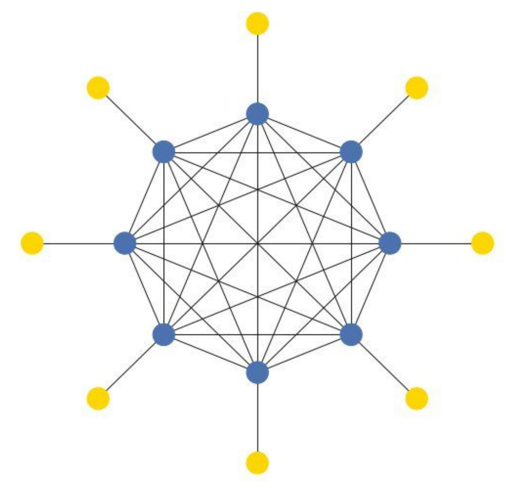
- **Hope to find the best social network density for innovation diffusion!**

Information Diffusion in Social Network:

- When social learning crowds out individual experimentation under different network density?
- Learning curve of individuals vs. network density
- Social welfare vs. network density
- Interpret Theory vs. Simulation

Model Setting

- Individuals can know their own and their neighbors' success
- Core-Periphery Network: K=core, L=periphery
- Define τ = individual's cutoff time to stop own experiment
  - optimal τ achieves equilibrium in individual's cost-benefit function
- If τ + 0.01, the effect on the cost-benefit function:
  - \+ expected benefit of a potential private success
  - – expected benefit of future social learning
  - – marginal effort cost **c**



Solving Cutoff Time across Network Density

- x=benefit of private success, discounted at rate r=2
- y=future benefit of success=(x-c)/r=1
- c=cost of private experiment=1
- I=number of individuals in network=1000
- K=number of individuals in core

- Indifference condition for core agents k

$$\psi_{k,\tau_k} = P^{\emptyset}(I\tau_k)\left(x + y\left(1 - \left(1 - e^{-(r+L)(\tau_\ell-\tau_k)}\right)\frac{L}{r+L}\right)\right) - c \le 0$$

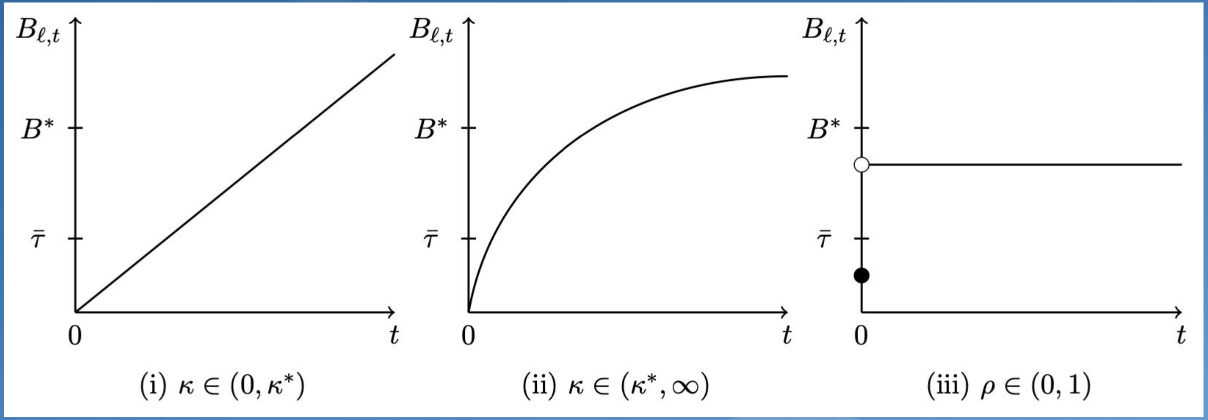
- Indifference condition for peripheral agents ℓ

$$\psi_{\ell,\tau_\ell} := P^{\emptyset}\left(B_{\tau_\ell} + \tau_\ell\right)\left(x + ry\int_{\tau_\ell}^{\infty} e^{-r(t-\tau_\ell)-(B_t-B_{\tau_\ell})}dt\right) - c = 0.$$

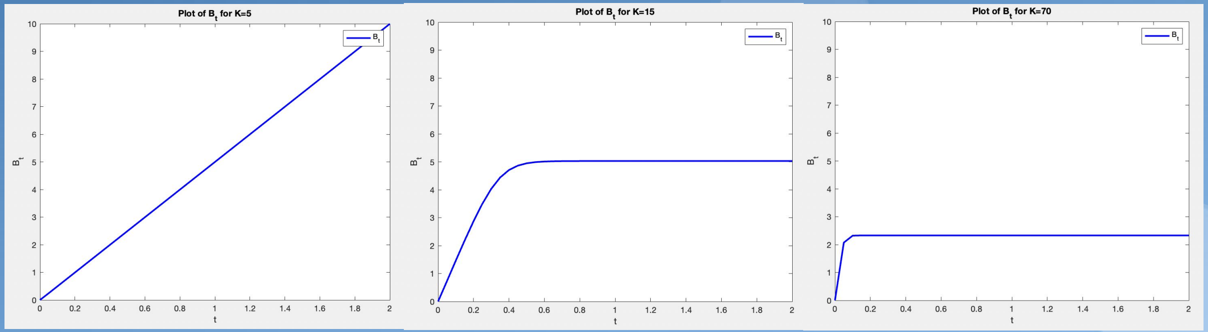
K	1	2	5	10	15	20	25	30	40	70	100
τ_k	0	0	0	0	0.00001	0.00002	0.00003	0.00004	0.00006	0.00010	0.00014
τ_l	0.20323	0.09393	0.02653	0.00885	0.00511	0.00404	0.00356	0.00328	0.00295	0.00250	0.00228

Learning Curve of Peripherials vs. Network Density

- As K increases:
  - No crowding out
  - Crowding out after a while
  - Crowding out immediately
- Core stops even earlier
- Total information generated in society drops as density rises

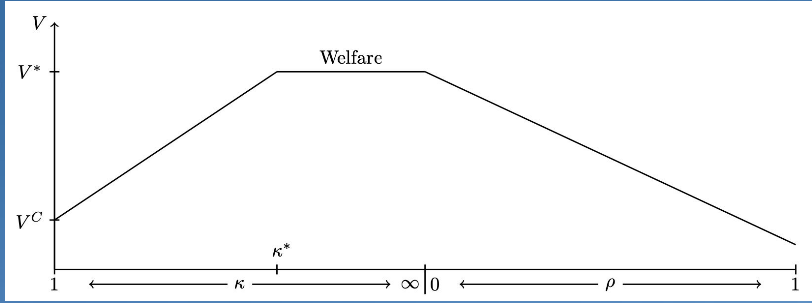


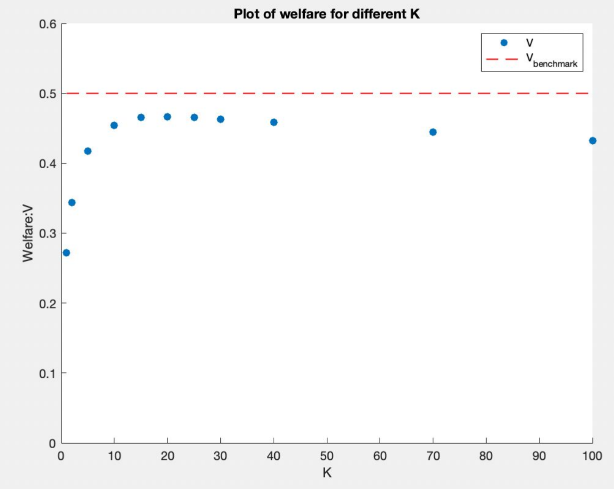
(i) $\kappa \in (0, \kappa^*)$ (ii) $\kappa \in (\kappa^*, \infty)$ (iii) $\rho \in (0, 1)$



Social Welfare vs. Network Density

- Theorem:
  - Welfare V is a single-peaked function of network density. It strictly rises, attains the benchmark V* and then strictly falls
- Simulation:
  - V rises as K<20
  - V approaches V* as K=20
  - V drops as K>20
- Optimal Density: K=20 (for I=1000)





Next Step

- Compare results of different parameters, aligned with real-life settings
  - I increases: larger network
  - p_o decreases: worse prior for success
- Expand simulation to other network formations
  - Random network
  - Trees

Thank you