The Effects of Social Networks on Employment and Inequality

Calvo-Armengol & Jackson (2004)

Unchitta Kanjanasaratool
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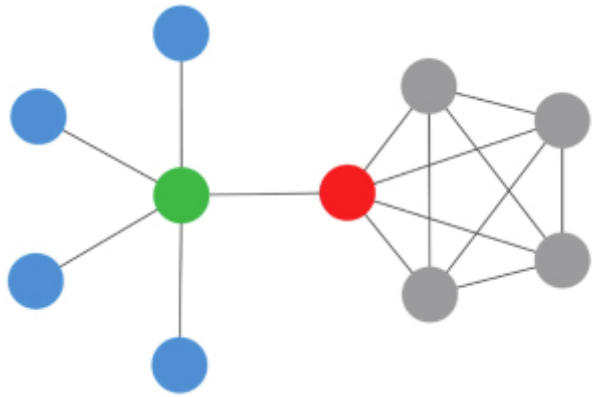
Dept. of Computational and Data Sciences, George Mason University
ukanjana@gmu.edu | @unchitta_kan

Why networked models of labor/employment?

- ⇢ Granovetter (1973, 1995); Rees (1966)
- ⇢ People hear about job opportunities through social contacts
- ⇢ Understanding the network and contagion effects can inform policies to increase employment and reduce social inequality



(Image courtesy of networkofthrones.wordpress.com)

Calvo & Jackson's Model

- Simplified version of Calvo-Armengol and Jackson (2003)
- n agents in the network g with some connections
- $g_{ij} = g_{ji} = 1$ if i and j are connected (agents are either connected or not throughout the simulations)
- Discrete time periods indexed by t
- s_t : employment status of agents at time t ($s_{it} = 1 \implies$ agent i is employed during period t

Calvo & Jackson's Model

- In each period, information about a job opening arrives and each agent independently hears about it with probability a
  - If an agent hears about a job and is unemployed, the agent takes the job
  - Otherwise, the agent passes on the information to one of its unemployed connections
    - So, information only flows between agents who know each other
- At the end of each period, an agent can (independently) lose their job with probability b, the breakup rate

Calvo & Jackson's Model

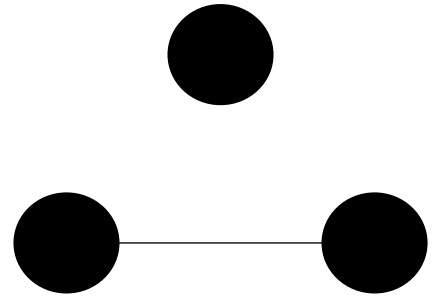
⇢ The probability that agent i learns about a job opportunity and agent j ends up with the job is given by

$$p_{ij}(\mathbf{s}) = \begin{cases} a & \text{if } s_i = 0 \text{ and } i = j, \\ \dfrac{a}{\sum_{k:s_k=0} g_{ik}} & \text{if } s_i = 1,\ s_j = 0, \text{ and } g_{ij} = 1; \text{ and} \\ 0 & \text{otherwise,} \end{cases}$$

where $\boldsymbol{s}$ is the employment vector at the beginning of the period.

⇢ We say that agents i and j are *path-connected* under the network g if there exists a sequence of links that form a path between i and j

Analytical results for very simple networks

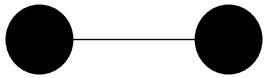


This stochastic process can be viewed as a finite state Markov chain (with states being the aggregate employment status of the network) whose steady-state distribution can be solved analytically.

Let $\mu_{isolated}$ be the long-run steady-state probability that the agent is employed:

$$\mu_{isolated} = (1-b)(\mu + a(1-\mu))$$

$$\mu_{isolated,limit} \approx \frac{a}{a+b}$$



Let μ_{dyad} be the long-run steady-state probability that either agent is employed in the limit as the time between period goes to 0:

$$\mu_{dyad,limit} \approx \frac{a}{a+b-\frac{ba}{2a+b}}$$

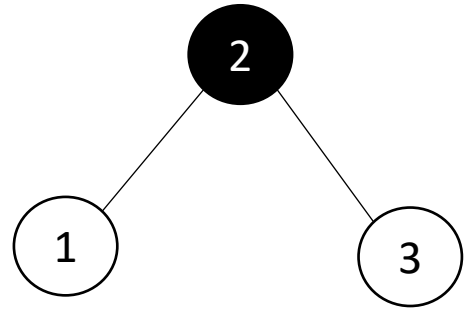
$$\mu_{dyad} > \mu_{isolated,limit}$$

Computer simulations were employed for more complicated networks as analytical results become intractable.

Job Competition

V.S.

Positive Employment Correlation



In the *short run*, you and the friends of your friends compete for job information.

In the *long run*, friends of your friends can help you obtain jobs. (E.g. they help your friends obtain job, which in turn increase your likelihood of hearing about a job.)

Employment Correlation & Network Structure $(n = 4, a = 0.100, b = 0.015)$

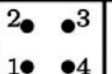
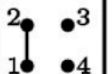
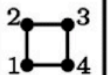
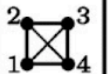
g	$\text{Prob}(s_1 = 0)$	$\text{Corr}(s_1, s_2)$	$\text{Corr}(s_1, s_3)$
	0.132	–	–
	0.083	0.041	–
	0.063	0.025	0.019
	0.050	0.025	0.025

Figure 2 from Calvo-Armengol and Jackson (2004)

1. Probability of being unemployed decreases as the number of connections an agent has increases, though with a decreasing marginal impact
2. Positive correlation of employment between agent in the long run even though agents are in competition for information

Employment Correlation & Network Structure $(n = 8, a = 0.100, b = 0.015)$

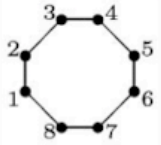
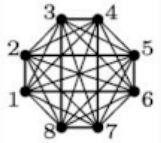
g	$\text{Prob}(s_1 = 0)$	$\text{Corr}(s_1, s_2)$	$\text{Corr}(s_1, s_3)$	$\text{Corr}(s_1, s_4)$	$\text{Corr}(s_1, s_5)$
	0.060	0.023	0.003	0.001	–
	0.030	0.014	0.014	0.014	0.014

Figure 3 from Calvo-Armengol and Jackson (2004)

1. Probability of unemployment decreases as the number of connections increases
2. Employment correlation decreases with geodesic distance

Your Position in the Network Matters for Your Employment:

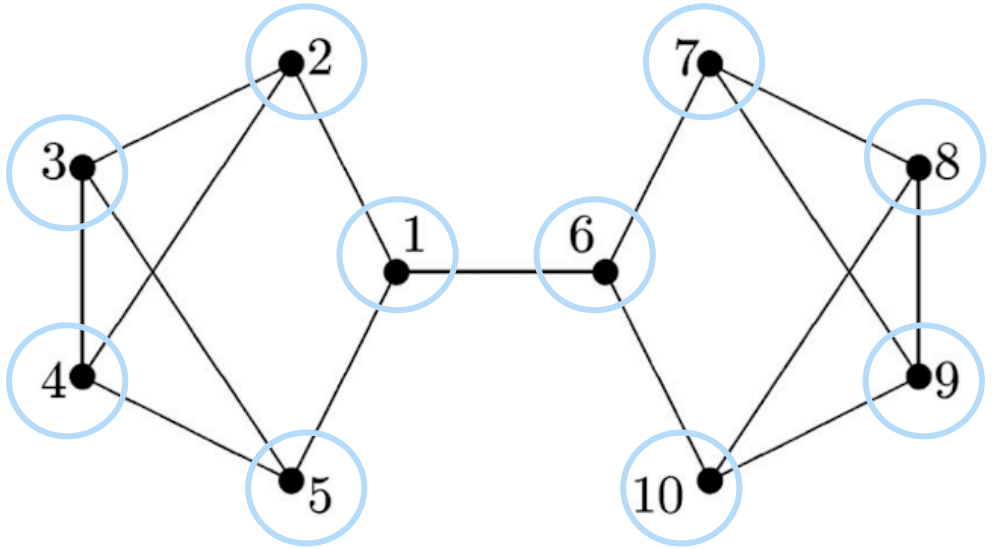


Figure 4 from Calvo-Armengol and Jackson (2004), also referred to as the "bridge network."

- 1 and 6 have the lowest steady-state unemployment probabilities (4.7%)
- 2, 5, 7, 10 have a steady-state unemployment probability of 4.8%
- 5% (highest) for the rest (3, 4, 8, 9)
  - Less diversified connections (in terms of average geodesic distance between two agents who are directly connected to these agents)

1 and 6 are known as the "bridges" in the social network literature.

Structure Also Matters:

Densely knit network →

Closely knit network →

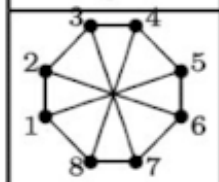
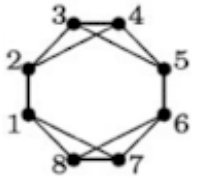
g	average path length	average unemployment
	1.571	0.048
	1.786	0.049

Figure 5 from Calvo-Armengol and Jackson (2004)

Duration Dependence

Q: If an agent has been unemployed for at least the last X periods, how likely is it for them to be employed at the end of this period?

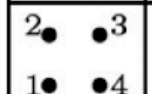
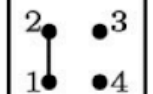
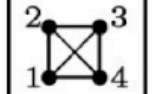
g	1 period	2 periods	10 periods	limit
	0.099	0.099	0.099	0.099
	0.176	0.175	0.170	0.099
	0.305	0.300	0.278	0.099

Figure 6 from Calvo-Armengol and Jackson (2004)

Proposition: *Under fine enough subdivisions of periods and starting under the steady-state distribution, the conditional probability that an individual will become employed in a given period is decreasing with the length of their observed (individual) unemployment spell.*

Duration Dependence

- Having many connections increase the employment likelihood significantly (consistent with our experience in real life, e.g. stigma even though it is not observable by the model).
  - Understanding this characteristic of the model helps explain the duration dependence that we observe in real life.
- The longer an agent has been unemployed, the higher the expectation their path connections are also unemployed. So, they will take the job themselves if they hear of one instead of passing on to the agent.
  - Social and policy implications
- Calvo & Jackson found that agents may have different reemployment likelihoods depending on the current state of their connections

Persistence in Aggregate Employment (Stickiness in the Dynamics)

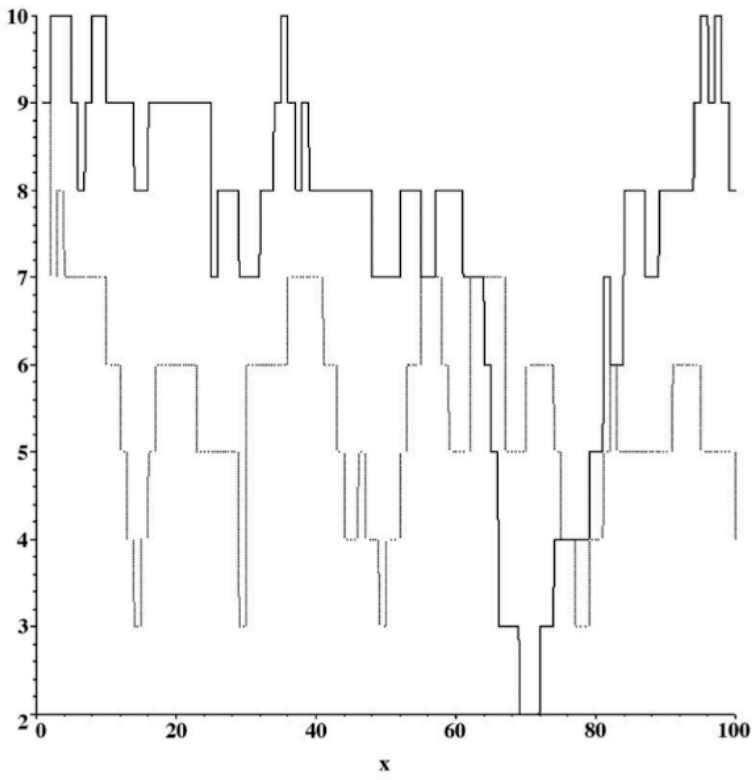
TABLE 1—PROBABILITY OF FINDING EMPLOYMENT FOR AGENTS IN THE BRIDGE NETWORK

Number of employed	0	1	2	3	4	5	6	7	8	9
$a = 0.100; b = 0.015$	10.0	10.4	12.0	14.5	17.9	20.7	25.4	25.7	28.7	34.4
$a = 0.050; b = 0.050$	5.0	5.9	6.2	6.9	8.6	9.3	11.3	12.2	15.0	18.5

Table 1 from Calvo-Armengol and Jackson (2004). The probabilities shown here are averaged and conditional on the number of employed agent in the network

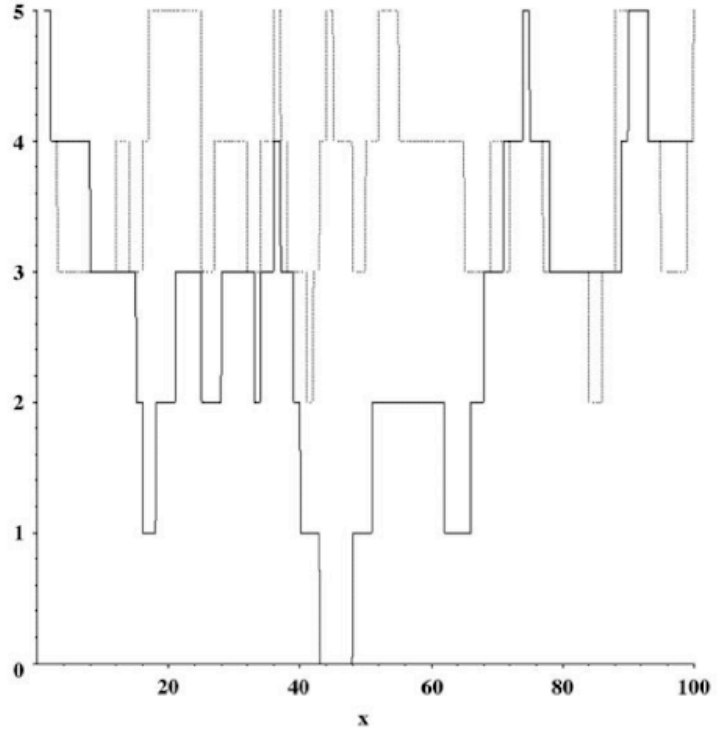
1. The more agents are employed, the more likely it is for an unemployed agent to find job.
2. This leads to a *"boom and bust"* effect, i.e. the closer the network gets to full employment, the stronger the attraction to that end. (Vice versa for unemployment).

Persistence in Aggregate Employment (Stickiness in the Dynamics)



Aggregate employment over time for a=0.050 and b=0.050

Figure 7 (bottom) from Calvo-Armengol and Jackson (2004). Time series of employment for networked (bridge network) versus disconnected agents.



Aggregate employment of agents 1 to 5 versus agents 6 to 10 over time for a=0.050 and b=0.050

Figure 8 (bottom) from Calvo-Armengol and Jackson (2004). Time series of employment for agents 1-5 in the bridge network (dotted line) and agents 6-10 (plain line).

Summary

- Calvo-Armengol and Jackson proposed a simple networked model of employment (2004) where agents hear about job opportunities and either take them or pass on the information to other unemployed connections
- Social connections increase the likelihood of an agent obtaining a job
- Positive employment correlation between path-connected agents
- The position in the network as well as structure of the network matters
- Duration dependence
- Persistence in employment: *(local)* boom and bust effects

References

- Calvo-Armengol, A., & Jackson, M. O. (2004). The effects of social networks on employment and inequality. American economic review, 94(3), 426-454.
- Jackson, M. O. (2008). Social and economic networks. Princeton university press.

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ukanjana@gmu.edu | @unchitta_kan