The Diffusion of Microfinance

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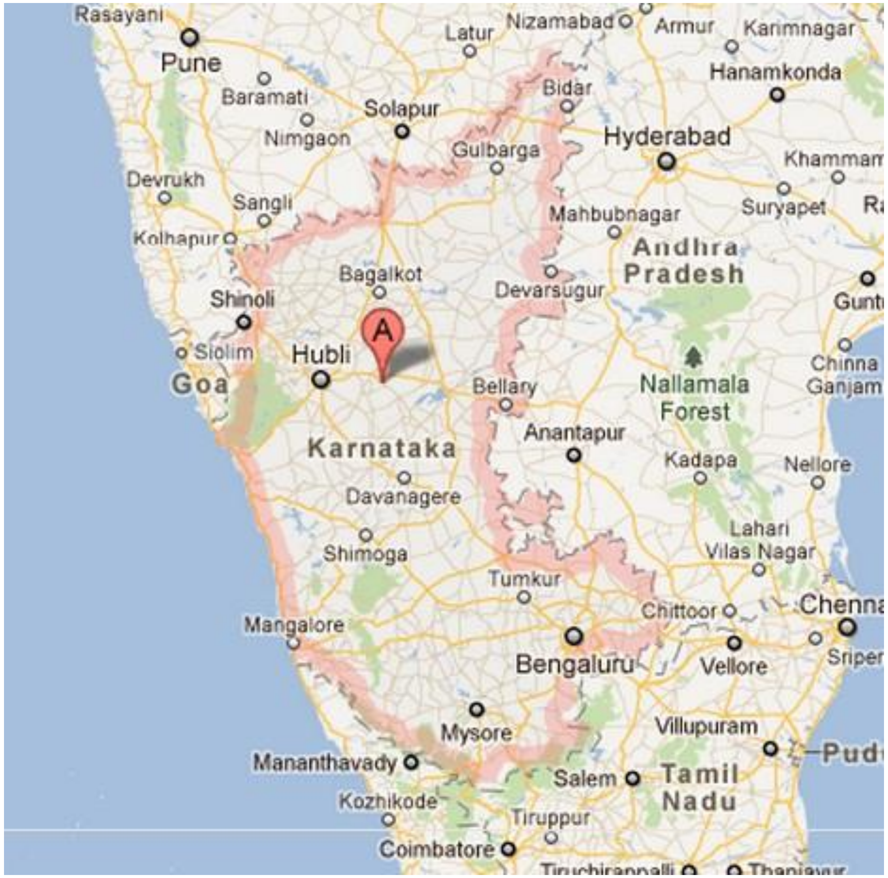
Purpose of the Paper

This paper…

- tries to find ***the role of injection points*** in the diffusion of information through the social network
- is to see ***how characteristics of the social networks***, as a whole, affect the diffusions
- studies some other characteristics of information transmission on networks

Background

Participation in a program of Bharatha Swamukti Samsthe (BBS) in rural southern Karnataka.



Background (continued)

- BSS operates a conventional ***group-based microcredit*** program: borrowers form groups of 5 women who are ***jointly liable*** for their loans
- The starting loan is approximately 10,000 ruppees (1 roupee = 2 cents, Feb 10th, 2012) and is reimbursed in 50 weekly installments with the annual interest rate of 28% (such a bad option, I think)

Background (continued)

- BBS first holds a private meeting with the ***leaders (injection points of the network)***
- At the meeting, credit officers explain the program, and then ask them
  1) to help organize a meeting to present the program to the village
  2) to ***spread the word*** about the program among their friends

Background (continued)

- After the meeting, interested eligible people, ***(women between 18 and 57 years)*** contact BSS, are trained and formed into groups, and credit disbursements starts

Data

- Six months ***prior to BSS's entry***, they conducted a baseline survey in all 75 villages
- This survey consists of a ***village questionnaire*** and a detailed follow-up ***individual survey*** of a ***subsample*** of individuals
- Information about social connections is collected from the individual survey

Data (continued)

- The individual surveys included a module which gathers ***social network data on thirteen dimensions***. For instance, which friends are relatives visits one's home, with whom the individual goes to pray (temple, church, or mosque), from whom the individual would borrow money, etc

Data (continued)

- They are proud of their rich dataset in that

  1) networks of full villages of individuals

  2) more than ten types of relationships

  3) in a developing country context

- This data set is available from their webpage

Data (continued)

- The social economic network is defined from the survey
- We consider the individual or the household as the unit of analysis: microfinance membership is limited to one per household
- We are interested in communication, so A and B are connected if A or B points out the other as a friend in any dimension
- Table 1 summarizes descriptive statistics

Data (continued)

- A important network characteristics is ***Eigenvector centrality***.
- For a given graph G=< V, E >, let A=($a_{v,t}$)be the adjacency matrix. Then ***the eigenvalue centrality score of vertex v*** is defined by

$$x_v = \frac{1}{\lambda} \sum_{t \in N(v)} x_t = \frac{1}{\lambda} \sum_{t \in G} a_{v,t} a_t$$

where λ *is the* ***greatest eigen value***.

Data (continued)

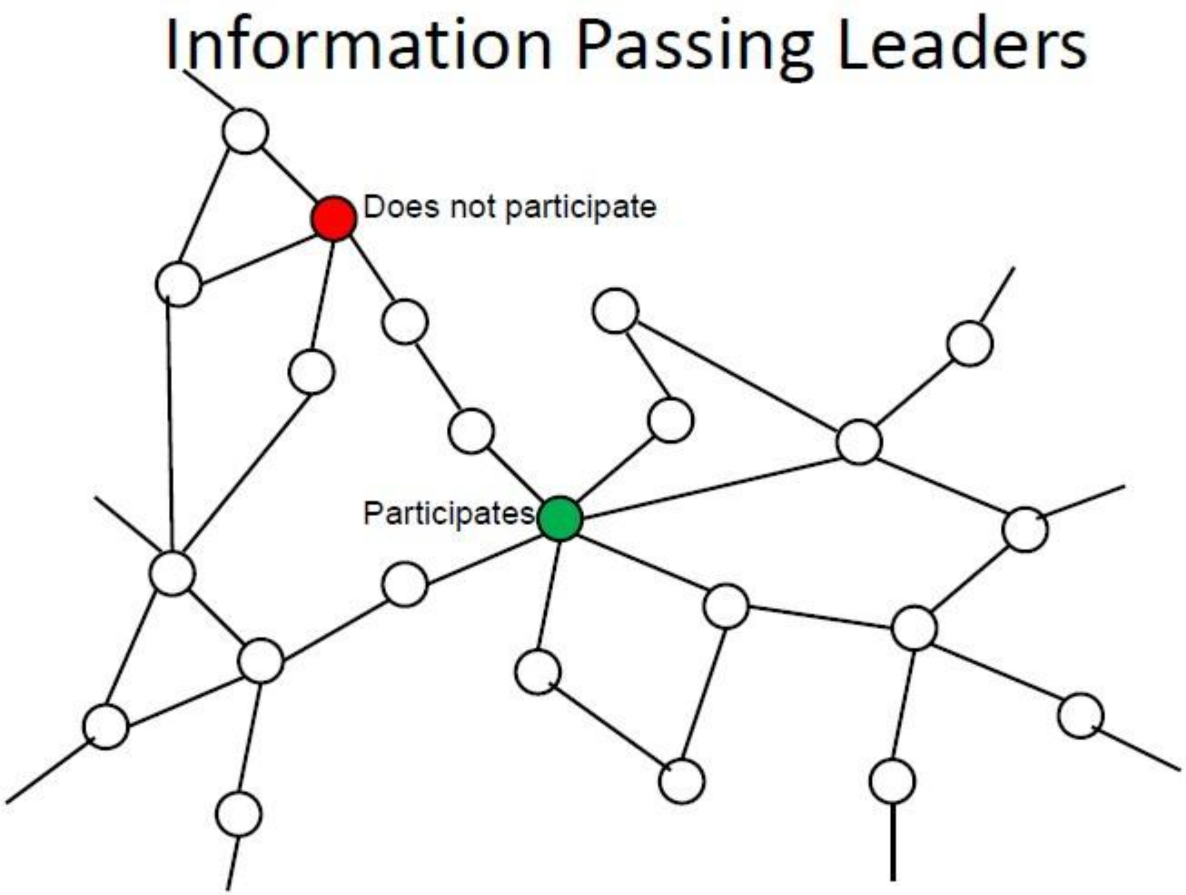
- The eigenvalue centrality is ***proportional to the sum of its neighbors' centrality***
- Leaders and non-leader households have ***comparable degrees***, leaders are more important in the sense of eigenvalue centrality That is, their average is ***0.07*** (0.018), as opposed to ***0.05*** (0.009) for the village as a whole

The Diffusion Model

- There are two primary categories on diffusion models
- Pure contagion models: the deriving force of diffusion is a mechanical transmission
- Endorsement effects models: There are interactive effects between individuals so their decision may depends on their neighbors

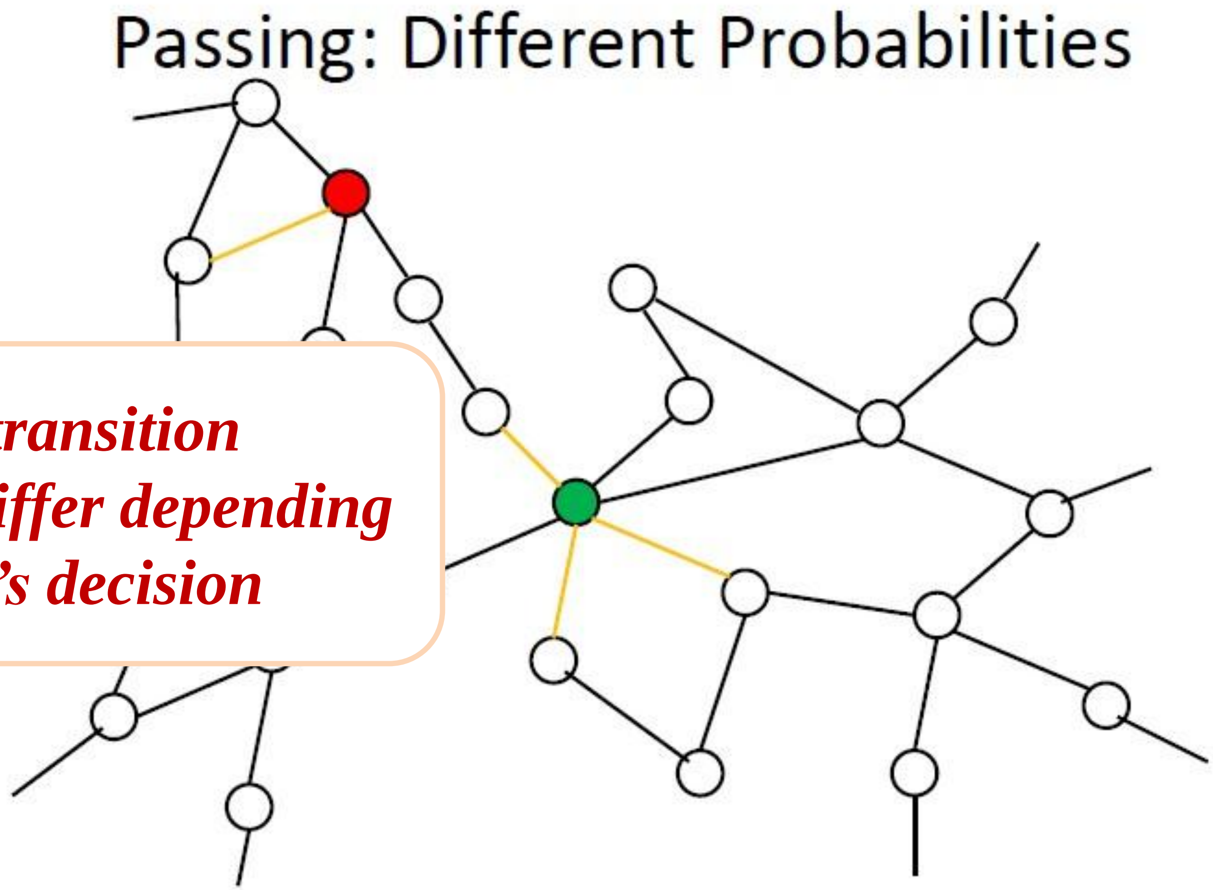
The Diffusion Model

STEP 0)



The Diffusion Model

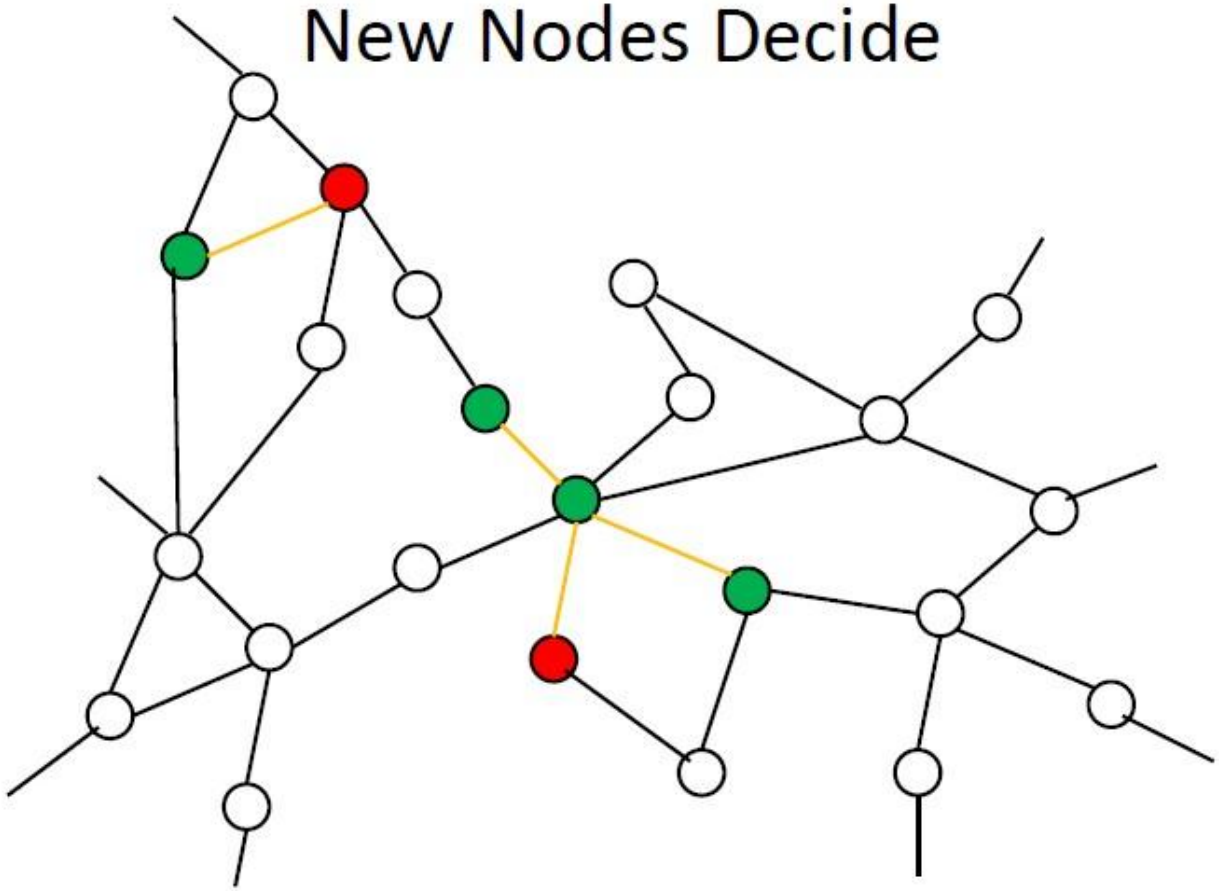
STEP 1)



The information transition probability may differ depending on the household's decision

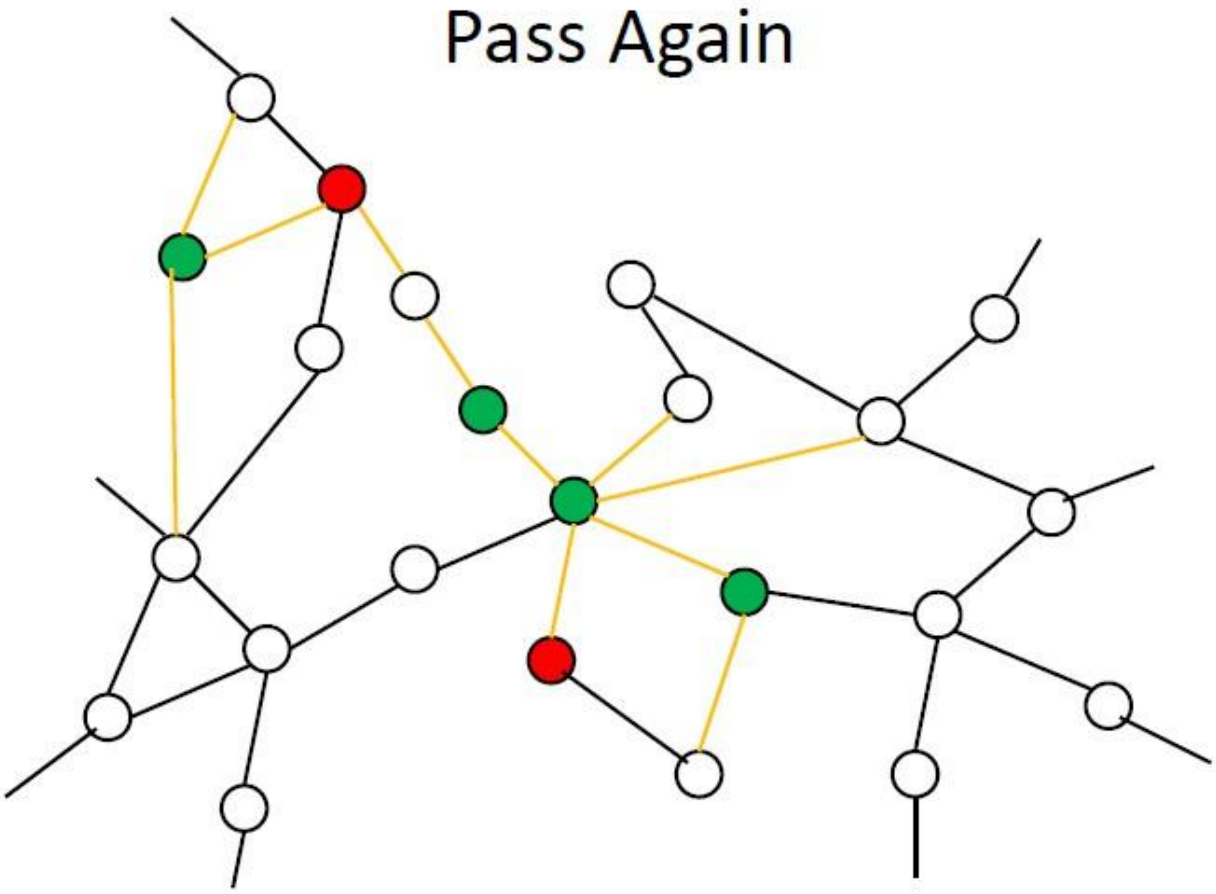
The Diffusion Model

STEP 2)



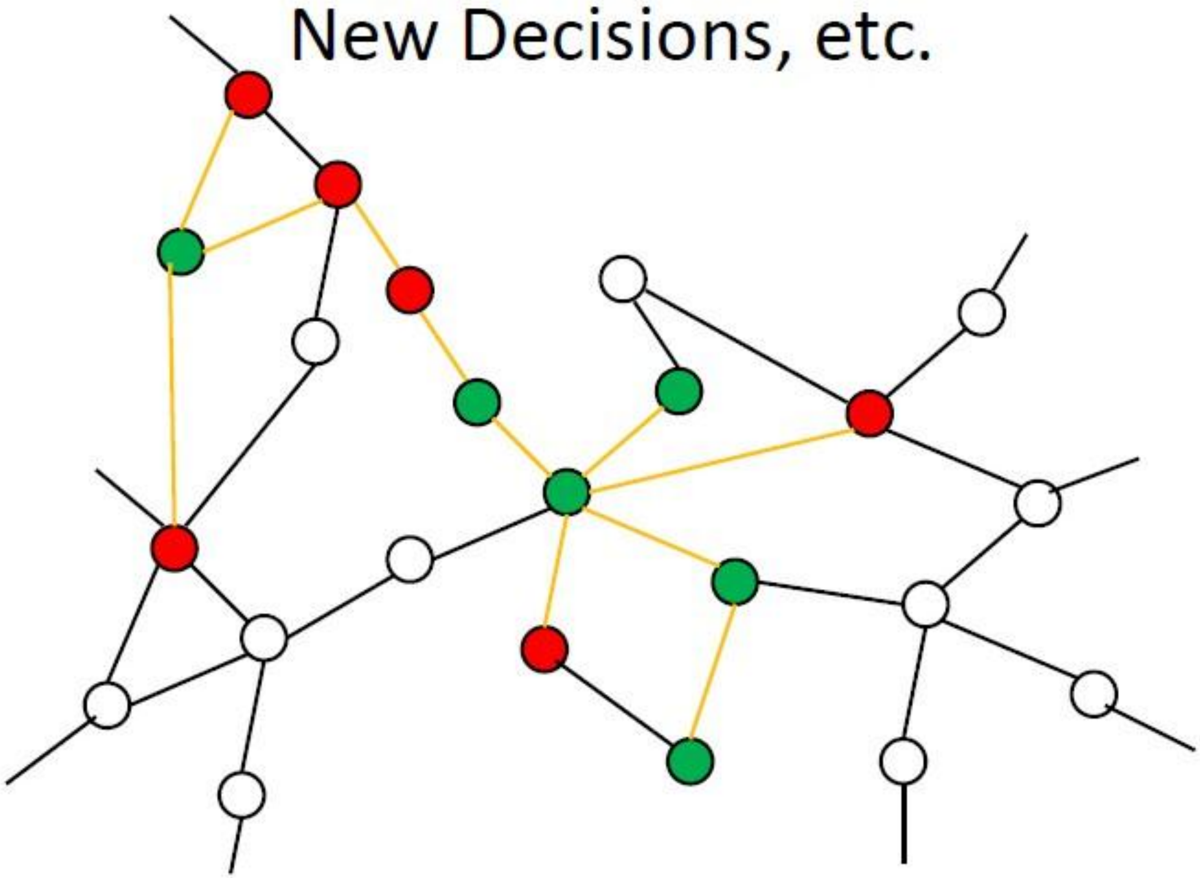
The Diffusion Model

STEP 3)



The Diffusion Model

STEP 4)



The Models

- The baseline model:
$$\Pr[\text{participation} | X_i] = \Lambda(\alpha + X_i\beta)$$

- The enriched model:
$$\Pr[\text{participation} | X_i] = \Lambda(\alpha + X_i\beta + \kappa F_i)$$
where F_i (a fraction of the participation of i's neighbors) captures ***endorsement effects***.

The Models

- Let q^N be the probability that an informed agent informs a given neighbor about the microfinance, conditional on the informed agent choosing not to participate
- Let q^P be the probability that an informed agent informs a given neighbor about the microfinance, conditional on the informed agent choosing to participate

The Models

- Information Model:

$$< q^N, q^P, p_i(\alpha, \beta) >$$

- Information Model with Endorsement Effects:

$$< q^N, q^P, p_i^E(\alpha, \beta, \kappa) >$$

Purpose of the Paper (again)

Recall that this paper

- tries to find ***the role of injection points*** in the diffusion of information through the social network
- is to see ***if characteristics of the social networks***, as a whole, affect the diffusions
- studies some other characteristics of information transmission on networks

Do Injection Points Matter?

- Related Literature

  Katz and Lazarsfeld (1955), Rogers and Rogers (2003), Valente and Davis (1999), Ballester et al. (2006), Feick and Price (1987), and Aral and Walker (Forthcoming).

Do Injection Points Matter? (continued)

- Leaders are selected when they are saving self-help group leaders, pre-school teachers, and shop owners.
- These individuals are ***fixed***, and does not vary from village to village.
- They are injected without any knowledge of their village's network characteristics.

Do Injection Points Matter? (continued)

- Table 2:
  Centrality is ***not correlated*** with other village variables

	Dependent Variable: Eigenvector Centrality of Leaders			
	(1)	(2)	(3)	(4)
Age	0.000353	0.000225		-0.000304
	(0.00118)	(0.00124)		(0.00148)
Education	0.00126	0.00205		0.00400
	(0.00328)	(0.00299)		(0.00386)
Fraction GM	-0.0149**	-0.0138*		-0.0128
	(0.00699)	(0.00717)		(0.00943)
Savings		0.0268		0.0215
		(0.0266)		(0.0409)
SHG Participation		0.0430		0.0414
		(0.0428)		(0.0418)
No. Beds			0.00737	0.00718
			(0.00816)	(0.0108)
Electricity			0.0176	0.0147
			(0.0220)	(0.0240)
Latrine			0.0120	0.0163
			(0.0143)	(0.0156)
Constant	0.0879*	0.0353	0.0117	-0.0110
	(0.0520)	(0.0761)	(0.0380)	(0.117)
Observations	43	43	43	43
R-squared	0.087	0.113	0.068	0.169

Do Injection Points Matter? (continued)

- For those reasons, the network characteristics of the leaders sets may be considered to be ***exogenous***: We know that they are the injection point and they are not selected with any network specific characteristics knowledge

- Hence we have a nice identification of the models

Do Injection Points Matter? (continued)

- Regression Model 1:

$$y_r = \beta_0 + \beta_1 \xi_r^L + W_r{}'\delta + \varepsilon_r$$

y_r: *the village level microfinance take-up*

ξ_r^L: *a vector of statistics for the leaders*

W_r: *a vector of village level controls*

Do Injection Points Matter? (continued)

- Regression Model 2:

$$y_r = \beta_0 + \beta_1 \xi_r^L + \beta_2 \xi_r^{LM} + W_r{}'\delta + \varepsilon_r$$

ξ_r^{LM}: *a vector of the set of leaders who became microfinance members.*

Do Injection Points Matter? (continued)

- Regression Model 3:

$$y_{rt} = \beta_0 + \beta_1 \xi_r^L \times t + (X_r \times t)'\delta$$
$$+\alpha_r + \alpha_t + \varepsilon_{rt}$$

y_{rt}: *the village level microfinance take-up at time t*

ξ_r^L: *the average degree/eigenvector centrality of the leaders*

X_r: *a vector of village level controls*

α_r: *village fixed effects*

α_t: *time fixed effects*

Results: Table 3

Table 3: Leaders/Injection points

	Take-up Rate	Take-up Rate	Take-up Rate	Take-up Rate	Take-up Rate	Take-up Rate
	(1)	(2)	(3)	(4)	(5)	(6)
Eigenvector Centrality of Leaders	1.634*		1.934**	1.843	1.254*	1.332*
	(0.904)		(0.967)	(1.101)	(0.735)	(0.782)
Number of Households	-0.000382	-0.000704***	-0.000270	-0.000273	-0.000305	-0.000299
	(0.000247)	(0.000188)	(0.000270)	(0.000280)	(0.000216)	(0.000226)
Degree of Leaders		-0.00111	-0.00324	-0.00237		
		(0.00231)	(0.00259)	(0.00276)		
Fraction of Taking Leaders					0.323***	0.317***
					(0.101)	(0.105)
Eigenvector Centrality of Taking Leaders					-0.175	-0.253
					(0.428)	(0.427)
Savings	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.0523
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(0.0854)
Fraction GM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-0.00792
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(0.0302)
Constant	0.150	0.362***	[illegible]	[illegible]	[illegible]	[illegible]
	(0.112)	(0.0573)	[illegible]	[illegible]	[illegible]	(0.186)
Observations	43	43	43	43	43	43
R-squared	0.293	0.235	[illegible]	[illegible]	[illegible]	0.502

Note: Dependent variable is the microfinance participation rate of non-leader households and report heteroskedastic robust standard errors.

Observation 1)
The eigenvalue centrality matters

Observation 2)
The average degree doesn't matter

Observation 3)
The eigenvalue centrality matters in the presence of the average degree

Observation 4)
Leaders are conduits of information regardless of their eventual participation

Observation 5)
Participation of the leaders does not matter in eventual take-up rate of the villages

Results: Table 4

	Take-Up Rate	Take-Up Rate
	(1)	(2)
Eigenvector Centrality of Leaders	0.3511***	0.3491**
	(0.128)	(0.1635)
Degree of Leaders	-0.00075	-0.00063
	(0.00082)	(0.00088)
Number of Households		-0.000016
		(0.00003)
Savings		0.0082
		(0.0109)
Fraction GM		0.0049
		(0.0031)
Observations	239	239
R-squared	0.943	0.944

Observation 6)

The eigenvalue centrality matters in each period

Do Network Structure Matter?

- Related Literature

  Jackson and Rogers (2007), Valente and Davis (1999), Pastor-Satorras and Vespignani (2000), Newman (200), Lopez-Pintado (2008), Jacson and Rogers (2007), Golub and Jackson (2009), and, most importantly, ***Shin (2012)***

Do Network Structure Matter? (continued)

- Regression Model 4:

$$y_r = W_r'\beta + X_r'\delta + \varepsilon_r$$

y_r: *the fraction of households joining the program*

W_r: *a vector of village-level network covariates*

X_r: *a vector of village-level demographic covariates*

Results: Table 5

- Observation 7: ***No network statistics is significant*** when we introduce them ***together***
- Observation 7': Some correlation is found when they are introduced individually. (However, there is a strong degree of correlation between them, so they cannot be examined independently)

Structural Estimation

- Consider ***the Information Model with Endorsement Effects*** that is denoted by $(q^N, q^P, p_i(\alpha, \beta, \kappa))$.
- We use ***the method of simulated moments (MSM).***
- There are two sets of moments that we work with.

Structural Estimation (continued, MSM)

- The set of moments:
  - Share of ***leaders*** who ***take up*** microfinance (for ***β***)
  - Share of ***household*** with ***no neighbors taking up*** who ***take up***
  - Share of ***households*** that ***are in the neighborhood*** of ***a taking leader*** who ***take up***.
  - Share of ***households*** that ***are in the neighborhood*** of ***a non-taking leader*** who ***take up***.

Structural Estimation (continued, MSM)

- The set of moments:
  - Covariance of the fraction of ***households taking up*** with the share of ***their neighbors who take up*** microfinance.
  - Covariance of the fraction of ***household taking up*** with the share of ***second-degree neighbors that take up*** microfinance.

Structural Estimation (continued, MSM)

- First estimate $\boldsymbol{\beta}$ using take-up decision among the set of leaders.
- To estimate $\boldsymbol{\theta} = (\boldsymbol{q}^N, \boldsymbol{q}^P, \boldsymbol{\kappa})$, discretize the parameter space, say $\boldsymbol{\Theta}$.
- For each $\boldsymbol{\theta}$, simulate the model 75 times, each time letting the diffusion process run for the number of periods from the data.
- For each simulation, the moments are clculated, and then take the average over the 75 runs.

Structural Estimation (continued, MSM)

- Denote the vector of average simulated moments by $m_{sim,r}$ for village r (and denote $m_{emp,r}$ for the empirical moments).

- With this, chose the set of parameters that minimize the criterion function, namely

$$\widehat{\theta} = \underset{\theta \in \Theta}{\operatorname{argmin}} \left(\frac{1}{R} \sum_{r=1}^{R} m_{sim,r}(\theta) - m_{emp,r} \right)' \left(\frac{1}{R} \sum_{r=1}^{R} m_{sim,r}(\theta) - m_{emp,r} \right)$$

Structural Estimation (continued)

- To estimate the distribution of $\hat{\boldsymbol{\theta}}$, we use a simple ***Bayesian bootstrap algorithm (BBA).***

- This exploits the independence across villages.

Structural Estimation (continued, BBA)

- For each grid, compute the divergence for the r-th village by calculating

$$d_r(\theta) \; = \; m_{sim,r}(\theta) \; - \; m_{emp,r}$$

- Bootstrap the criterion function by resampling from the set of 43 villages. For each bootstrap sample, estimate a weighted average

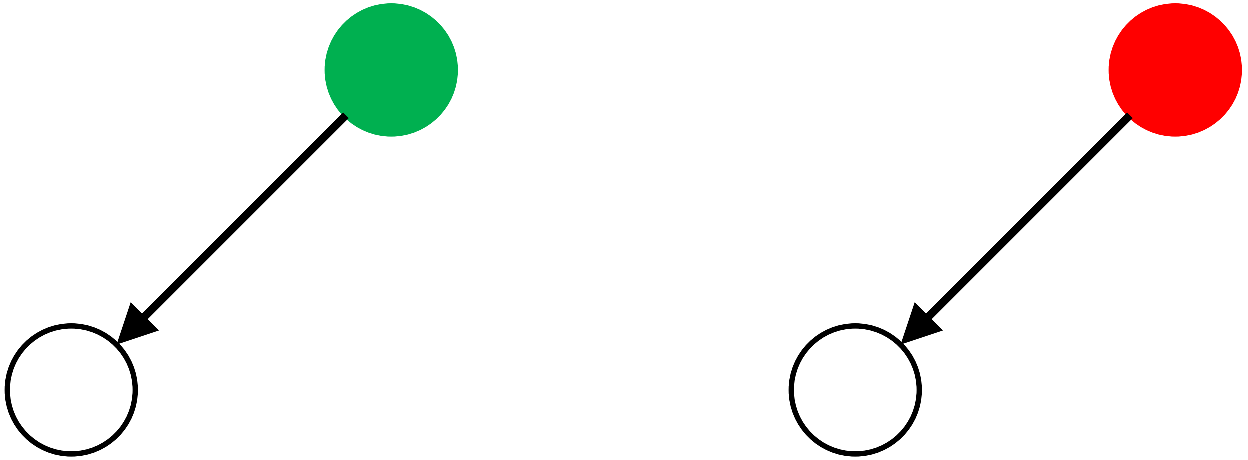
$$D_b(\theta) = \frac{1}{R}\sum_{r=1}^{R} \omega_r^b \cdot d_r(\theta)$$

- Then find

$$\widehat{\theta}^b = \mathrm{argmin}_{\theta \in \Theta} \, D_b(\theta)' D_b(\theta)$$

Identification Issue

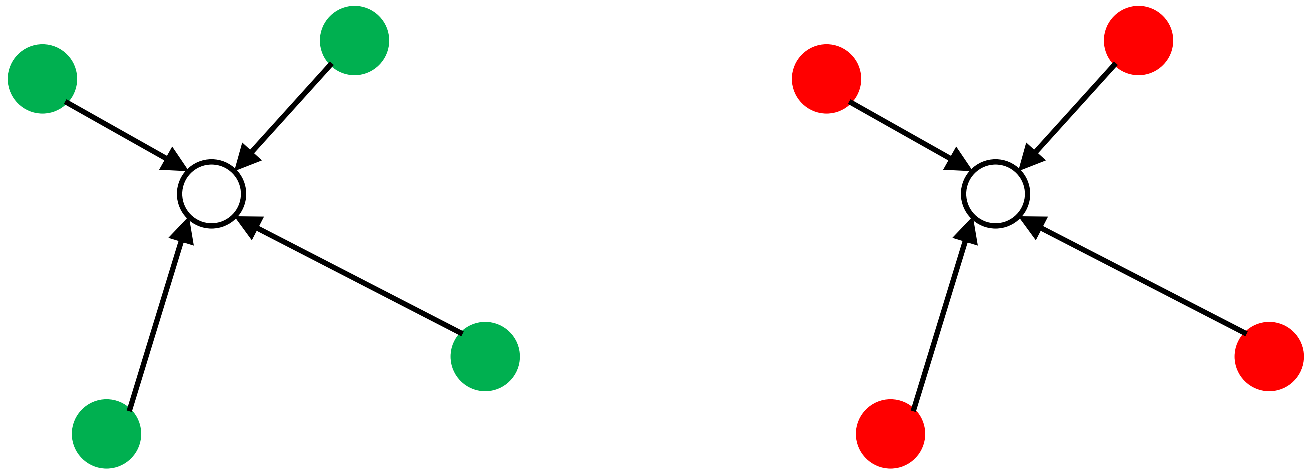
- Assume that $q^N = 0.10, q^P = 0.50$, and run 6 times



P[informed] = 98% **P[informed] = 41%**

Identification Issue (continued)

- Assume that $q^N = 0.10, q^P = 0.50$, and run 6 times



P[informed] = 100% **P[informed] = 92%**

Identification Issue (continued)

- Pure information model may not distinguish the third person and the fourth person
- Thus we need to consider endorsement effects model
- However, it is possible that households who are neighbors of people who take up are themselves more likely to need microfinance
- In their model they might end up attributing this to endorsement in the estimation

Results (continued, Table 6)

	(1)	(2)	(3)	(4)
Panel A: Standard Moments				
Panel A.1	q^N	q^P		$q^N - q^P$
Information Model	0.10	0.50		-0.40
	[0.0481]	[0.1693]		[0.1718]
Panel A.2	q^N	q^P	λ	$q^N - q^P$
Information Model w/ Endorsement	0.10	0.45	0.15	-0.40
(Eigenvector weighted)	[0.0382]	[0.1544]	[0.1227	[0.1635]
Panel A.3	ρ			
Distance from Taking Leader Model	-0.25			
	[0.0404]			
Panel B: Alternative Moments	q^N	q^P		$q^N - q^P$
	0.05	0.60		-0.55
	[0.0318]	[0.1444]		[0.1449]
Panel C: Tiled Roofing	q^N	q^P		$q^N - q^P$
	0.90	0.80		0.10
	[0.0336]	[0.0763]		[0.0766]
Panel D: Nested Model	q^N	q^P	ρ	$q^N - q^P$
	0.15	0.90	-0.05	-0.75
	[0.2558]	[0.1247]	[0.0620]	[0.2784]

Results (continued)

- Result 1: People who take up microfinance themselves are ***more likely to inform*** their neighbors than people who do not

- Result 2: Conditional on being informed, an agent's decision to take up microfinance is ***not affected*** by what their neighbors chose to do themselves

Robustness

- Issue 1: What if people who are close to each other behave similarly?

  - Put $d(i, L^P)$, the distance of agent I to the set of participating leaders, into the previous model. We will say a mechanical ***distance model***

  - We will be happy if the ***structural models do better*** in explaining the moments than a mechanical distance model

Robustness (continued, Table 7)

- Model Selection: ***Table 7 supports structural model*** rather than a mechanical distance model

	5th Percentile (1)	Median (2)	95th Percentile (3)
Information Mode	-0.058	-0.037	-0.004

Robustness (continued)

- Issue 2: Does the model predict tile roof adoption?

  - If we are really missing some unobservable correlation effects that end up biasing our model, then they would also end up biasing the model

  - A possible "placebo" outcome: does a household have a tiled roof?

Robustness (continued, Table 6)

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Panel A: Standard Moments				
Panel A.1	q^N	q^P		$q^N - q^P$
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Panel A.3	ρ			
Distance from Taking Leader Model	-0.25			
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Panel C: Tiled Roofing	q^N	q^P		$q^N - q^P$
	0.90	0.80		0.10
	[0.0336]	[0.0763]		[0.0766]
Panel D: Nested Model	q^N	q^P	ρ	$q^N - q^P$
	0.15	0.90	-0.05	-0.75
	[0.2558]	[0.1247]	[0.0620]	[0.2784]

Robustness (continued, Table 6)

- The estimated parameters in the model must be high in order to permit decisions to not be affected by information

- Thus if there is no effect, the parameters should be close to 1 and no differ from each other, which matches to the result in table 6

THE END