ETH zürich

Diffusion of Innovation and the Characteristics of Seeds

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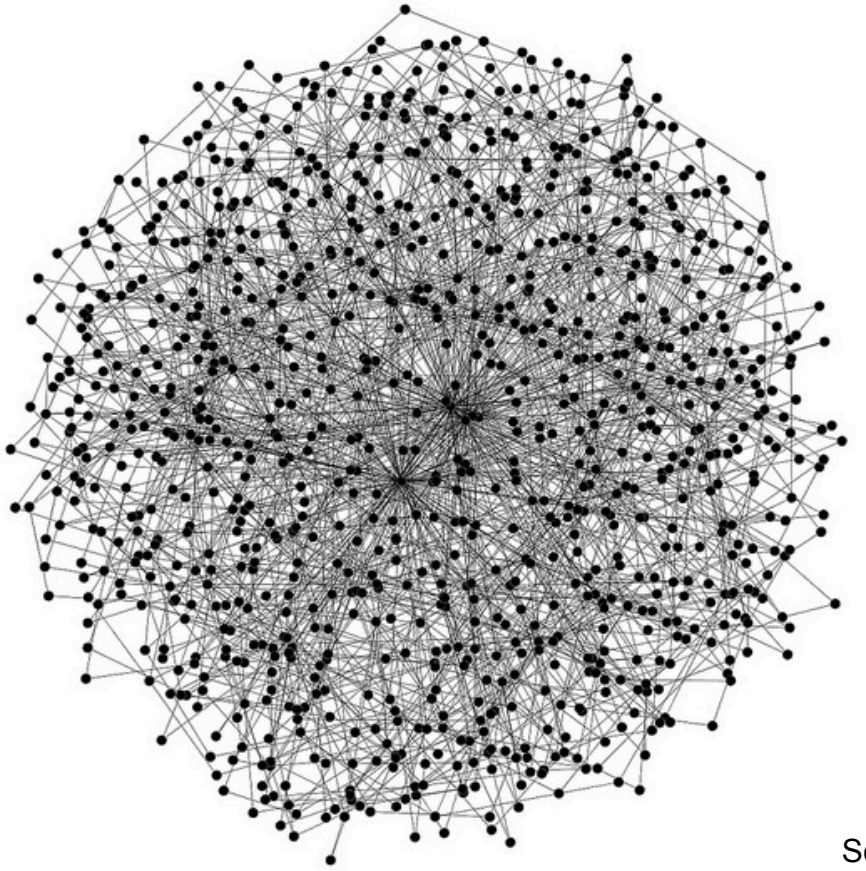
You have news for this given world. Whom do you tell first?



Degree
Betweenness Centrality
Eigenvector Centrality
Local Clustering Coefficient

?

Scale-free network by Simon Cockell
(https://www.flickr.com/photos/sjcockell/4684828794/l)

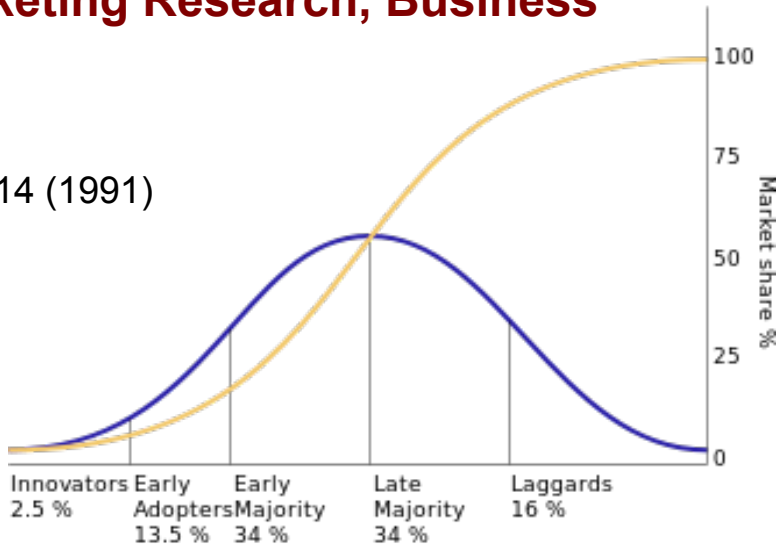
Goal: Which parameters of innovation seeds have an effect on the diffusion success? How large is it?

- **No knowledge on the seeds of innovation**
- **Very few parameters of nodes are known to be important**
  - Degree and Eigenvector Centrality (Delre et. al *JPIM*, **27**: 267-282 (2010)
  - Number of easily influenced neighbors (Watts & Dodds, *JCR*, **34**(4): 441-458 (2007)
- **Main possible application: programmability of innovation diffusion**
  - Increase initial speed of news messages
  - Introduction of (disruptive) technology
  - Marketing strategies for novel products
  - ...

The Theory of Innovation Diffusion

- **Founded in 1960s**
  - Fourt & Woodlock, *Journal of Marketing*, **25**(2), 31-38 (1960)
  - Rogers, *Diffusion of Innovations* (1962)
  - others

- **Research mostly dominated by Marketing Research, Business Administration, Social Sciences**
- **Few work by Network Sciences**
  - Start at: Freeman, *Research Policy*, **20**, 499-514 (1991)
- **Most common model**
  - Social contagion model with threshold and memory of past events



Model

- **McCullen**

$$u_i(t) = \alpha p_i + \beta s_i + \gamma m_i \ ,$$

$$\alpha = 0.3,\ \beta = 0.6,\ \text{and}\ \gamma = 0.1$$

$$s_i(t) = \frac{1}{k_i} \sum_j^N A_{ij} x_j(t) \ , \qquad m_i = \frac{1}{N} \sum_i^N x_i(t) \ .$$

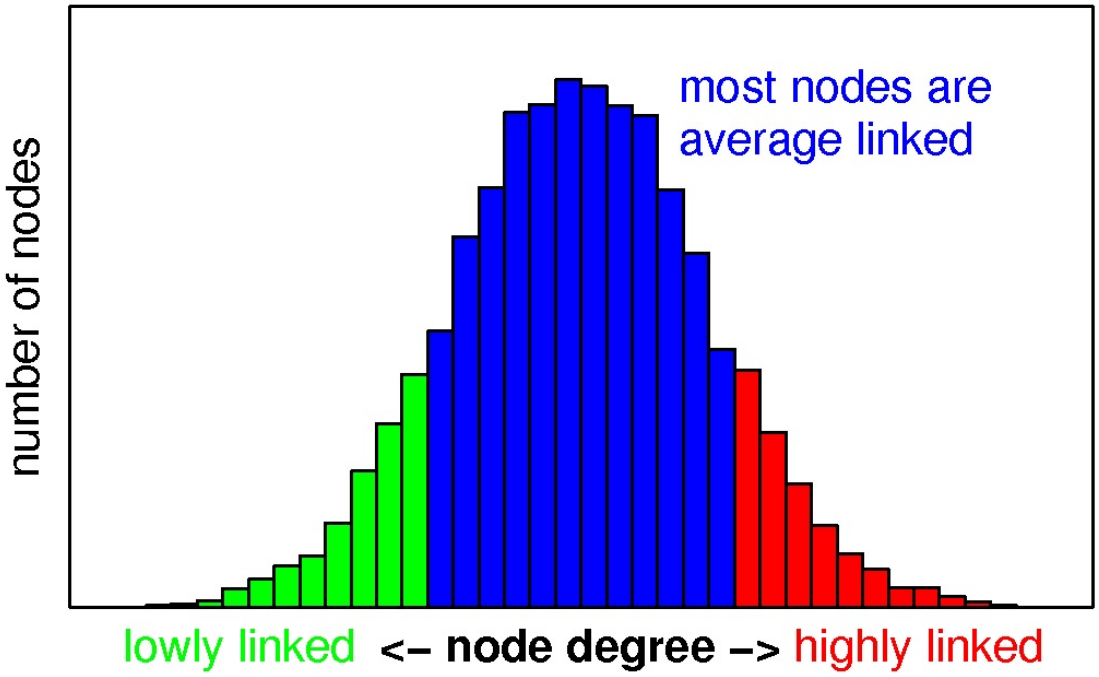
Model cont.

- Neighborhood utility has big effect
- Threshold based synchronous update

$$x_i(t+1) = \begin{cases} 1 \text{ if } x_i(t) = 1 \\ 1 \text{ if } x_i(t) = 0 \text{ and } u_i(t) > \theta \\ 0 \text{ otherwise.} \end{cases}$$

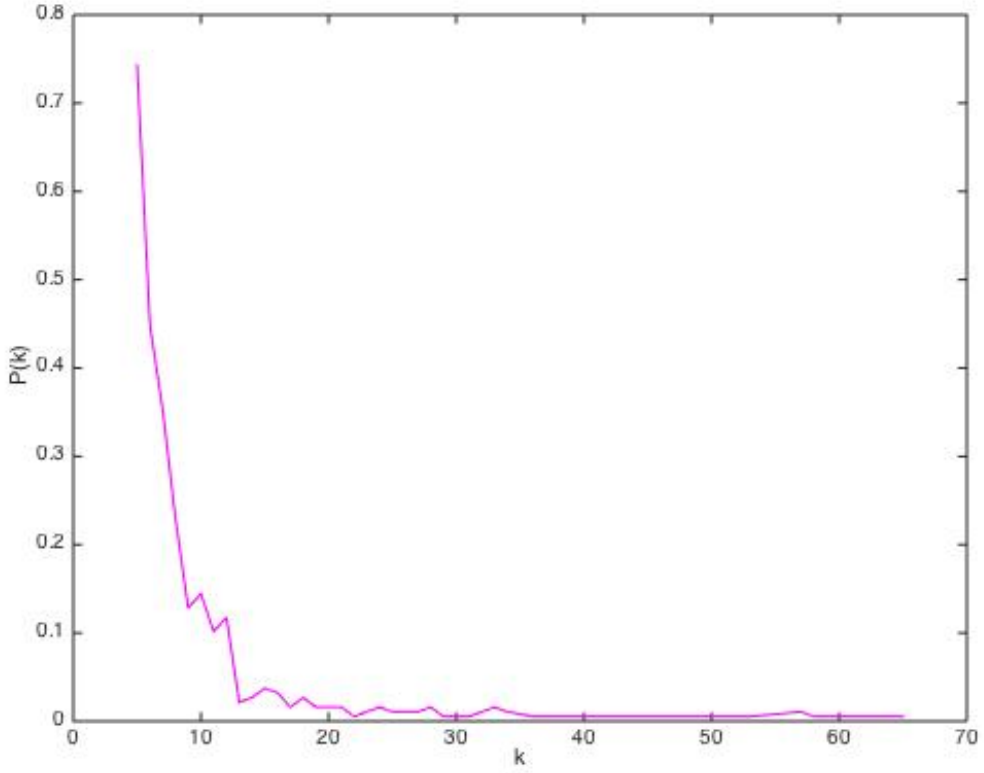
Network topology

- **Small-world**



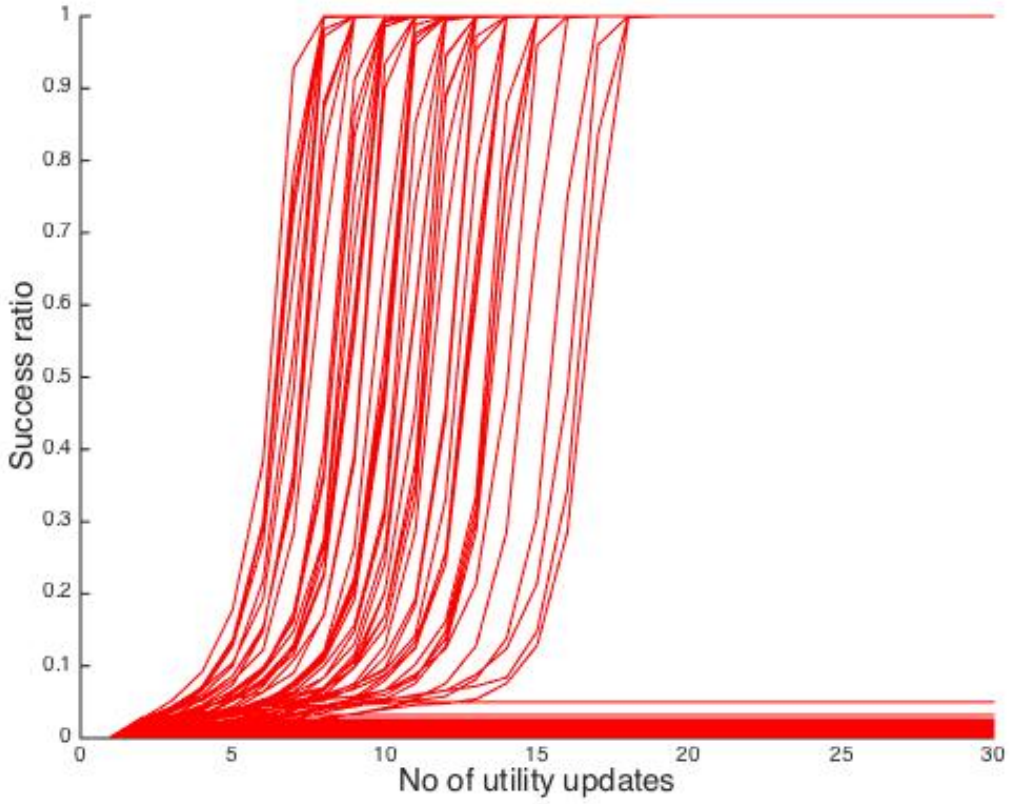
Network topology

- **Power-law**



Implementation

- %10 success
- 30 iterations

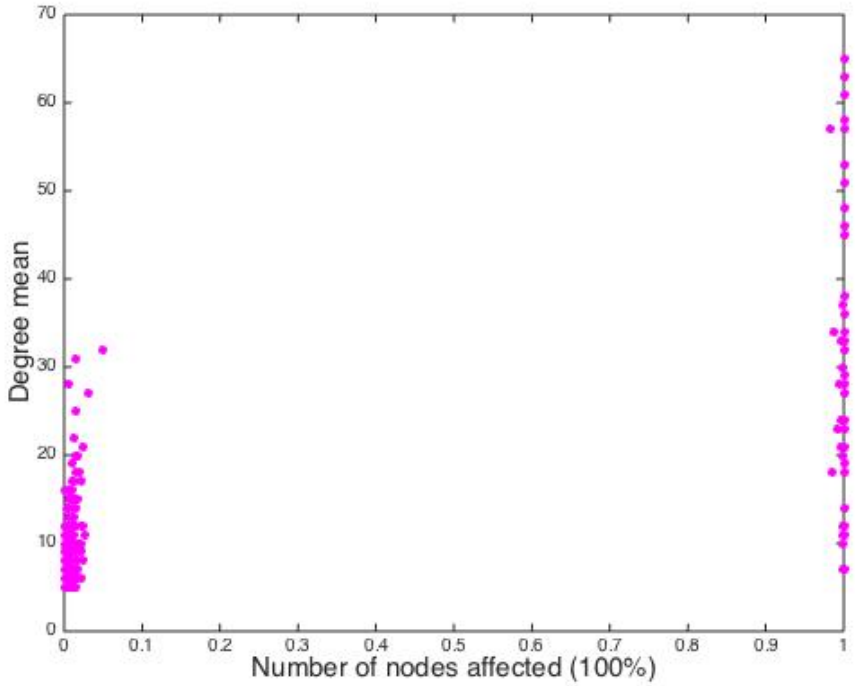


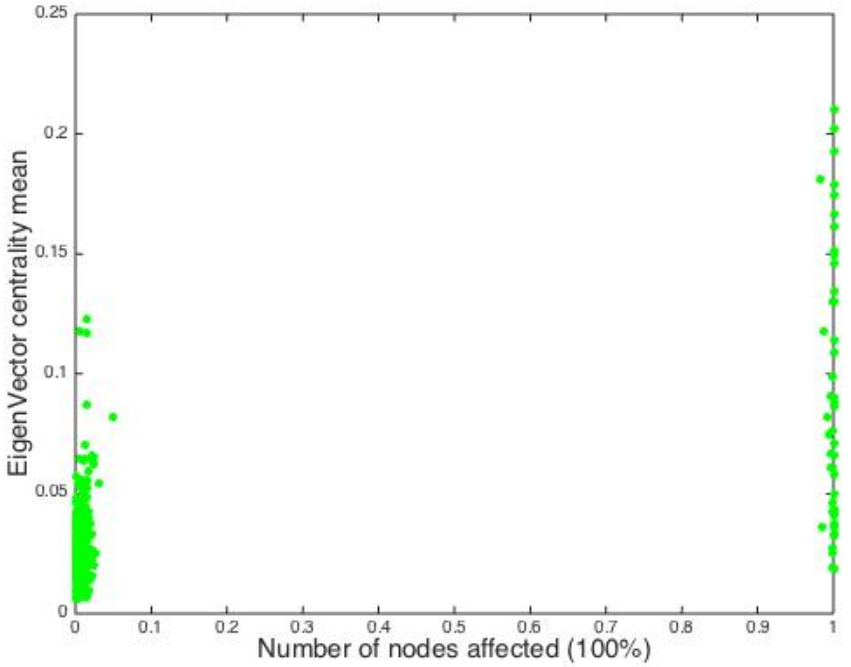
Results I – Descriptives

Table 1: Descriptive Statistics

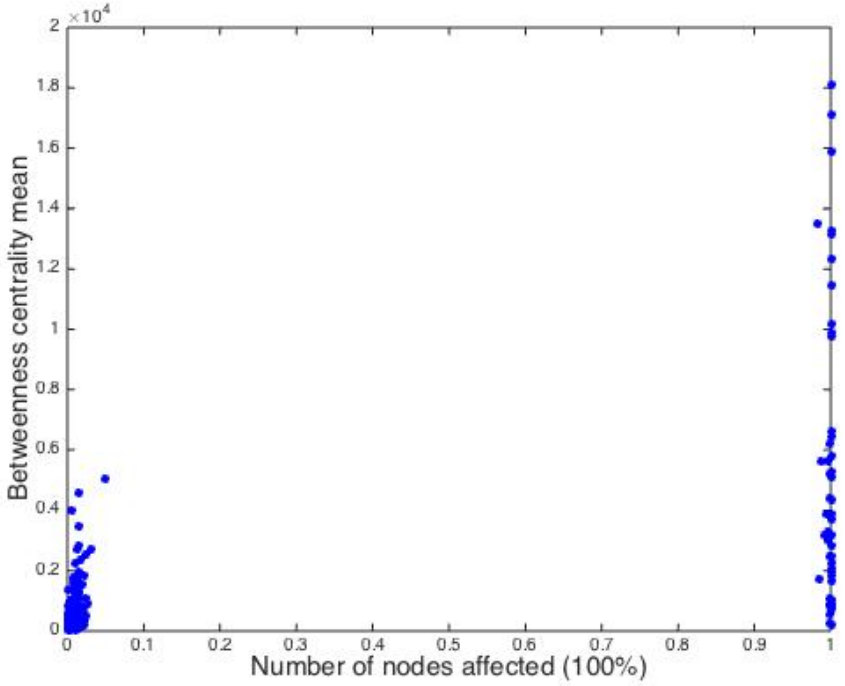
Statistic	N	Mean	St. Dev.	Min	Max
success	500	0.104	0.306	0	1
seed_perspref	500	0.504	0.103	0.143	0.831
seed_degree	500	9.944	8.999	5	65
seed_eigenc	500	0.033	0.030	0.006	0.210
seed_betweenness	500	885.040	2,139.630	35.768	18,131.290
seed_localc	500	0.125	0.138	0.000	0.800

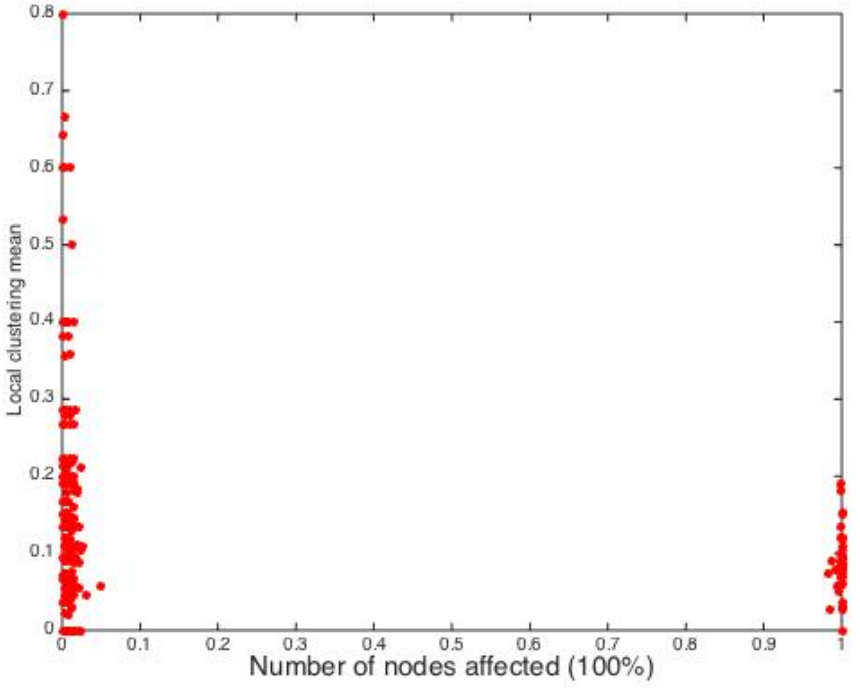
Results II - Plots





Results III - Plots





Results IV

Table 3: Results Seed Characteristics

	Dependent variable:					
	success					
	(1)	(2)	(3)	(4)	(5)	(6)
seed_degree	2.255***					3.434***
	(0.269)					(1.247)
seed_perspref		0.208				0.463**
		(0.147)				(0.225)
seed_betweenness			3.039***			−0.110
			(0.397)			(1.694)
seed_eigenc				1.910***		−1.049
				(0.255)		(0.738)
seed_localc					−0.421**	−0.289
					(0.193)	(0.483)
Constant	−3.004***	−2.171***	−2.661***	−2.796***	−2.214***	−3.268***
	(0.252)	(0.149)	(0.225)	(0.219)	(0.156)	(0.357)
Observations	500	500	500	500	500	500
Log Likelihood	−80.498	−165.890	−83.792	−96.150	−164.016	−75.784
Akaike Inf. Crit.	164.997	335.780	171.584	196.301	332.031	163.568
Note:						*p<0.1; **p<0.05; ***p<0.01

Results V

Table 6: Results Maximum Value of Neighboring Nodes

	Dependent variable:					
	success					
	(1)	(2)	(3)	(4)	(5)	(6)
neighsmax_degree	1.322***					−3.434*
	(0.298)					(1.853)
neighsmax_perspref		1.215***				1.243***
		(0.185)				(0.243)
neighsmax_betweenness			1.179***			2.190**
			(0.235)			(1.065)
neighsmax_eigenc				1.465***		2.291*
				(0.329)		(1.302)
neighsmax_localc					1.166***	0.822***
					(0.145)	(0.161)
Constant	−2.663***	−2.663***	−2.611***	−2.744***	−2.713***	−3.583***
	(0.243)	(0.209)	(0.221)	(0.261)	(0.210)	(0.351)
Observations	500	500	500	500	500	500
Log Likelihood	−149.235	−139.638	−147.970	−147.932	−128.118	−101.682
Akaike Inf. Crit.	302.470	283.275	299.940	299.864	260.237	215.365
Note:						*p<0.1; **p<0.05; ***p<0.01

Conclusion and Outlook

- **Seeds**
  - Centrality measures of seeds positively correlate with diffusion success
  - Local clustering negatively correlates (Reason: inert local clustering)
  - Degree is best predictor
- **Neighboring Nodes**
  - Complex results
  - Local clustering positively correlates
- **Outlook**
  - Network: Use empirical scale-free network with directed and weighted edges, and others
  - Model: Threshold model is new (2013); improved future models can be easily incorporated into simulation

Thank you for your attention!

Appendix I

Table 2: Correlation Table of Independent Variables

	seed_perspref	seed_degree	seed_eigenc	seed_betweenness
seed_perspref				
seed_degree	-0.01			
seed_eigenc	-0.01	0.95***		
seed_betweenness	-0.02	0.97***	0.93***	
seed_localc	0.04	-0.11*	0.05	-0.09*
			Note:	*p<0.1; **p<0.05; ***p<0.01

Appendix II

Table 5: Results: Mean of Neighboring Nodes

	Dependent variable:					
	success					
	(1)	(2)	(3)	(4)	(5)	(6)
neighs_degree	−0.590***					−6.834***
	(0.175)					(1.533)
neighs_perspref		0.190				0.288
		(0.148)				(0.179)
neighs_betweenness			−0.469***			2.926***
			(0.174)			(0.966)
neighs_eigenc				−0.366**		3.449***
				(0.162)		(1.026)
neighs_localc					0.796***	0.491***
					(0.146)	(0.173)
Constant	−2.279***	−2.168***	−2.233***	−2.204***	−2.402***	−2.827***
	(0.164)	(0.148)	(0.158)	(0.153)	(0.176)	(0.237)
Observations	500	500	500	500	500	500
Log Likelihood	−160.441	−166.057	−162.782	−164.162	−151.131	−134.517
Akaike Inf. Crit.	324.882	336.115	329.563	332.325	306.263	281.035
Note:						*p<0.1; **p<0.05; ***p<0.01

Appendix III

Table 4: Results Model Comparison with different Variable Sources

	Dependent variable:			
	success			
	(1)	(2)	(3)	(4)
seed_params	x			
seed_params & neighsmax_params		x		
seed_params & neighs_params			x	
seed_params & neighsmax_params & neighs_params				x
Observations	500	500	500	500
Log Likelihood	−75.681	−68.753	−67.338	−63.118
Akaike Inf. Crit.	163.362	159.507	156.677	158.236
Note:				*p<0.1; **p<0.05; ***p<0.01