Who to Fund? Identifying Strategic Collaborations and Stimulative Policies for Dynamic Research Networks

Funding strategies that strengthen overall network connectivity appear to generate the highest levels of research productivity

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ABSTRACT

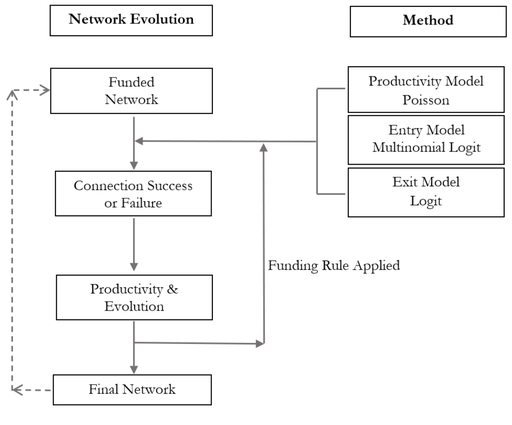
Black liquor is a by-product of papermaking. Boiling black liquor supplies ~3% of US electricity; and this potentially doubles if black liquor is gasified. Like many specialized bioenergy research communities, this research community is also small. We represent all collaborations as a social network to compare funding strategies. One allocates funds to the most productive pairs. Others fund pairs that tighten overall network connectivity.

We collected the universe of published work from 1991 to 2007, funding sources, and the number of publications and estimate expected productivity for any possible collaboration. Using limited dependent variable methods, we estimate the number of publications and the entry or exit of active researchers within the network. We simulate each funding strategy over five cycles and update the network to create an outcome distribution.

Direct Optimization funds co-authorship pairs expected to generate the highest expected number of publications. This increases expected publications by 92% and active researchers by 17%. Smart Small World funds pairs that create the largest number of researchers within two degrees of separation. This strategy increases publications by 113% and adds 18% more researchers. Finally, a fairness rule minimizes overall pathlength, and increases publications by 111% and active researchers by 22%.

METHODS & PROCEDURE

- Poisson regression is used to estimate productivity for connection. We simulate the number of publications for network in each period with probabilities from the regression.
- Multinomial logit is used to estimate the probability of new permanent entrance into network; with this for each pair of cells, we simulate how many new cells will enter the system.
- Logit regression is used to estimate which people exit a network. We estimate probability that a connection is broken. With the probability of exit for each pair, we simulate how many cells will exit the system.

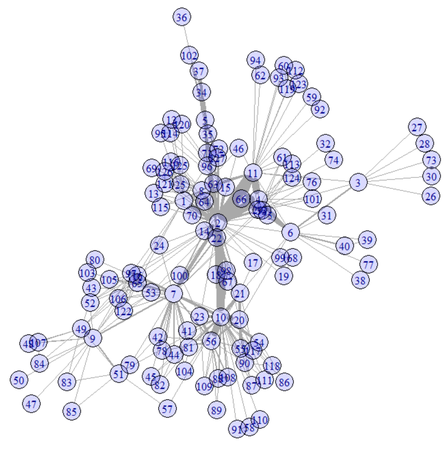


KEY RESULTS

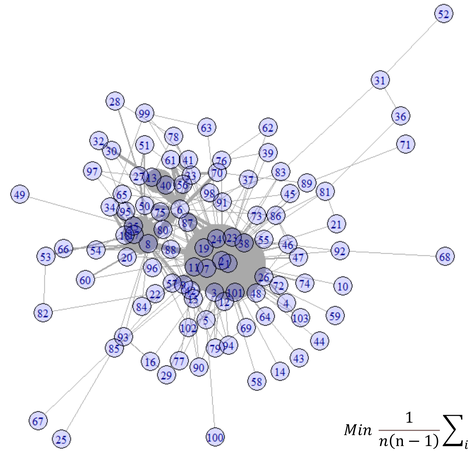
- Strategic funding decisions tend to tighten networks and eventually exhibit short path lengths and high clustering coefficients.
- Funding the most productive existing collaborations yield significant improvements in overall network density over baseline results.
- Funding strategies that strengthen overall network connectivity network appear to generate the highest levels of research productivity.

NETWORK SIMULATIONS

Static Network

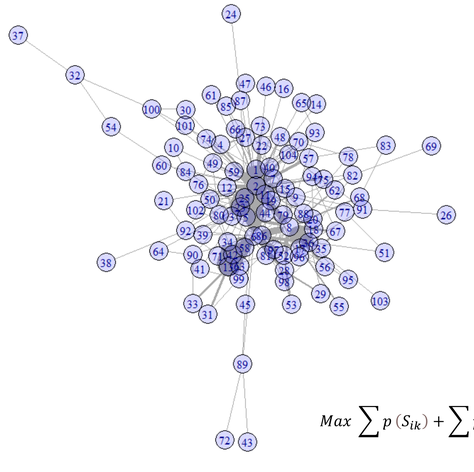


Fairness Rule



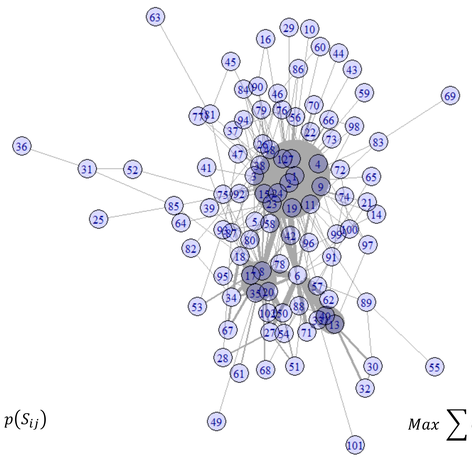
$$Min \frac{1}{n(n-1)} \sum_{i \neq j} d_{ij}$$

Direct Optimization



$$Max \sum p(S_{ik}) + \sum p(S_{jm}) + p(S_{ij})$$

Smart Small World



$$Max \sum C_{i,k} + \sum C_{j,m} + C_{ij}$$

SIMULATION RESULTS

Measures of Network Connectivity and Effectiveness

Average pathlength: average number of steps along the shortest paths for all possible pairs of network nodes; generally, the smaller the pathlength, the more efficient the network.

Clustering coefficient: measure of the degree to which nodes in a graph tend to cluster together; roughly speaking, it tells how well connected the neighborhood of the node is.

Density: describes the portion of the potential connections in a network that are actual connections; generally, the higher the density, the more connected the network.

Table 1: Policy Results

	Number of Pubs	Number of Authors	Avg. No. of Pathlengths	Clustering Coefficient	Density
Static	126	127	3.898	0.442	0.048
Direct Optimization	242.299	148.010	2.952	0.480	0.054
Smart Small World	268.055	149.797	3.073	0.500	0.052
Fairness Rule	266.103	155.166	2.897	0.499	0.050

Conclusion

Small bioenergy research communities are essential to meet future clean energy needs. Funding strategies that strengthen overall network connectivity network appear to generate the highest levels of research productivity.