

NETWORKS AND SPACE

(from Zuckerman, *JEL*, June 2003)

Can analysis of networks shed light on observed behaviour and outcomes of activity on an economic network (EN)?

Well, yes, sometimes.

Three concepts of ENs:

- 1. as concentrated exchange**
- 2. as primordial affiliation**
- 3. as structures of mutual orientation.**

An EN can be described as “a set of nodes and a pattern of ties among such nodes”, but this begs five questions.

What is an Economic Network (EN)?

Five questions:

- 1. What is a node?**
- 2. How is the boundary of the set of nodes defined?**
- 3. What is a tie?**
- 4. What is a pattern?**
- 5. When is a network an EN, and not just a social network (SN)?**

I. Network Nodes

What is a node?

There are two main types of node in an EN:

- human beings**
- organisations**

but possibly others: the country, the industry, the innovation, and the product.

Need to specify how nodes relate to actors: is the link explicit and justified?

- a. aggregation — common effects or common causes**
- b. nodes proxy for unobserved actors.**

2. Delimiting the Set of Nodes

Two questions about the “boundary specification problem:”

- a. are the rules for including or excluding nodes sensible?**
- b. do the rules generate data that are not artefacts of those rules?**

There are two broad approaches:

- 1. the “nominalist” approach — the set comes from a priori criteria**
- 2. the “realist” approach — actors (nodes) are included if they are judged relevant by the actors themselves**

e.g. an analysis of competitors in an industry:

**nominalist: use an ANZSIC code at a particular fineness
(number of digits)**

**realist: look for evidence among the actors on who’s in and out
— Erickson’s “snowball” sampling approach**

Boundary Specification cont.

The Realist approach:

- **include relevant nodes, and exclude irrelevant nodes,**
- **but this is likely to be highly contingent to time and place**
- **and moreover the data collection method might skew the boundaries.**

e.g.

Two further boundary issues:

- single type of actor, or two types? (One mode or two?)
e.g. buyer or seller or possibly both?**
- the “node specification” problem of death and birth
e.g. firms are born, firms merge, firms exit**

One- or Two-Mode Networks?

SN analysis is general of “one-mode networks,” that is, for instance, every actor (node) might both potentially “send” and “receive” a tie of interest to every other actor, with no a priori typing.

But ENs are usually “two-mode networks:” with two types of nodes: either “sender” or “receiver” nodes, but not “send” AND “receive” nodes.

So markets are “interfaces” between, say, buyers and sellers.

∴ the EN modeller must generally delimit two sets of nodes: “buyers” and “sellers”

or: sometimes no clear-cut distinction in an EN:

e.g. traders on eBay can both buy and sell (one-mode), but most specialise.

Nonetheless, the pattern of specialisation might be significant.

The Meaning of the Absence of a Tie?

Q: How to interpret the absence of a tie (of a specific kind) between two nodes, when absence

- either indicates impossibility? or**
 - or indicates actors' choice not to tie?**
- e.g.**

Moreover, what do inter-firm relations mean?

- another form of network tie?
using reliance on networks to predict the location
of the firm's boundaries, or**
- something different from market integration?
qualitative increase in commitment → need a
theory of the firm to analyse ENs.**

Ties? Patterns? EN v. SN? → Q6

3 + 4 + 5 →

6. *What manner of orientation among the nodes is meaningful such that it constitutes a structure that has causal implications for outcomes of interest?*

A network is an EN if it has effects on future events that are considered economic.

An EN is of interest if it *cannot* be fully reduced to the constrained choices made by actors, that is, a complete account requires attention to the EN and its patterns.

“manner of orientation” among nodes →

- tie definition:
infinite possibilities of what the ties model;**
- and pattern:
central to the analysis of ENs.**

Pattern is Central to Analysis of ENs

Two meanings of “network:”

- the pattern of ties among a set of nodes, or
- *a high degree of pattern in the ties among nodes, with a specific theoretical or empirical meaning.*
e.g. network v. market
e.g. network v. organisation

EN: “any collection of actors ($N > 2$) that pursue repeated, enduring exchange relationships with one another and, at the same time, lack a legitimate organisational authority to arbitrate and resolve disputes that might arise during the exchange.” — self-organisation

Four Approaches to ENs

- I. **Ties as market exchanges.**
The EN is more patterned or concentrated than expected from market models.
- II. **ENs are economic interactions shaped by ascribed or primordial relationships**
Do network structures (or commitments) have causal impact?
But “primordial” blurs the distinction between ENs and SNs.
- III. **ENs as structures of mutual orientation**
(I and II are subsets of III)
- IV. **Increasingly, the structures of inter-firm orientation designed to be *orthogonal* to market exchange.**
To meet needs unmet by market exchange (e.g. coopetition)

Do ENs have Causal Implications?

Not just a pretty picture?

Does the structure of the EN have causal implications for the actors of interest?

Two issues (Reagans et al. 2003):

- 1. unobserved heterogeneity, and**
- 2. reverse causality**

→ To argue that particular network position confers advantage, it's necessary to show, first, that any observed association between position and success does not reflect underlying differences in actor "type" or, second, that expectations of success did not determine the observed network pattern.

Some Network Metrics (from Tesfatsion/Zhou)

Graph Theory: Node = Vertex; Tie = Edge

Vertex Set: $V(G) = \{1, \dots, N\}$

Edge Set: $E(G)$, $A_{ij} = 1$ iff $(i, j) \in E(G)$

Directed Graph (DiGraph) for two-mode network, and Weighted Graph possible.

Vertex Degree: $k(v)$ = no. of vertices directly connected to vertex v

Clustering Coefficient: $C(v) = \frac{\text{Actual}}{\text{Total possible}}$ measures how well connected my neighbouring vertices are, where Actual = number of connections among my neighbouring vertices.

Distance L_{ij} = shortest path length between vertices i and j

Characteristic Path Length of Graph $G = L(G)$ = the average of L_{ij} for all i, j in graph G , $i \neq j$.

Properties of Graph Models

	Path length $L(G)$	Clustering $C(v)$
Regular	Longest	Largest
SWN	Short	Large
Random	Shorter	Small
Scale-Free	Shortest	Small

Small World Networks (SWN) are resilient against random failures of vertices (nodes), but highly vulnerable to deliberate attacks on hubs (vertices of high degree $k(v)$).

Limitations (from Girvan)

We need to think more about the interplay between network topology and dynamics.

Can we find “universality classes” with respect to topology and dynamics?

Can we determine which topological features are most important to different types of dynamics?

- **Are networks a fad?**
- **What are we doing wrong in the field of complex networks?**
- **Where do we go from here?**

Scientific “Fads” from statistical physics

Their claims have often been over-asserted:

- **Self-organized criticality SOC**—a supposed explanation for why we see power laws in so many natural systems when power laws in physics are only seen at critical points.
- **Econophysics** — the application of statistical physics toward the understanding of market patterns.
- **Fractals** — self-similar patterns observed in a variety of natural systems — snowflakes, river networks, forest fires?
- **Spin glasses (or spin systems generally)** applied to neural networks, gene regulation, economy, opinion formation, war, . . .
- **The edge of chaos, EOC**
- **And networks?**

Are networks a fad? Yes, but . . .

Network results developed by statistical physicists have been *exported* to other fields, but they have not been *integrated* with other fields.

Networks can still be useful, if . . .

- **You have knowledge of the system that you are studying**
- **You have a problem that naturally calls for a network-based approach. Complex networks should not be the answer in search of the problem.**
- **You understand that just considering the topology of system interactions will not magically allow you to unify quantum mechanics and gravity, explain the origin of life, or elucidate the meaning of life.**

References

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- [3] **Michelle Girvan, lecture 4 in *The structure and dynamics of complex networks*,**
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