Social Networks

An Overview of Approaches to Visualize their Structure, Model their Emergence, and Understand their Influence on Economic Transactions

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Virtual Center for Supernetworks

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This support is gratefully acknowledged.

Outline

- Definition of a Social Network
- Representations of Social Networks
- Modeling the Emergence of Networks
- Flows on Networks
- The Role of Relationships in Economic Transactions
- A Supernetwork Approach to Model the Influence of Relationships in Supply Chain and Financial Networks

Definition of Social Networks

- “A social network is a set of actors that may have relationships with one another. Networks can have few or many actors (nodes), and one or more kinds of relations (edges) between pairs of actors.” (Hannemann (2001))

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Social Network Analysis

- Social network analysis is based on graph theory. It studies the pattern of links among independent actors.
  - Krackhardt (2000): Overview of the methods in social network analysis
  - Freeman (2004): History of social network analysis
  - International Network for Social Network Analysis www.insna.org

Matrices (based on Hannemann, 2001)

- Square array of measurements
- Rows and columns are cases, subjects, or observations (nodes)
- Cells represent relationships (edges)
- Example: Who reports liking whom?

	Ann	Rob	Sue	Nick
Ann	---	1	0	0
Rob	1	---	1	0
Sue	1	1	---	1
Nick	0	0	1	---

How are actors embedded in the network?
How is the overall density?

Graphs - Sociogramms

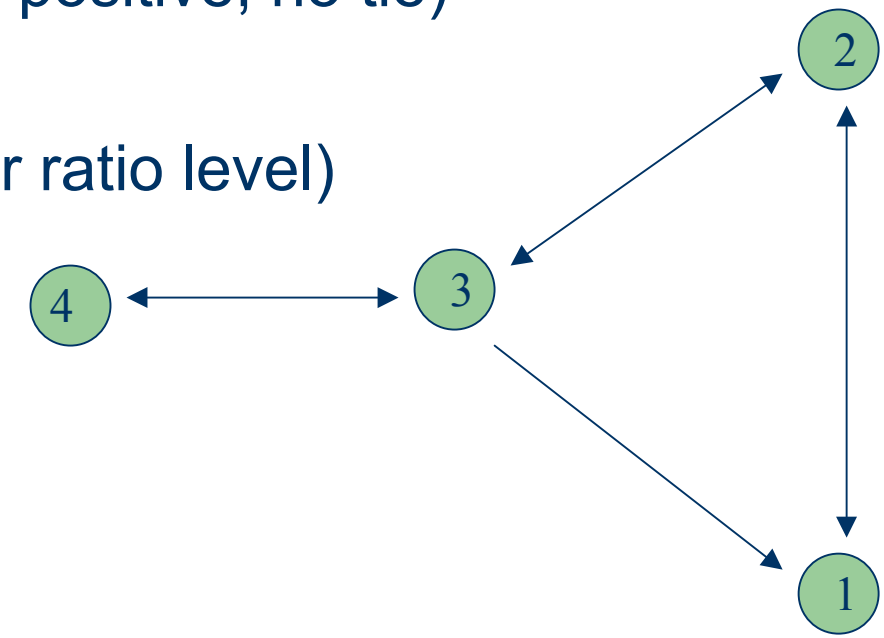
(based on Hannemann, 2001)

- Labeled circle for each actor in the population
- Line segments between pairs of actors represent ties between them
- A graph may represent a single type of relation or more than one kind
- Each tie can be directed or represent co-occurrence
- Arrows represent directed ties

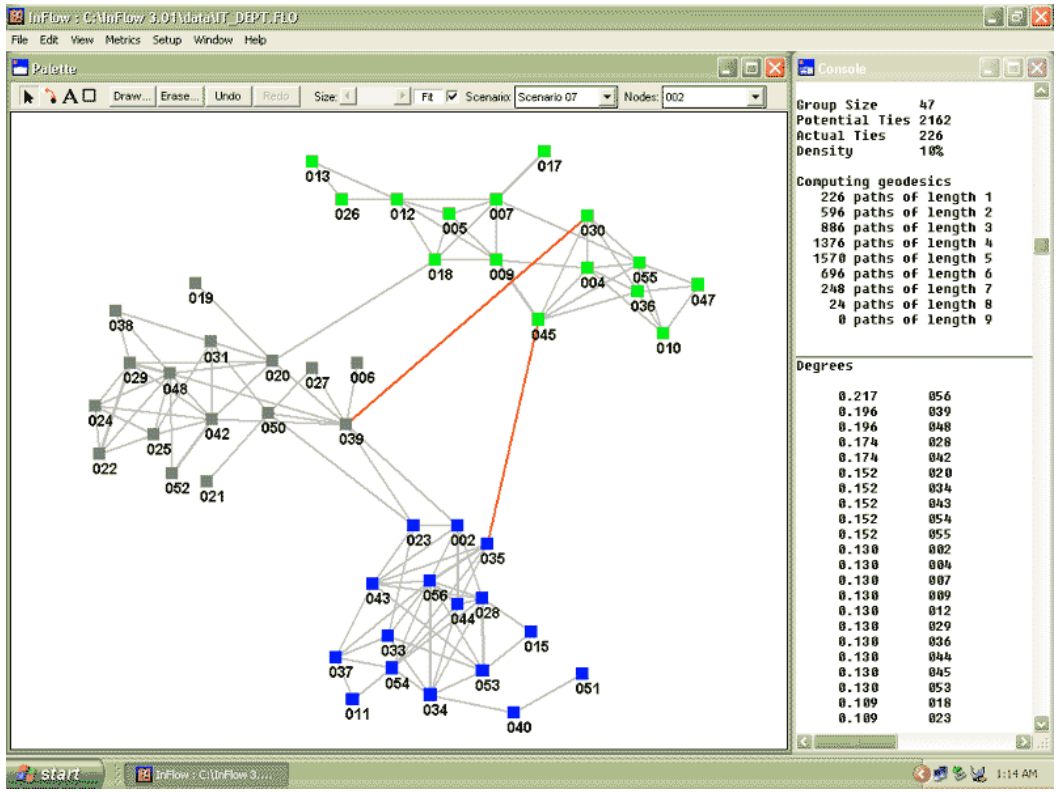
Graphs – Sociogramms 2

(based on Hannemann, 2001)

- Strength of ties:
  - Nominal (presence or absence)
  - Signed (negative, positive, no tie)
  - Ordinal
  - Valued (interval or ratio level)
- Example



Social Network in an Organization



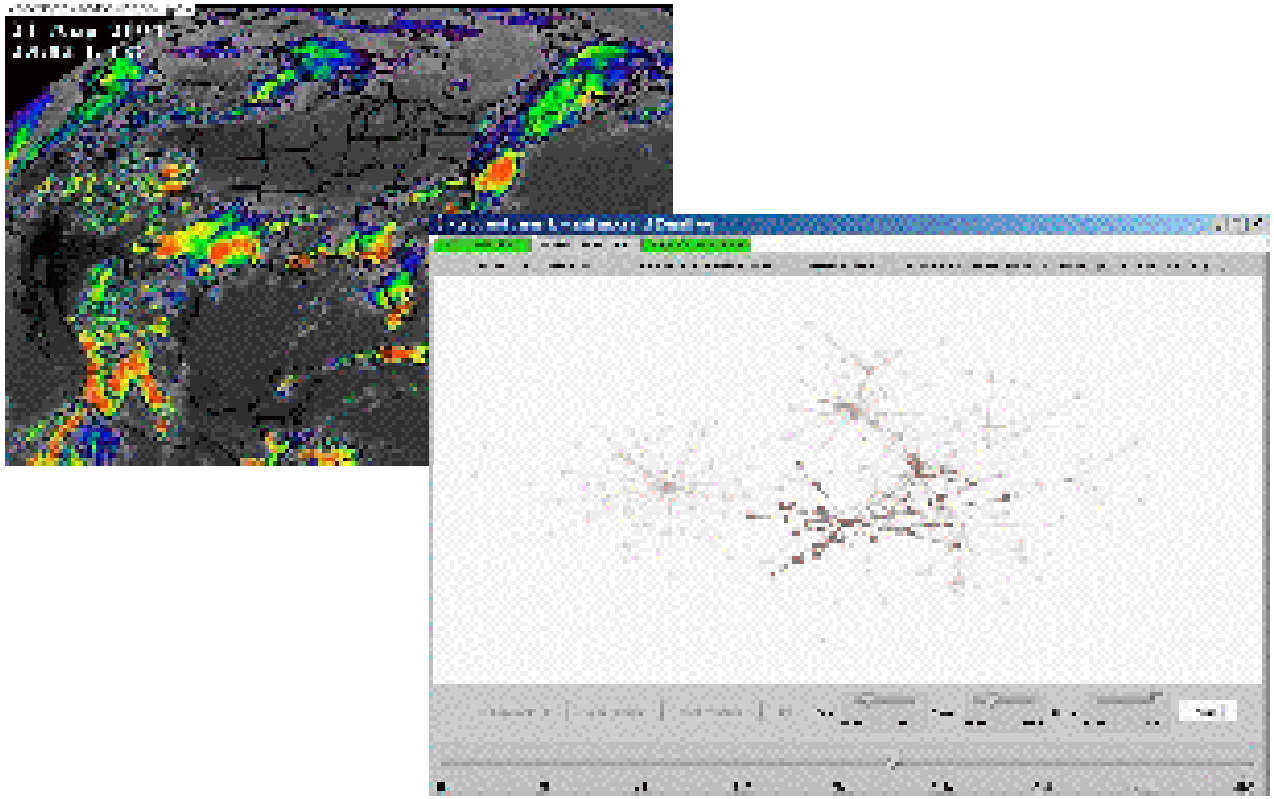
Source: Krebs: www.orgnet.com

Measurement of Relationships

- Observation
- Questionnaires

- Recording of emails
- Recording of telephone calls

Dynamic Representation of Social Networks



Source: Gloor and Zhao: http://www.ickn.org/JoSS_subm/TeCFlow4JoSS.htm

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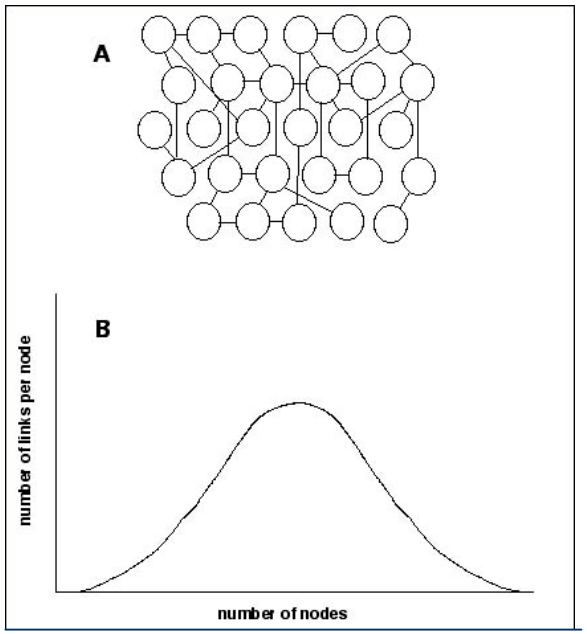
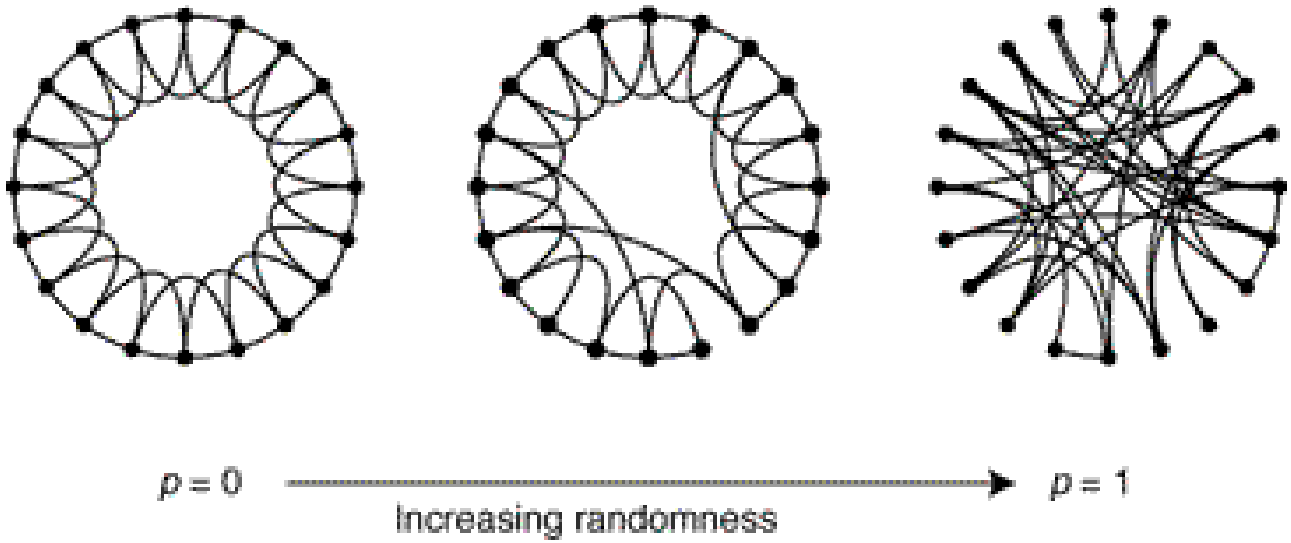
Randomly Generated Networks



Erdös and Renyi (1959, 1960)

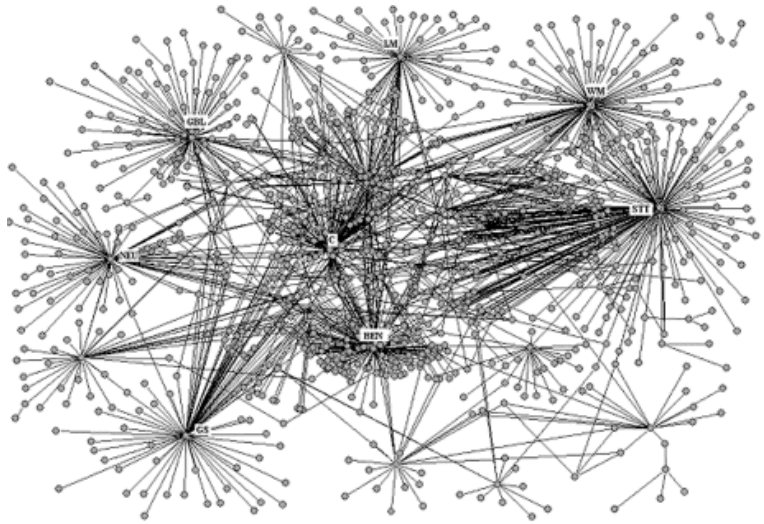
Source: Smith: http://www.integralworld.net/smith17.html

Small-World Network (cf. Watts and Strogatz (1998))



Source: Watts (2004), Princeton Studies in Complexity

Scale-Free Networks (cf. Barabasi and Albert (1999))



The graph of ownership for stocks traded in 2001
on the New York Stock Exchange

Source: Guido Caldarelli, *SIAM News*, Volume 37

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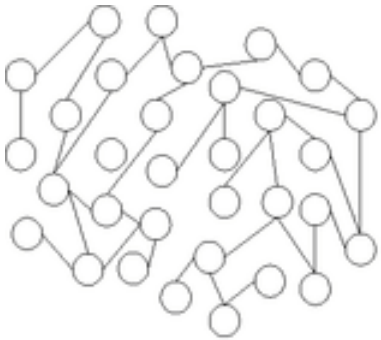
Flows on Networks

- Strength of weak ties (cf. Granovetter (1973))
- Importance of hubs (cf. Barabasi (2003))



(a) Random network

(b) Scale-free network

Source: Wikipedia, http://en.wikipedia.org/wiki/Scale-free_network

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Relationships in Supply Chains

- Can reduce risk (cf. Baker and Faulkner (2004), p. 92)
  - By reducing "information asymmetry between buyer and seller"
  - By reducing "opportunism due to imposed social obligations and effective sanctions on the seller"

Relationships in Supply Chains

- Can reduce transaction costs by
  - Increasing response rates (cf. Spekman and Davis (2004))
  - Increasing levels of trust (cf. Dyer (2000))
- Can enhance shared innovation, product adaptation, learning from customers, and quality improvements (cf. Richardson and Roumasset (1995))

Relationships in Financial Transactions

- Make firms more likely to get loans and to receive lower interest rates on loans (cf. Uzzi (1999))
- Play an important role in micro-financing (cf. Ghatak (2002) and Anthony (1997))
- Can protect investors in partly fraudulent businesses (cf. Baker and Faulkner (2004))

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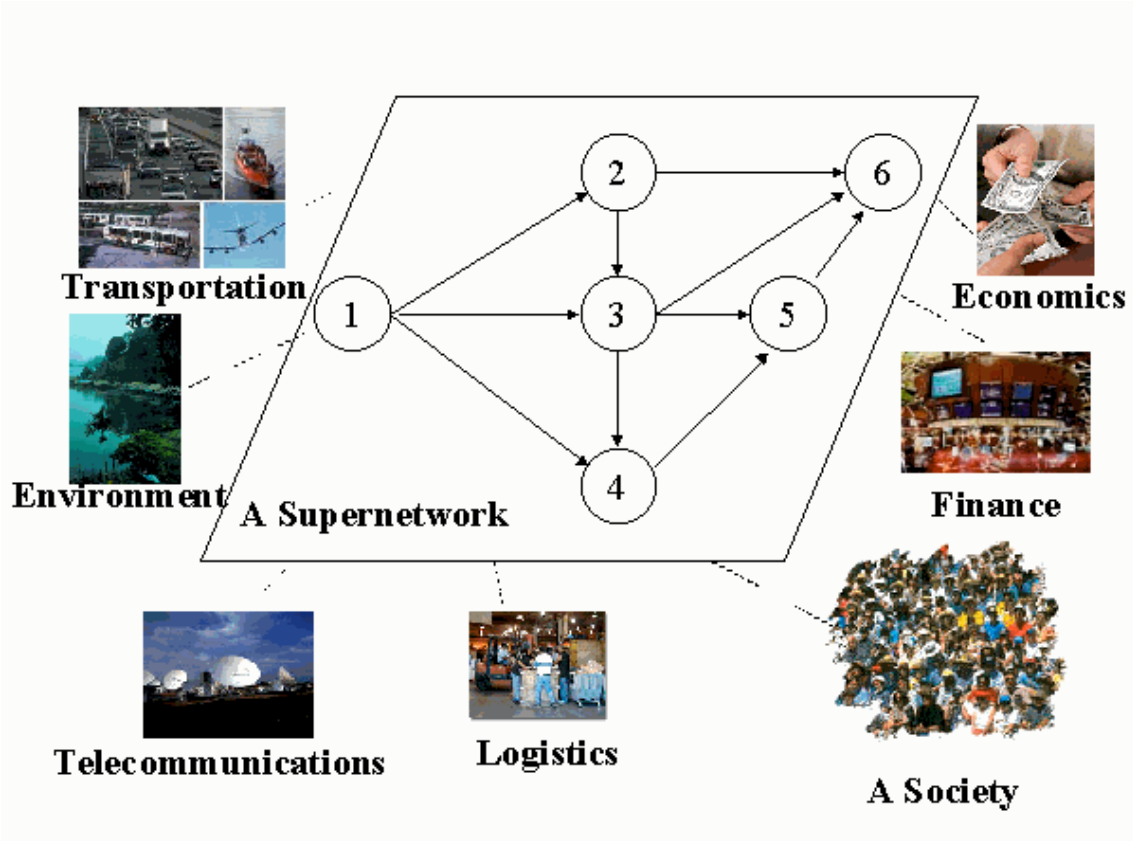
A Supernetwork Approach



Source: Nagurney (2004), in Transforming Enterprise, MIT Press

Tools That We Have Been Using

- Network theory
- Optimization theory
- Game theory
- Variational inequality theory
- Projected dynamical systems theory
- Network visualization tools

Novelty of Our Research

- Supernetworks show the dynamic co-evolution of economic (product, price and even informational) flows and the social network structure
- Economic flows and social network structure are interrelated
- Network of relations has a measurable economic value

Supernetworks Integrating Social Networks with Economic Networks

- We have formulated and analyzed supernetworks consisting of:
  - Supply chain and social networks
  - Financial and social networks
  - International supply chain and social networks
  - International financial and social networks

Supernetwork Integrating a Social with a Supply Chain Network

Dynamic Supernetworks for the Integration of Social Networks and Supply Chains with Electronic Commerce: Modeling and Analysis of Buyer-Seller Relationships with Computations

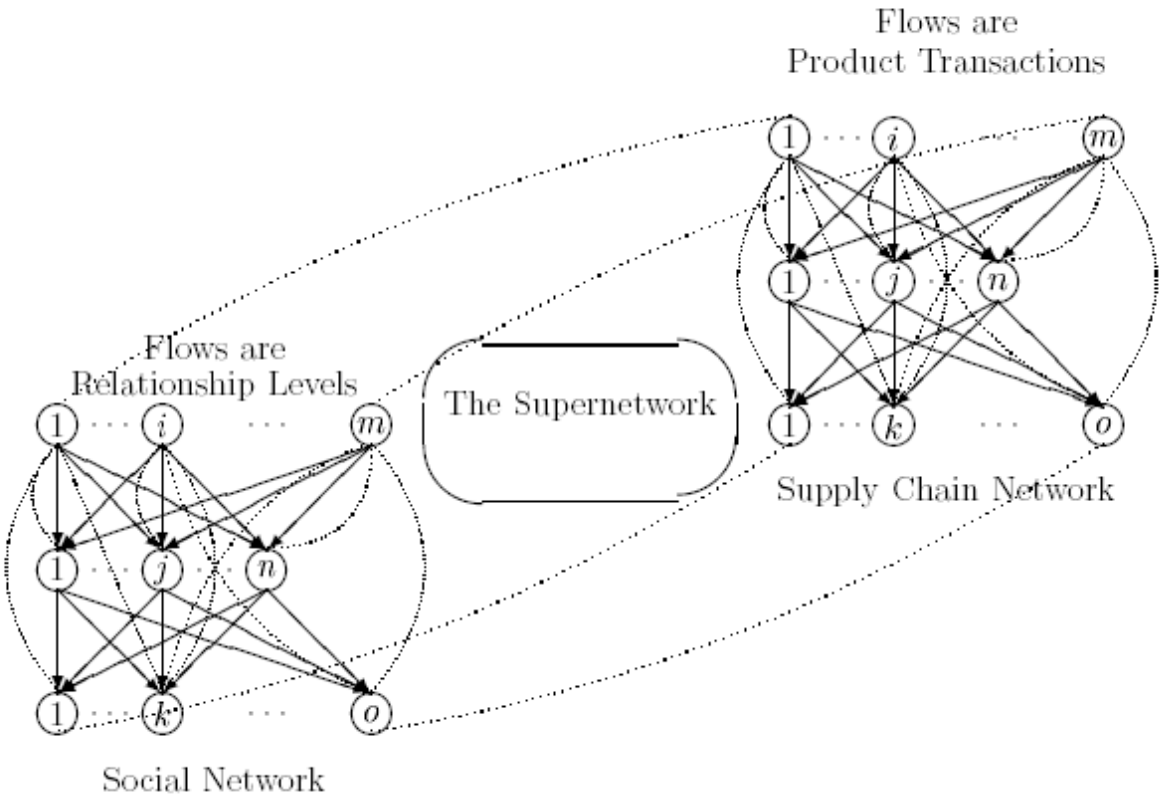
Tina Wakolbinger and Anna Nagurney

Netnomics 6: (2004), pp 153-185

Supernetwork Integrating a Social with a Supply Chain Network

- Models the interaction of a supply chain and a social network
- Captures interactions among individual sectors
- Includes electronic transactions
- Incorporates transaction costs and risk

Supernetwork Structure: Integrated Supply Chain/Social Network System



Source: Wakolbinger and Nagurney (2004)

Assumptions of the Model

- Manufacturers can transact either physically or electronically with the intermediaries.
- Manufacturers can transact directly with the demand markets via Internet links.
- Retailers can transact through physical links with demand markets.
- Manufacturers and retailers maximize profit and relationship value and minimize cost.

Supernetwork Integrating a Social with a Supply Chain Network

- Decision-makers in the network can decide about the amount of product that they want to transact and the relationship levels [0,1] that they want to establish.
- Establishing relationship levels incurs some costs.
- Higher relationship levels
  - Reduce transaction costs
  - Reduce risk
  - Have some additional value (“relationship value”)

Qualitative Properties

- We have established
  - Existence of a solution to the VI
  - Uniqueness of a solution to the VI
  - Conditions for the existence of a unique trajectory to the projected dynamical system
  - Convergence of the Euler method

Types of Simulations

- We can simulate
  - Changes in production, transaction, handling, and relationship production cost functions
  - Changes in demand and risk functions
  - Changes in weights for relationship value and risk
  - Addition and removal of actors
  - Addition and removal of multiple transaction modes

Summary

- We model the behavior of the decision-makers, their interactions, and the dynamic evolution of the associated variables.
- We study the problems qualitatively as well as computationally.
- We develop algorithms, implement them, and establish conditions for convergence.
- We have studied to-date "good behavior". Fascinating questions arise when there may be situations of instability, multiple equilibria, chaos, cycles, etc.

The full text of the papers can be found under Downloadable Articles at:

http://supernet.som.umass.edu

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Thank you!

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