“The influence of network properties on the agility of seafood supply chains”

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Introduction

- **Seafood supply chain** (SSC) can be conceptualized as a network of agents (nodes) linked through buyer-seller relationships.

- The functioning of the SSC is not the result of an additive aggregation of the individual firms' decisions, but an autonomous global behavior emerges from the interrelationship structure of the SSC (topology).

OBJECTIVE:

- This paper analyzes the influence of the network topology on the agility of the SSC (the ability to respond quickly to sudden changes in supply and demand).

- Considering that:

- **Agility in SC** can be defined as the ability to respond quickly to sudden changes in supply and demand and is considered as one of the dimensions of a resilient SC (Christopher and Peck, 2004).

- **SC resilience** alludes to the ability of supply chains to respond to disturbances and disruption.

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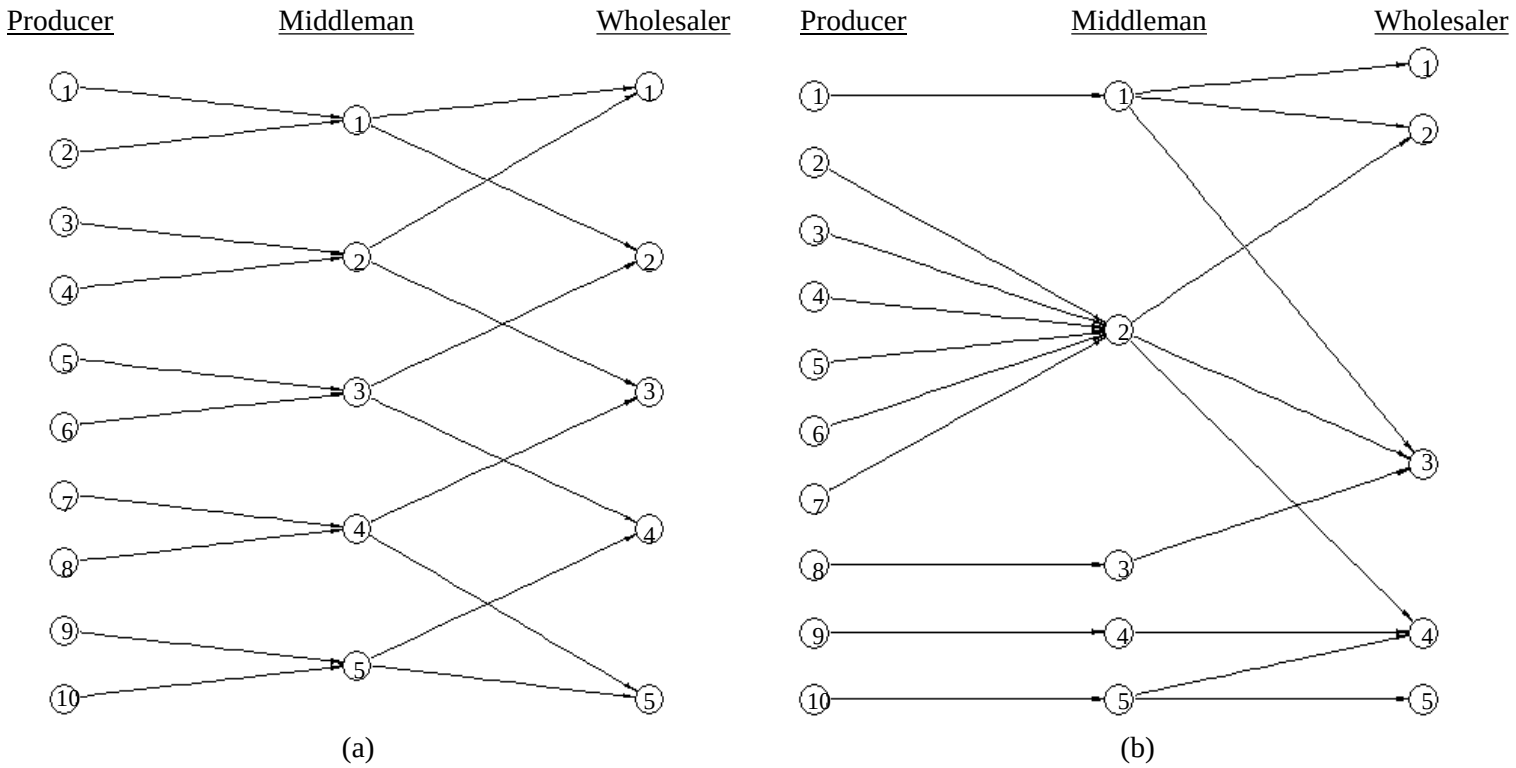
Examples



- Two examples of a SSC with three tiers (producer, middleman, wholesaler) :

a) Homogeneous-degree topology; b) Heterogeneous-degree topology

Examples

- The two previous examples present specific characteristics for SSC in small-scale fisheries:

  - Restricted interrelationships among firms (producer->middleman->wholesaler).

  - Absence of horizontal relationship among middlemen

- Supply networks in other industries (e.g., automotive, textile) do not show these restrictions.

- Some previous studies show that in these industries, supply networks with heterogeneous topologies show highest levels of agility than with homogeneous topologies

Hypotheses

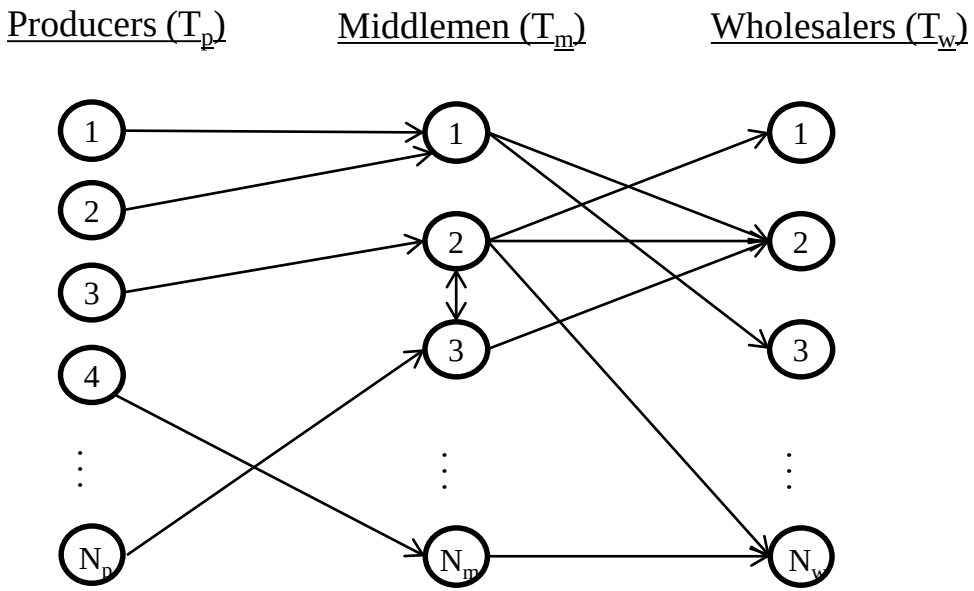
- We formulate the following hypotheses:

H1: Agility in restricted interrelationship SSC is higher with homogeneous-degree topologies than with heterogeneous-degree topologies

H2: The larger the number of horizontal relationships among firms in the same tier, the more agile a restricted interrelationship SC is.

Methodology: supply chain model

- To check the hypotheses, we build an agent-based model that includes three tiers (producers, middlemen and wholesalers) and their pattern of interrelationships



- The topology of the SSC includes two bipartite random graphs (producer/middlemen and middlemen/wholesaler)
- Three degree distributions are considered: two homogeneous (regular and Poisson) and one heterogeneous (power-law)

Methodology: metric for agility

- Assumptions for the simulations:
  - Every producer has identical production capacity.
  - The total demand in the system is equal to the total production capacity.
  - Every wholesaler demands the same amount of fish for every link.
  - Hierarchy to fulfill orders: orders from a wholesaler are handled once the orders of a precedent wholesaler have been fully treated.

- An algorithm to estimate the unfulfilled orders e from the total demand D is designed. Agility a is approached by the order fulfillment rate, which is

$$\mathrm{a} = 1 - \frac{e}{D}$$

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Simulation results

Table 1. Order fulfillment rate (OFR) in the supply chain random network (SCRN). Identical probability distribution for the middlemen's in- and out-degree (k_m^{out}) is assumed and no horizontal relationships among them.

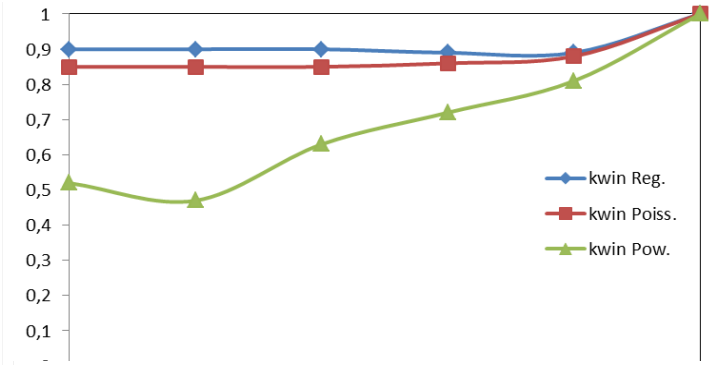
	k_w^{in}											
	(a) $\bar{k}_w^{in} = 2$			(b) $\bar{k}_w^{in} = 2$ (deg. corr.)			(c) $\bar{k}_w^{in} = 4$			(d) $\bar{k}_w^{in} = 8$		
k_m^{out} *	Reg.	Poiss.	Pow.	Reg.	Poiss.	Pow.	Reg.	Poiss.	Pow.	Reg.	Poiss.	Pow.
Reg.	0,9**	0,85	0,52	0,9	0,95	0,58	0,93	0,89	0,54	0,96	0,93	0,52
Poiss.	0,9	0,85	0,55	0,95	0,9	0,54	0,93	0,89	0,59	0,96	0,92	0,58
Pow.	0,87	0,83	0,68	1	0,99	0,74	0,92	0,86	0,84	0,94	0,92	0,95

(a) Relationships among middlemen and wholesalers are randomly assigned, not having into account in and out-degrees;
(b) Relationships among middlemen and wholesalers are ordered according to their degrees, so the wholesaler with the highest number of relationships trade with the middlemen with the highest out-degree, and so on;
(c) Same as (a) with $\bar{k}_w^{in} = 4$;
(d) Same as (a) with $\bar{k}_w^{in} = 8$.

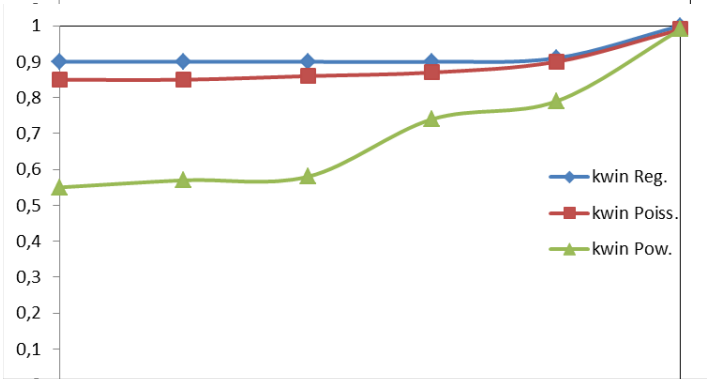
Simulation results. Horizontal links.

OFR with respect to the percentage of middlemen with horizontal links. The cases represent three out-degree distributions of middlemen (k_m^{out}): (a) Regular; (b) Poisson; (c) Power-law.

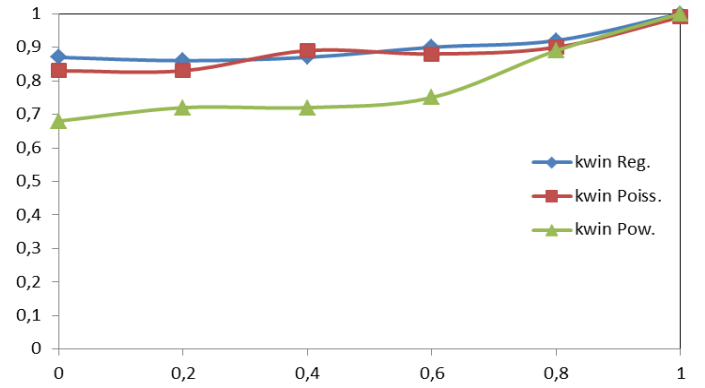
(a)



(b)



(c)



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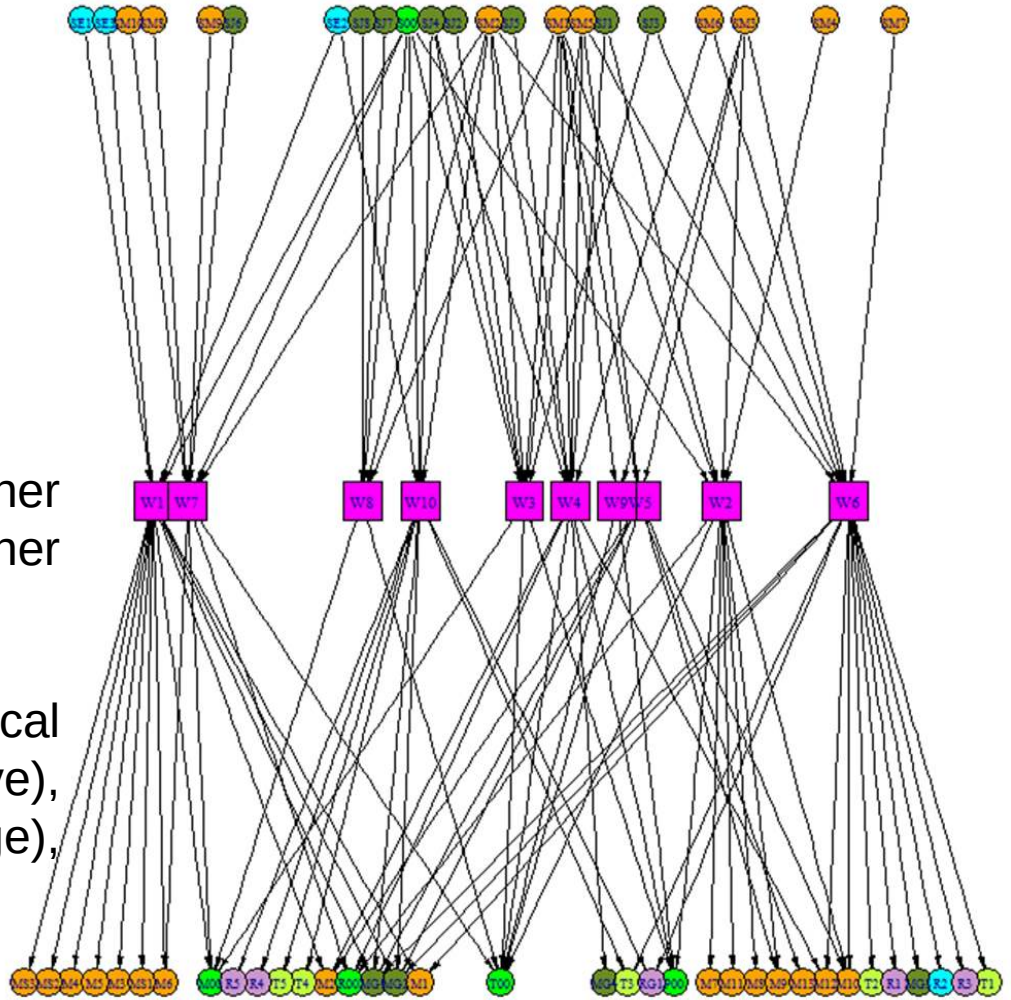
The case study

Seafood supply chain throughout ten wholesalers in Mercado del Mar, Guadalajara, Mexico. Suppliers and buyers, aggregated according the region/state/country where is located.

CLASSIFICATION

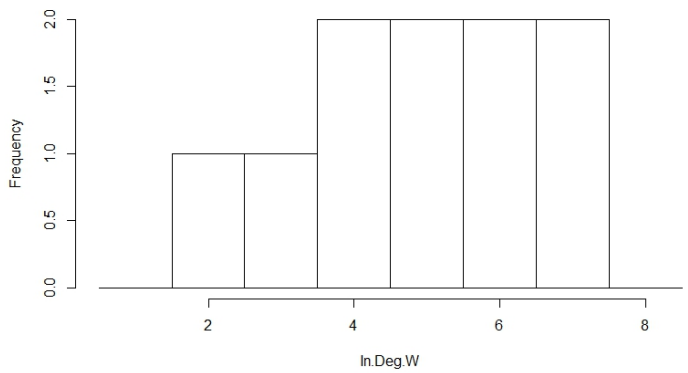
- Suppliers: general (green), foreigner (cyan), local (olive) and from other estates (orange).
- Wholesalers: 10 square boxes
- Retailers: general (green), local markets (olive), tianguis (soft olive), markets from other states (orange), restaurants (violet), foreigner (cyan).



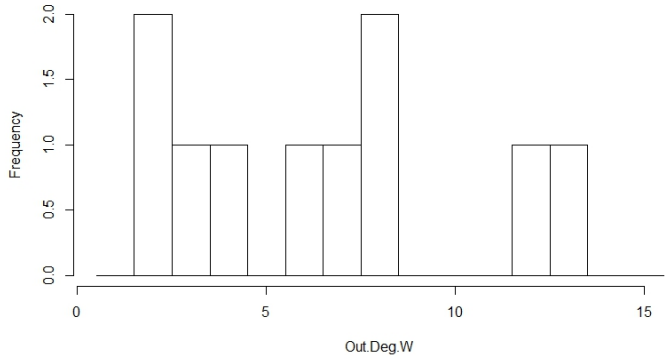
The case study

Degree distributions in the sample of the MM:

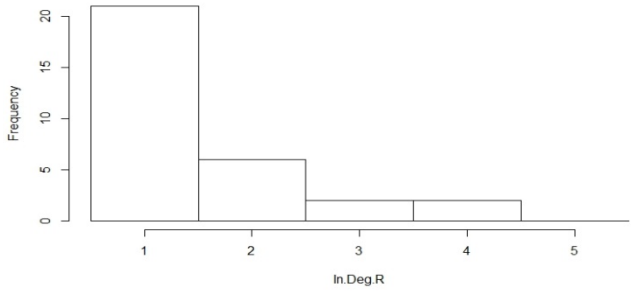
(a) in-degree distribution of wholesalers;



(b) out-degree distribution of wholesalers;



(c) in-degree distribution of retailers



Conclusions

- In seafood supply chains, homogeneous distribution of links result in higher agility of response to sudden demand changes than heterogeneous distributions of links, such as that one induced by scale-free topologies.

- Higher agility levels are obtained by increasing the number of relationships among firms in two subsequent tiers.

- Horizontal relationships favor agility, although their effect is higher when a certain threshold is surpassed.

- The study includes some limitations: a) the algorithm includes a non-realistic mechanistic way of trading, strategic behavior is not considered; b) Other strategies to improve agility are not included, such as adding capacity and increasing inventory levels.

Acknowledgments

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