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# Performance and resilience in the extended organisational ecosystem

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EDUCATING LEADERS FOR 800 YEARS

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*with*
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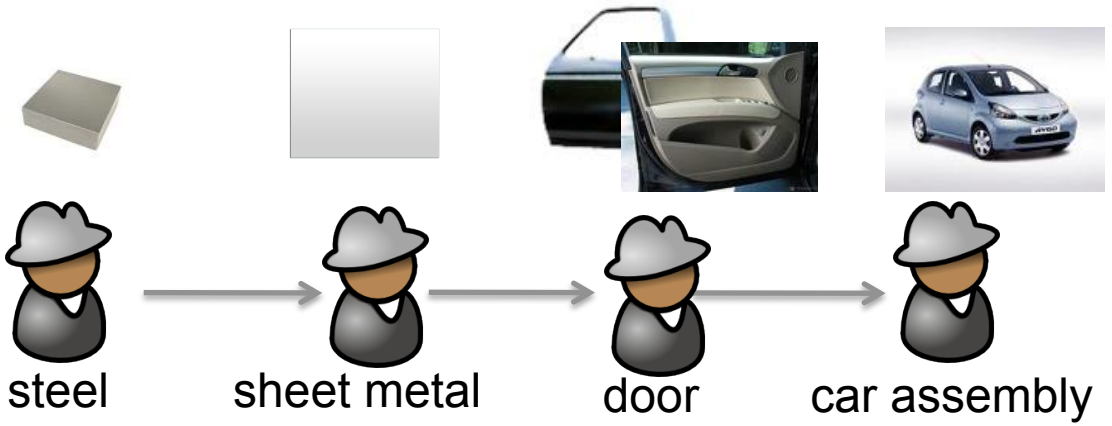
steel
sheet metal
door
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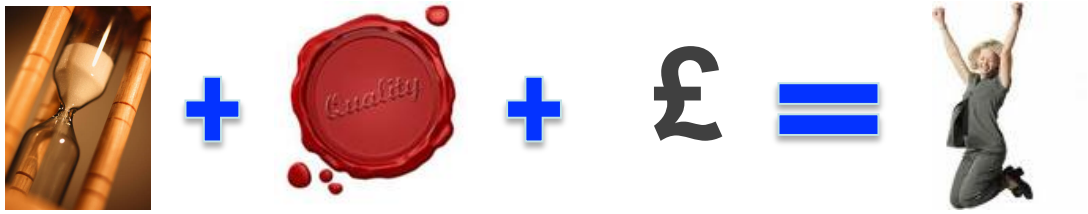
Quality
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## Theories of the organisational ecosystem

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- Transaction cost economics: Focus on transaction costs, risk, and uncertainty as the basis of ‘‘make or buy’’ decisions (Williamson 1975)

- Resource dependency: Each member tries to avoid becoming dependent on others and tries to make others dependent on it (Pfeffer and Salancik 1978)

- Embededness: Created to maximize supply chain performance (Uzzi 1997)

    - *What global structure do these local interactions result in?*

# Why does the extended ecosystem matter?

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## Traceability

**Nestle recalls Milky Bar buttons**
*Food Standards Agency* April 26, 2011

**Nestle recalls coffee in glass scare**
*The Telegraph* May 21, 2010

## Growth

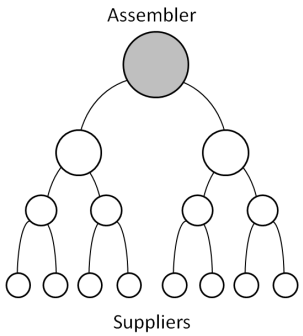
**Wal-mart growth faces supply chain hurdle**
*Reuters* July 28, 2011

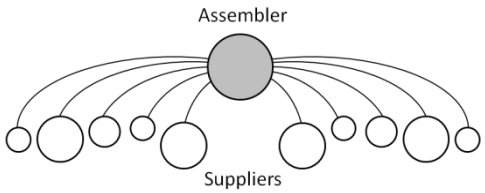
## Robustness

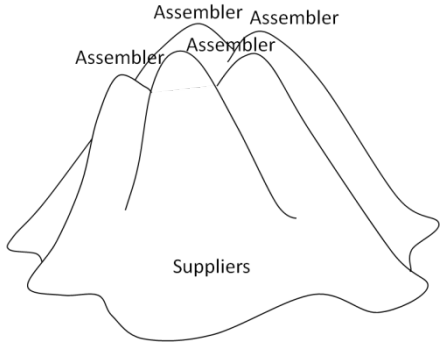
**Japan supply chain fears rattle world stock markets**
*BBC* March 15, 2011

## Operations

**Chief hails emergence of new, simpler Aviva**
*Financial Times* August 4, 2011




*No empirical maps of supply chains exist!*

## Time to look at real data…

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- Iconic production system & supply chain:
  - –Robust:
    - Demand fluctuations
    - Disruptions: Aisin fire, Niigataken Chuetsu-oki earthquake
  - –Knowledge sharing
  - –Global

# The real picture!

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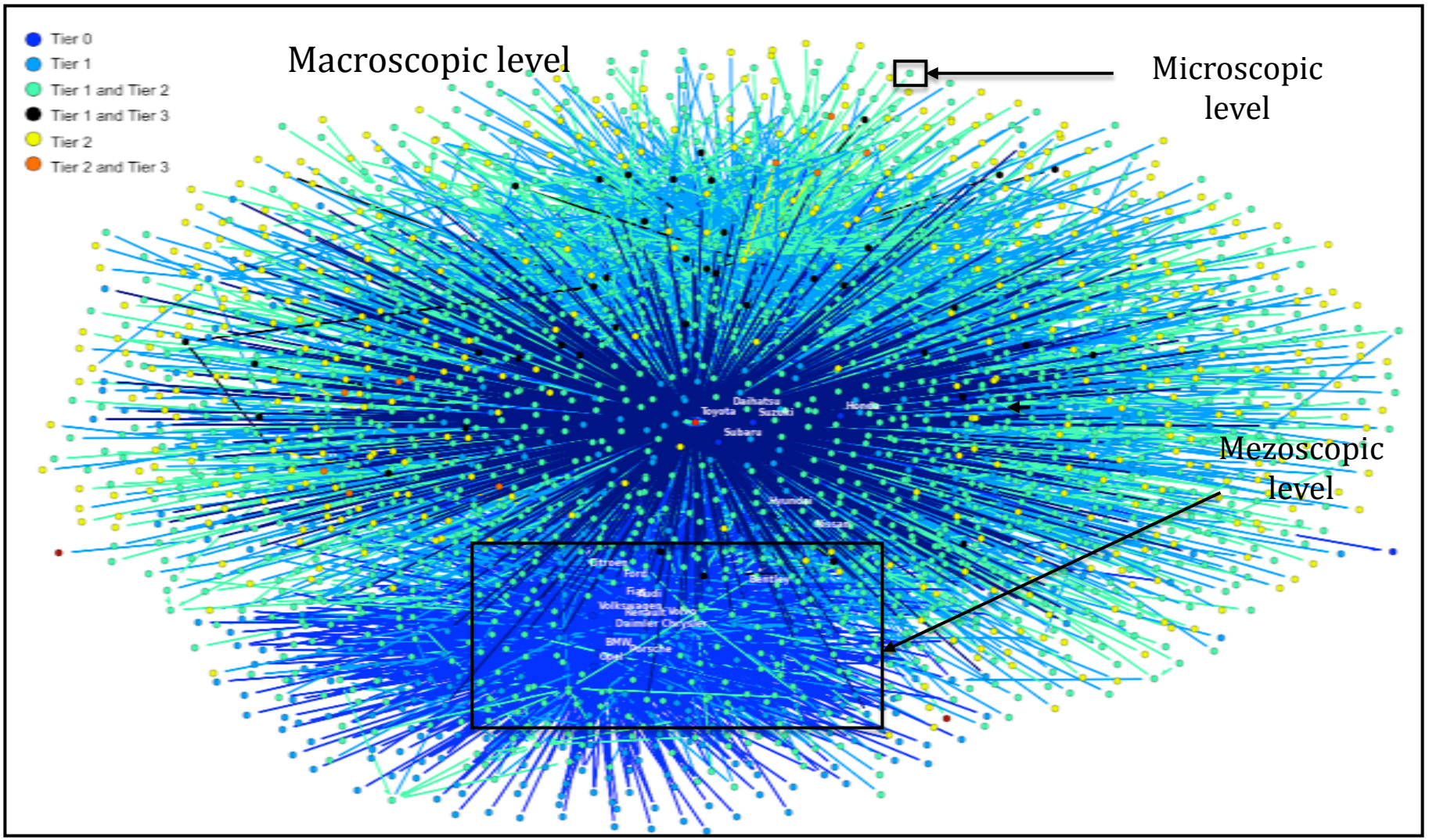

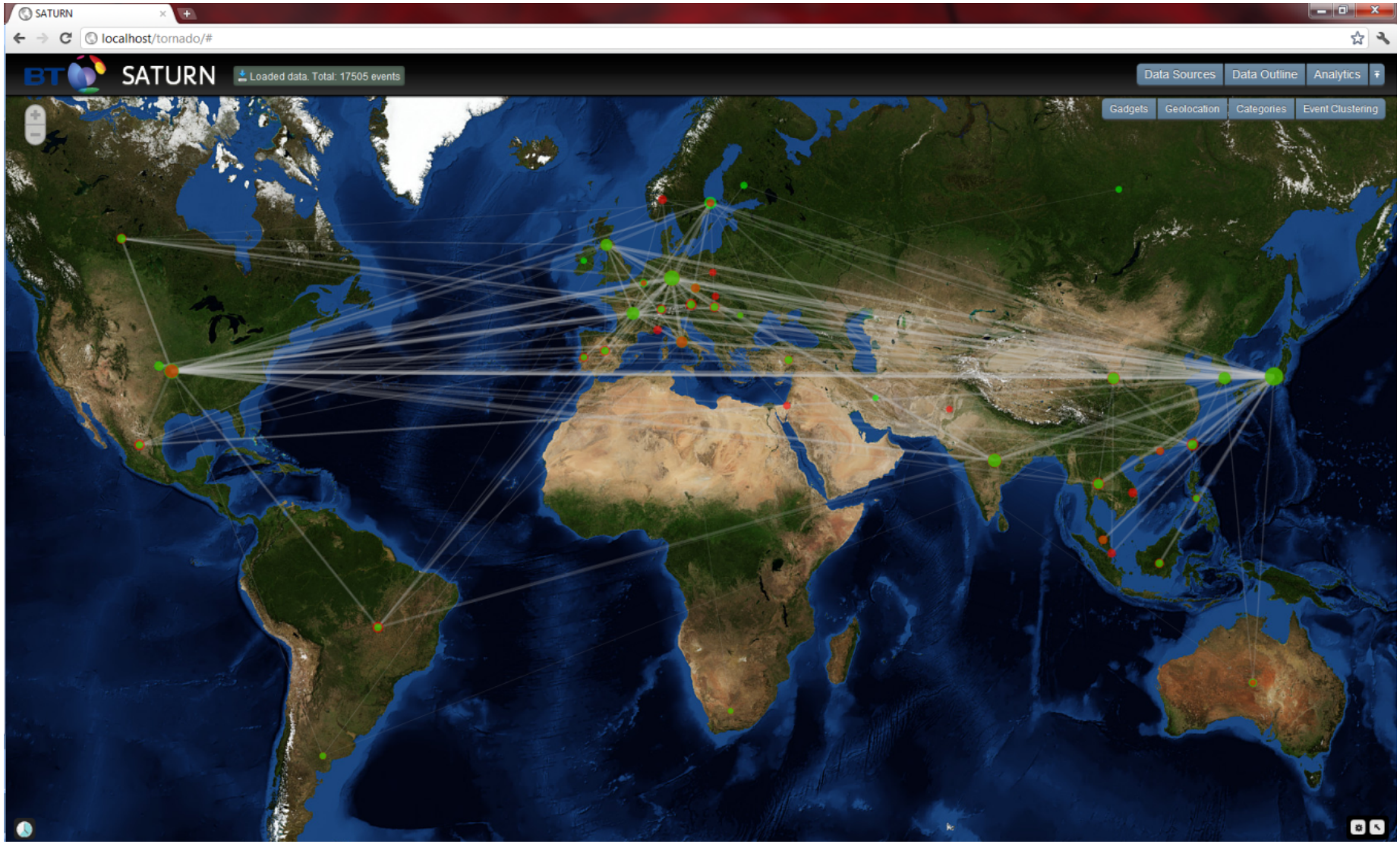
SATURN
localhost/tornado/#
BT
SATURN
Loaded data. Total: 17505 events
Data Sources
Data Outline
Analytics
Gadgets
Geolocation
Categories
Event Clustering

# Redefining tiers

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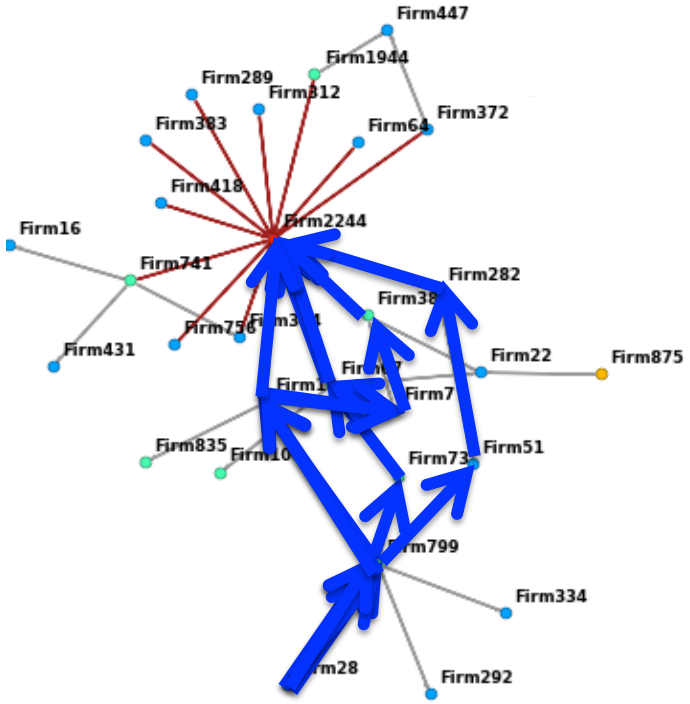


- Traditional definition: shortest length to top
- Reality is multi-tier
- Frequency or mean of paths tells us more

# It's a small world!

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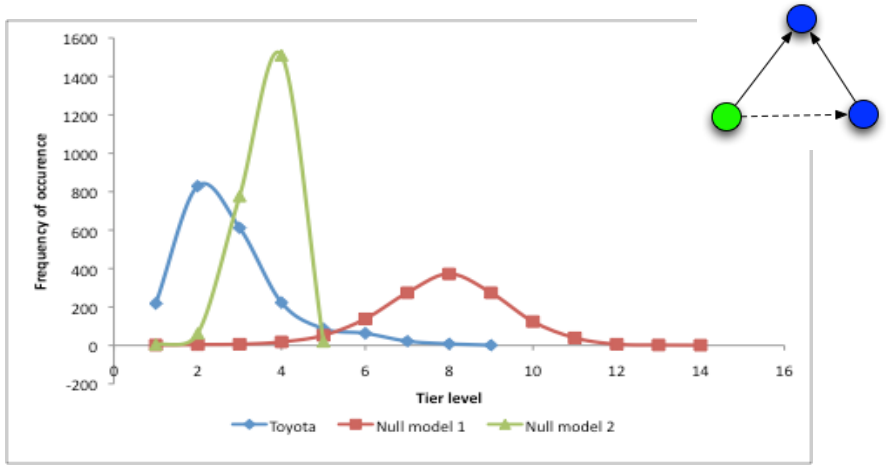
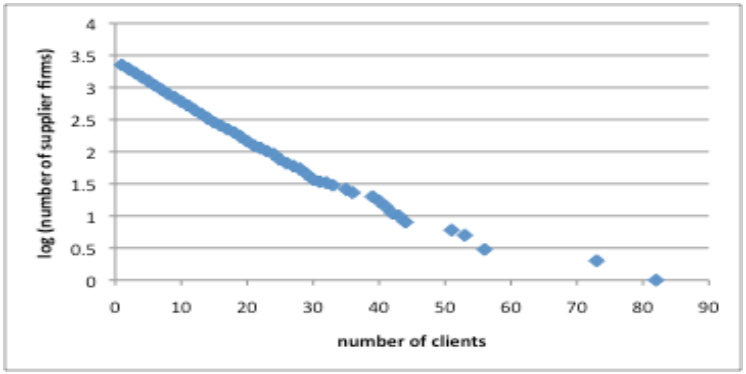
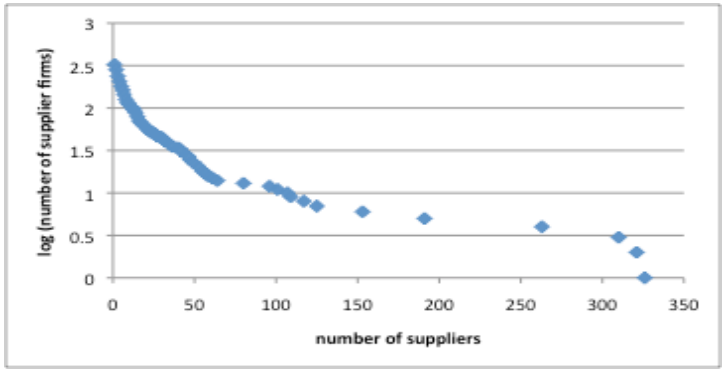



- Average degree of separation is 2.1
  - Fostering diffusion of reputation and facilitation of trust?
- 24% chance for a triad
  - Many firms depend on many other firms directly or indirectly

# Robustness




- Multi-sourcing (5.2 per product type)
- Robust to random failures (6.2 consecutive failures)
- Vulnerable to failures in
  - –Link hubs (3.8 consecutive failures)
  - –Rare product hubs (3.2 consecutive failures)
  - –Japanese firms (5.1 consecutive failures)

# Resilience: Coopetition

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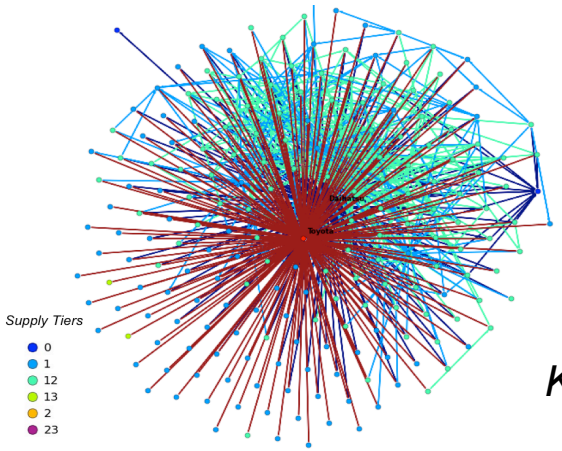
$$C = \sum_{p}^{P} \frac{2l_p}{n_p(n_p - 1)}, 0 \le C \le 1$$

$P$ total number of product types
$l_p$ number of existing links between suppliers who produce Product type $p$
$n_p$ total number of suppliers of Product type $p$




*Kyoho-kai supplier association*
*C=0.21*

- At last we have a real picture of supply chains!
- Metrics to measure how closely strategy aligns with topology
  - –Robustness, information diffusion and cooperation
- Questioned long-standing stylised sketches and  redefined tiers

**Robustness:**
Cascades of disruptions
Synergies in improvement
Trade offs

**Dynamics:**
Adaption
Shrinkage and growth

**Strategy:**
Changing incentive structures - Dyads to Triads
Network positioning

# Sneak peek: *Network effects on firm performance*

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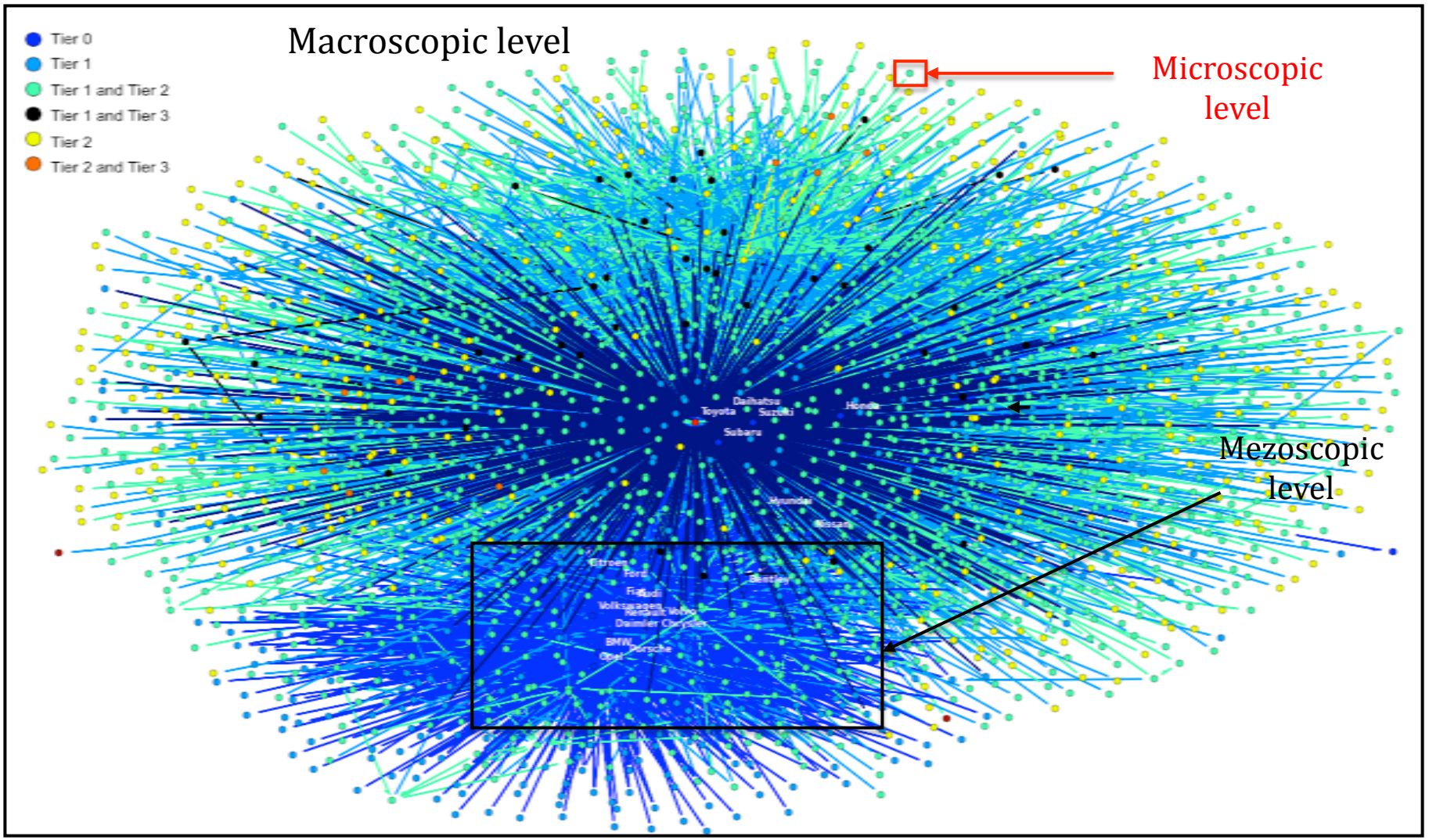

# Sneak peek: *Network effects on firm performance*

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**How is firm performance impacted by the way the firm embeds itself in a supply network?**

- **Methodology:** GLS regression (with Lasso)

- **Dependent variable**: Total annual revenues, Return on assets, EBITDA, Net Profit

  **Independent variables:**

  –General dimensions that impact performance

    - Age (Stinchcombe 1965 ), Firm size (Sørenson and Stuart 2000)

  –Controls:

    - Public/ Private, Japanese/Other (Hennart, Roehl, and Zietlow, 1999 )

  –Network dimensions: *centrality, tiers, triads*

# Network dimensions:
# (1) Supply Network Centrality (SNC)

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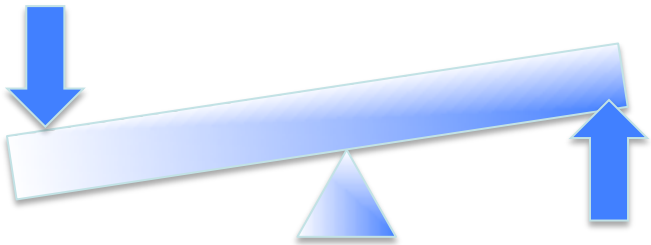
Division of attention (Berry et al 1991)
Relationship instability (Lawson 2008)



**Performance**

Power and control (Kim and Choi 2011)
Risk reduction (Wagner and Bode 2006)

# Network dimensions:
# (1) Supply Network Centrality (SNC)

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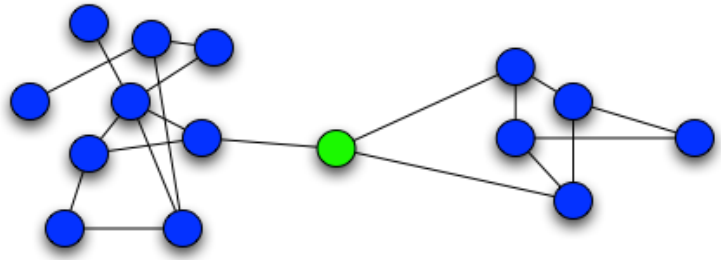
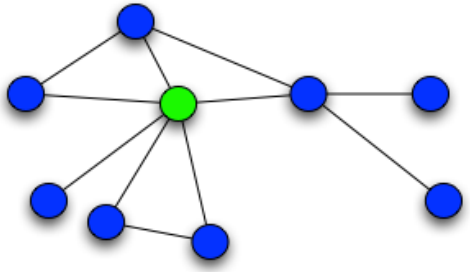
*Positioning for business flow*

- Betweenness centrality



- Degree centrality



# Network dimensions:
# (1) Supply Network Centrality (SNC)

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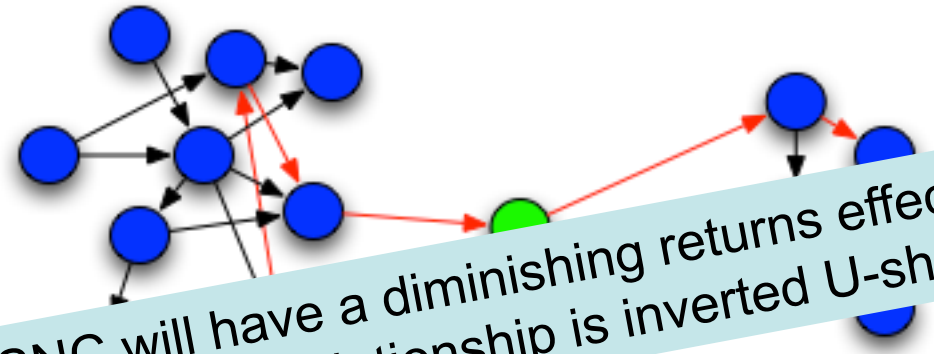
- Supply Network Centrality (SNC):



Hypothesis: SNC will have a diminishing returns effect on performance, hence the relationship is inverted U-shaped

$$M_{ij} = \sum_{k=1}^{N} A_{ik} A_{kj} = \left[A^2\right]_{ij}$$

$$M_{ij}^{L} = \left[A^L\right]_{ij}$$

$$SNC_i = \sum_{l=1}^{L} \sum_{j=1}^{N} \left[M^l\right]_{ij}$$

*N= num nodes*
*L=max tier length*
*i=node*
*j=all other nodes*

# Network dimensions:
# (2) Supply Network Tier Level (SNTL)

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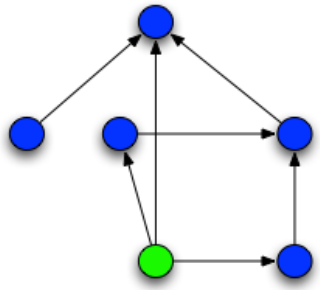
*Positioning for information flow*

$$SNTL_j = \frac{\sum_{l=1}^{L} [M^l]_{ij} .l}{\sum_{l=1}^{L} [M^l]_{ij}}$$



*L=max tier length*
*i=target node*
*j=node*

Hypothesis: SNTL has a negative effect on performance

# Network dimensions:
# (3) Triads

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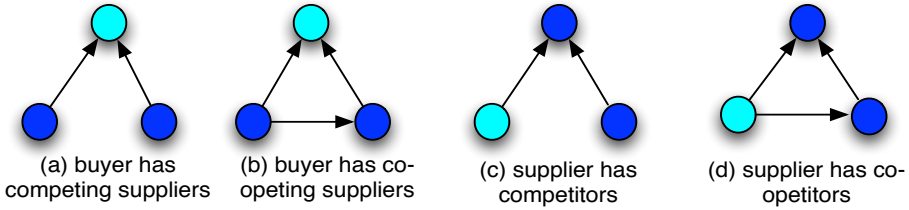
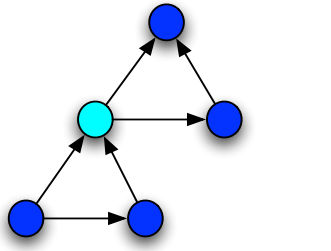
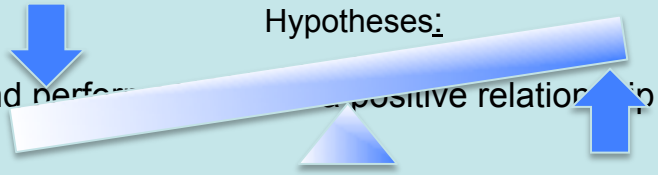



Complexity (Havila 2004, Philips 1998)
Bargaining power loss (Asanuma 1994)
Structural over- embededness (Uzzi 1997)

Hypotheses:

- The number of triads and perfor[illegible]positive relation[illegible]p for both buyers and suppliers



Performance

Structural holes – non redundant information (Burt 1972)
Innovation and cooperation (Hines 1996, Sako 1992)
Efficiency (Kim and Choi 2005, Dubois 2008)
Structural embededness (Uzzi 1997)

- Participation in both upstream and downstream triads will increase complexity and negatively effect firm performance

## The boring but necessary bit…

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- N=115
- There is multicollinearity – divided model into 7 sub-models max VIF 1.05
- Kolmogorov-Smirnov test shows sample is not statistically different
- Performance data from OneSource (inter-resource reliability > 0.71)

# Results

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Tier length

Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate |
|---|---|
| | **Model 1** |
| **Intercept** | 0.002 |
| ***Independent variables*** | |
| SNTL1 | |
| SNTL2 | |
| SNC | |
| $(SNC)^2$ | |
| SSC | |
| SSH | |
| BSC | |
| BSH | |
| SSC X BSC | |
| ***Control variables*** | |
| AGE | 0.186* |
| SIZE | 0.270** |
| PUB | 0.001 |
| JAP | 0.123 |
| | |
| $R^2$ | 0.16 |
| Adjusted $R^2$ | 0.13 |
| F | 5.05 |
| p-value | 9.23e-04 |
| Improvement over base $R^2$ | |

*$p < 0.10$; * $p < 0.05$; ** $p < 0.01$;*** $p < 0.001$*

# Results

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Tier length

Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | |
|---|---|---|
| | **Model 1** | **Model 2** |
| **Intercept** | 0.002 | -0.002 |
| ***Independent variables*** | | |
| SNTL1 | | -0.254** |
| SNTL2 | | |
| SNC | | 0.422*** |
| $(SNC)^2$ | | |
| SSC | | |
| SSH | | |
| BSC | | |
| BSH | | |
| SSC X BSC | | |
| ***Control variables*** | | |
| AGE | 0.186* | 0.248** |
| SIZE | 0.270** | 0.174* |
| PUB | 0.001 | 0.048 |
| JAP | 0.123 | |
| | | |
| $R^2$ | 0.16 | 0.39 |
| Adjusted $R^2$ | 0.13 | 0.35 |
| F | 5.05 | 10.63 |
| p-value | 9.23e-04 | 3.818e-09 |
| Improvement over base $R^2$ | | 0.22 |

*p < 0.10; * p<*

SNTL has a negative impact

SNC has a positive impact

# Results

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Tier length

Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | | |
|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** |
| **Intercept** | 0.002 | -0.002 | -0.811 |
| ***Independent variables*** | | | |
| SNTL1 | | -0.254** | |
| SNTL2 | | | -0.195** |
| SNC | | 0.422*** | 0.366*** |
| $(SNC)^2$ | | | |
| SSC | | | |
| SSH | | | |
| BSC | | | |
| BSH | | | |
| SSC X BSC | | | |
| ***Control variables*** | | | |
| AGE | 0.186* | 0.248** | 0.128** |
| SIZE | 0.270** | 0.174* | 0.256** |
| PUB | 0.001 | 0.048 | 0.054 |
| JAP | 0.123 | | 0.718 |
| | | | |
| $R^2$ | 0.16 | 0.39 | 0.40 |
| Adjusted $R^2$ | 0.13 | 0.35 | 0.37 |
| F | 5.05 | 10.63 | 12.47 |
| p-value | 9.23e-04 | 3.818e-09 | 1.061e-10 |
| Improvement over base $R^2$ | | 0.22 | 0.23 |

*p < 0.10; * p< 0.05; ***

SNTL has a negative impact

SNC has a positive impact

# Results

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Tier length

Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | | | |
|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| **Intercept** | 0.002 | -0.002 | -0.811 | -0.011 |
| ***Independent variables*** | | | | |
| SNTL1 | | -0.254** | | -0.244** |
| SNTL2 | | | -0.195** | |
| SNC | | 0.422*** | 0.366*** | 0.342** |
| $(SNC)^2$ | | | | -0.194* |
| SSC | | | | |
| SSH | | | | |
| BSC | | | | |
| BSH | | | | |
| SSC X BSC | | | | |
| ***Control variables*** | | | | |
| AGE | 0.186* | 0.248** | 0.128** | 0.286** |
| SIZE | 0.270** | 0.174* | 0.256** | 0.174* |
| PUB | 0.001 | 0.048 | 0.054 | 0.045 |
| JAP | 0.123 | | 0.718 | 0.032 |
| | | | | |
| $R^2$ | 0.16 | 0.39 | 0.40 | 0.43 |
| Adjusted $R^2$ | 0.13 | 0.35 | 0.37 | 0.39 |
| F | 5.05 | 10.63 | 12.47 | 9.53 |
| p-value | 9.23e-04 | 3.818e-09 | 1.061e-10 | 1.023e-09 |
| Improvement over base $R^2$ | | 0.22 | 0.23 | 0.27 |

*$p < 0.10$; * $p < 0.05$; ** $p < 0.01$;*** $p < 0.001$*

Centrality has a diminishing returns effect on performance

To find the optimal number of paths a firm can sustain without its returns being diminished, we calculate the absolute value of the partial derivative with respect to SNC:

$$0.34/(2*0.194)=0.88$$

transform variables to their original values

X = mean + standard deviation * z-score, or

X = 285.24+(566.03 * 0.88) = 785.54

# Results

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Tier length

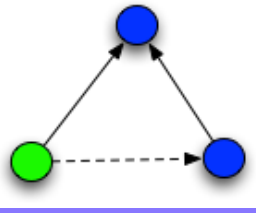
Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | | |
|---|---|---|---|
| | Model 1 | | Model 5 |
| **Intercept** | 0.002 | | -0.003 |
| ***Independent variables*** | | | |
| SNTL1 | | | -0.289** |
| SNTL2 | | | |
| SNC | | | |
| $(SNC)^2$ | | | |
| SSC | | | 0.408*** |
| SSH | | | 0.094 |
| BSC | | | |
| BSH | | | |
| SSC X BSC | | | |
| ***Control variables*** | | | |
| AGE | 0.186* | | 0.241** |
| SIZE | 0.270** | | 0.185* |
| PUB | 0.001 | | 0.035 |
| JAP | 0.123 | | |
| | | | |
| $R^2$ | 0.16 | | 0.42 |
| Adjusted $R^2$ | 0.13 | | 0.38 |
| F | 5.05 | | 10.44 |
| p-value | 9.23e-04 | | 8.323e-10 |
| Improvement over base $R^2$ | | | 0.26 |

*$p < 0.10$; * $p < 0.05$; ** $p < 0.01$;*** $p < 0.001$*



Both SSC & SSH have positive impact

# Results

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Tier length

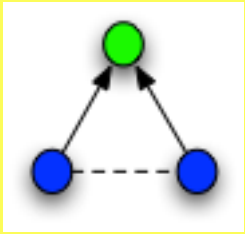
Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | | |
|---|---|---|---|
| | Model 1 | | Model 6 |
| **Intercept** | 0.002 | | -0.001 |
| ***Independent variables*** | | | |
| SNTL1 | | | -0.206 ** |
| SNTL2 | | | |
| SNC | | | |
| $(SNC)^2$ | | | |
| SSC | | | |
| SSH | | | |
| BSC | | | 0.425*** |
| BSH | | | 0.167* |
| SSC X BSC | | | |
| ***Control variables*** | | | |
| AGE | 0.186* | | 0.292** |
| SIZE | 0.270** | | 0.138* |
| PUB | 0.001 | | 0.020 |
| JAP | 0.123 | | |
| | | | |
| $R^2$ | 0.16 | | 0.46 |
| Adjusted $R^2$ | 0.13 | | 0.42 |
| F | 5.05 | | 12.18 |
| p-value | 9.23e-04 | | 3.387e-11 |
| Improvement over base $R^2$ | | | 0.29 |

*p < 0.10; * p< 0.05; ** p < 0.01;*** p < 0.001*



Both BSC & BSH have positive impact

# Results

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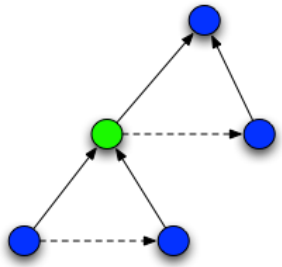
Tier length

Centrality

Suppliers' triads and holes

Buyers' triads and holes

| | Standardized estimate | | |
|---|---|---|---|
| | Model 1 | | Model 7 |
| **Intercept** | 0.002 | | 0.878 |
| ***Independent variables*** | | | |
| SNTL1 | | | -0.193** |
| SNTL2 | | | |
| SNC | | | |
| $(SNC)^2$ | | | |
| SSC | | | 0.343* |
| SSH | | | |
| BSC | | | 0.490* |
| BSH | | | |
| SSC X BSC | | | -0.481• |
| ***Control variables*** | | | |
| AGE | 0.186* | | 0.118 |
| SIZE | 0.270** | | 0.229 |
| PUB | 0.001 | | 0.056 |
| JAP | 0.123 | | 0.662 |
| | | | |
| $R^2$ | 0.16 | | 0.42 |
| Adjusted $R^2$ | 0.13 | | 0.37 |
| F | 5.05 | | 9.71 |
| p-value | 9.23e-04 | | 4.219e-10 |
| Improvement over base $R^2$ | | | 0.25 |



Positive impact diminishes when taken together

*$p < 0.10$; * $p < 0.05$; ** $p < 0.01$;*** $p < 0.001$•*

## Micro contributions



- Questioned centrality in a supply network
- Network measures should be specific to supply networks
- Network does have a significant impact on performance
- Need:
  - –Comparative studies
  - –Other industries

# Paving the path to complex supply networks

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*Challenge 1: Proof*

- Traceability technology
- Responsibility of the big guys

*Challenge 2: Acceptance*

- How much stochasticity, how much complexity

*Challenge 3: Understanding*

- New models

# Thank you