# Supply Network in Korean High-Tech and Low-and-Medium Tech: Social Network Approach

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# INTRODUCTION

# Motivation

### Traditional Perspective

Traditionally supply chain studies have focused on dyadic and linear perspectives

### Recent Interest

Recent researches have shown interest in the network structure of supply network as a complex system

### Supply chain as a complex system

Supply chain as a complex system that interactions, relationships, and flows between the individual firms and how the structural characteristics influence the outcome.

# Purpose of Study

This study aims to reveal distinctive structural characteristics between industries by comparing Korean high-tech and low-and-medium-tech industry's supply networks.

# Research Questions

**Research Question 1**

What are the structural characteristics in the Korean electronics industry's supply network as a high-tech and steel industry's supply network as a low-and-medium tech supply network?

**Research Question 2**

What are the similarities and differences in the both industries' supply networks?

**Research Question 3**

How is the structural equivalence established in both supply network?

# RELATED LITERATURE

# High and Low Technology Industry

- Traditional technologies and LMT sectors are vital for general economic growth.
  - The interaction between the old and the emerging technological paradigms leads to dynamic innovation processes.
  - The viability of highly innovative sectors depends heavily on the health of established and mature industries that comprise the rest of the economy

*Robertson, P.L., Pol, E., Carroll, P., 2003.*

### Reasoning for comparison

It is important to identify the unique network characteristics and structural configuration of the high- and low- tech industries that lead national development in Korea in order to expend knowledge how the structural position among the companies influence their outcomes.

# Social Network in Supply Chain

## Network Embededness

In the network perspective an individual firm's behavior and strategic decision are dependent on the firm's network position and other actors' behavior and structural location that is represented in network embededness (Borgatti & Li, 2009; Vasudeva et al., 2013).

## Social network perspective in supply chain context

Since the time in which the social network analysis was introduced into the supply chain study, a need for interpreting social network indicators corresponding to supply chain context has continuously been identified (Bellamy & Basole, 2013; Borgatti & Li, 2009; Kim et al., 2011).

## Definition of Supply Network

Kim, Choi, Yan and Dooley (2011) maintained that supply network "consist of inter-connected firms that engage in procurement, use, and transformation of raw materials to provide goods and services" (p.195).

## SNA study classification in supply chain literature

Bellamy and Basole (2012) derived three research themes from the supply chain research that used social network perspectives such as SCS structure, SCS dynamics and SCS strategy.

### Material flow and contractual relationship

Kim et al. (2011) suggested a framework that differentiates the supply network as material flow and contractual relationship. This taxonomy provides an analytic framework for interpreting social network indicators in supply chain context.

### Interpretation SNA indicator in supply network

Borgatti and Li (2009) introduced key theoretical perspectives of social network analysis corresponding to supply chain management perspective, and provide network concepts and interpretation of social network indicator that reveal complex behaviors and interactions in supply networks.

# METHOD

# Sample

- Data Collection (total 7,687 firms from 6 industry)
  - Cretop Corporation Credit Report
  - Relational Information from major customer and major procurement
- High- and low tech classification
  - OECD: Technology Intensity Definition
  - ISIC: Eurostat, High-tech industry and knowledge-intensive service
  - The Korean Standard Industrial Classification
    - C241: Manufacture of Basic Iron and Steel
    - C242: Manufacture of Basic Precious and Non-ferrous Metals
    - C243: Cast of Metals
    - C261: Manufacture of Semiconductor
    - C262: Manufacture of Electronic Components
    - C264: Manufacture of Telecommunication and Broadcasting Apparatuses

# Procedure

- Data Collection
- Data Cleaning
- Building Network Structure
- Extracting Networks by Configuration
    - All industry
    - Seperated industry (E and S)
    - Directed
    - Undirected
    - All Graph
    - Component

- Electronics Industry Network (Including other industry's nodes)
  - Nodes: 4676
  - Edges: 6382
  - Giant Component Nodes: 4374
  - Giant Component Edges: 6117
- Steel Industry Network (Including other industry's nodes)
  - Nodes: 3095
  - Edges: 4360
  - Giant Component Nodes: 2982
  - Giant Component Edges: 4264

- Electronics Industry Network (excluding other industry's nodes)
  - Nodes: 734
  - Edges: 1456
- Steel Industry Network (excluding other industry's nodes)
  - Nodes: 486
  - Edges: 864

# FINDINGS

# Network Visualization

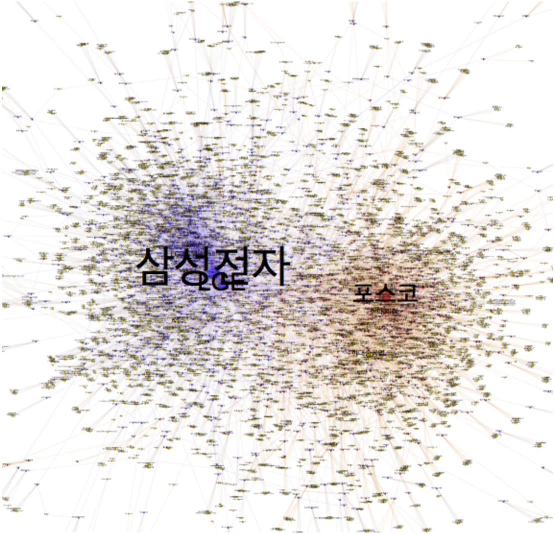



Figure 1: Electronic and Steel Industry

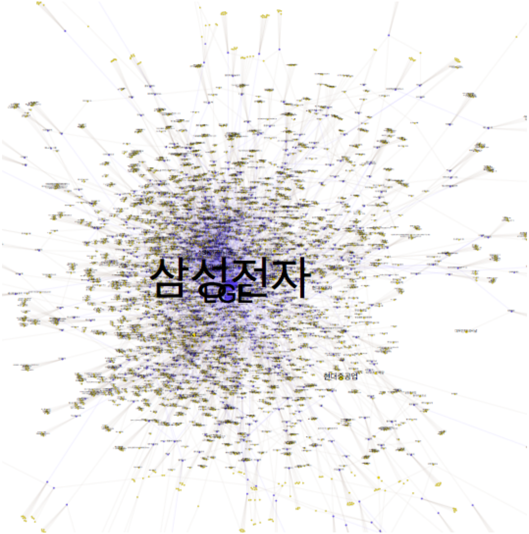



Figure 2: Electronic and Steel Industry

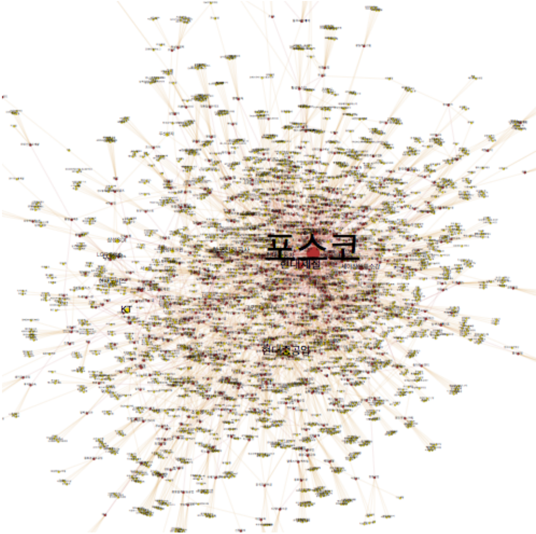



Figure 3: Electronic and Steel Industry

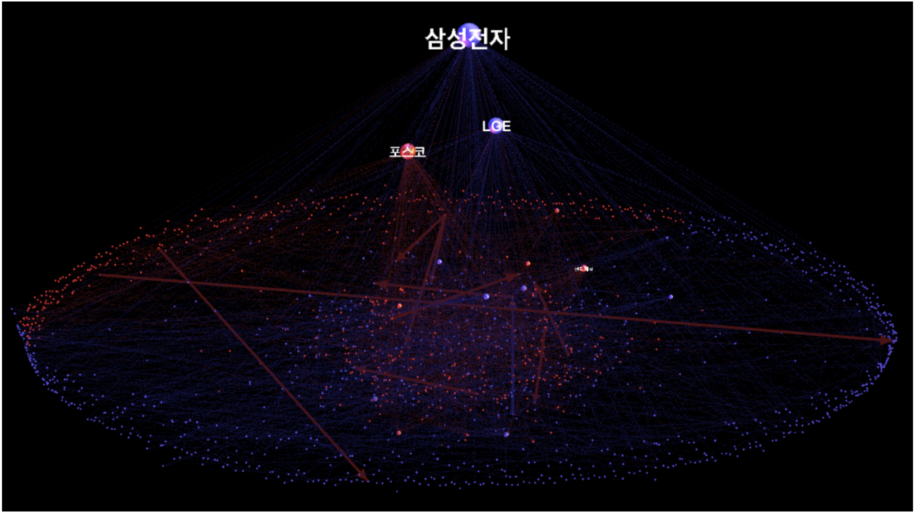



Figure 4: Electronic and Steel Industry

# Network Analysis - Graph Level

Table 1: Graph Charateristics 1

| | Node | Edge | Density |
|---|---|---|---|
| Electronics | 734 | 1456 | 0.0027 |
| Steel | 486 | 864 | 0.0036 |

| | Diameter | Average Path Length | Clustering Coefficient |
|---|---|---|---|
| Electronics | 19 | 6.12 | 0.016 |
| Steel | 14 | 4.78 | 0.023 |

Table 2: Graph Charateristics 2

| | Reciprocity | Mutuality | Transitivity |
|---|---|---|---|
| Electronics | 0.105 | 77 | 0.024 |
| Steel | 0.134 | 58 | 0.022 |

| | Centralization Degree | Centralization Betweenness | Centralization Closeness |
|---|---|---|---|
| Electronics | 0.1482 | 0.1237 | 0.0002 |
| Steel | 0.1636 | 0.1177 | 0.0033 |

# Network Analysis - Node Level

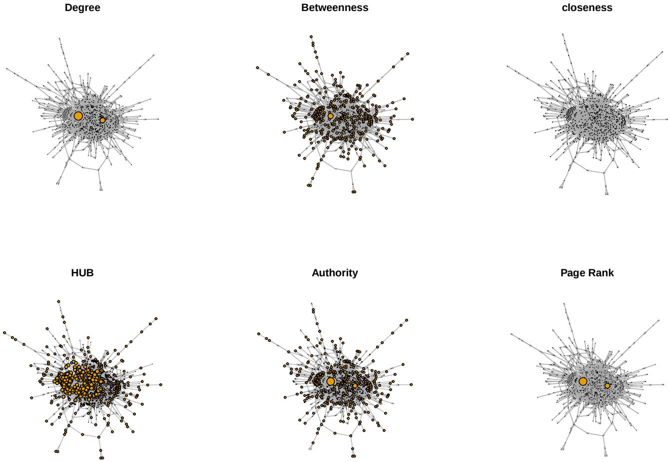
Table 3: Centrality - Electronics

| Rank | Degree | | Betweenness | | Closeness | |
|---|---|---|---|---|---|---|
| | Node Id | Value | Node Id | Value | Node Id | Value |
| 1 | E0876 | 221 | E0876 | 67221 | E0217 | 2.81E-6 |
| 2 | E0892 | 134 | E0171 | 31586 | E0055 | 2.80E-6 |
| 3 | E0193 | 56 | E0844 | 30531 | E0112 | 2.79E-6 |
| 4 | E0592 | 50 | E0892 | 28752 | E0011 | 2.78E-6 |
| 5 | E0115 | 48 | E0560 | 25352 | E0097 | 2.76E-6 |

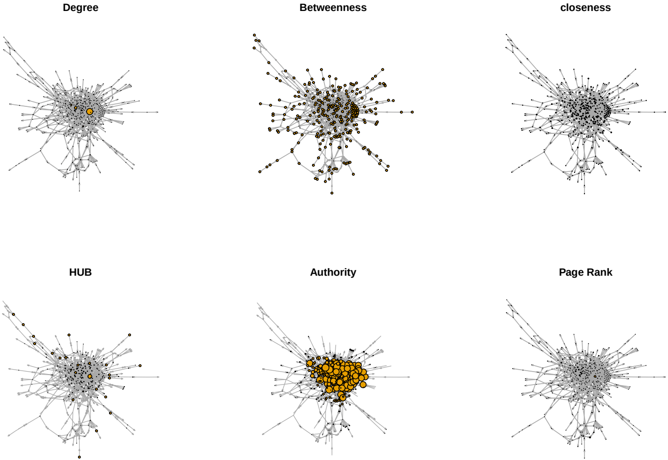
Table 4: Centrality - Steel

| Rank | Degree | | Betweenness | | Closeness | |
|---|---|---|---|---|---|---|
| | Node Id | Value | Node Id | Value | Node Id | Value |
| 1 | S0454 | 162 | S0454 | 27888 | S0389 | 1.31E-05 |
| 2 | S0020 | 66 | S0143 | 13925 | S0387 | 1.31E-05 |
| 3 | S0075 | 37 | S0395 | 12150 | S0630 | 1.24E-05 |
| 4 | S0005 | 32 | S0020 | 8037 | S0050 | 1.24E-05 |
| 5 | S0002 | 28 | S0002 | 7547 | S0650 | 1.24E-05 |

# Electronics Industry



## Steel Industry



# Rev. by Degree and Constrain

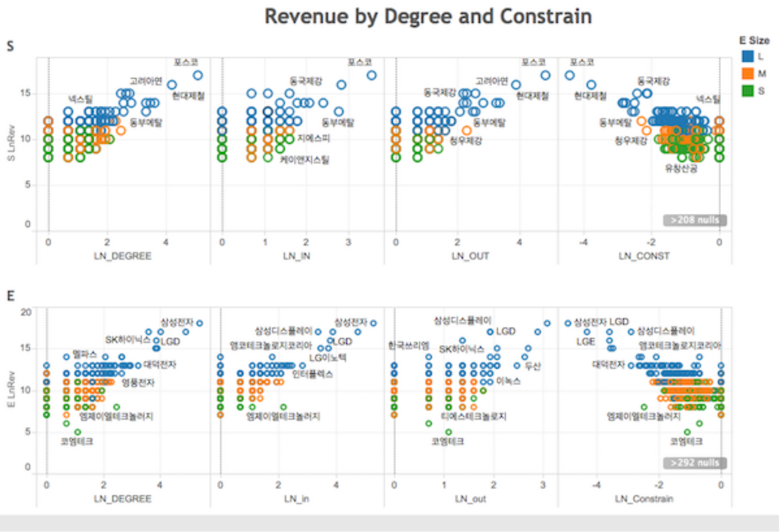



Figure 5:

# NETWORK CHARACTERISTICS

# Census

Dyad Census - Electronics

```
## $mut
## [1] 77
##
## $asym
## [1] 1302
##
## $null
## [1] 267632
```

```
## $mut
## [1] 58
##
## $asym
## [1] 748
##
```

```
##                              Electronics    Steel
## 003 A,B,C                       64667379 18641197
## 012 A->B, C                       882163   329270
## 102 A<->B, C                       51236    26252
## 021D A<-B->C                        1263     9445
## 021U A->B<-C                       26792      901
## 021C A->B->C                        4724     4995
## 111D A<->B<-C                       4331      420
## 111U A<->B->C                        413     1266
## 030T A->B<-C, A->C                   167      112
## 030C A<-B<-C, A->C                     6        3
## 201 A<->B<->C                        166       54
## 120D A<-B->C, A<->C                   17       14
## 120U A->B<-C, A<->C                    6        7
## 120C A->B->C, A<->C                   13        3
## 210 A->B<->C, A<->C                    8        1
## 300 A<->B<->C, A<->C                   0        0
```

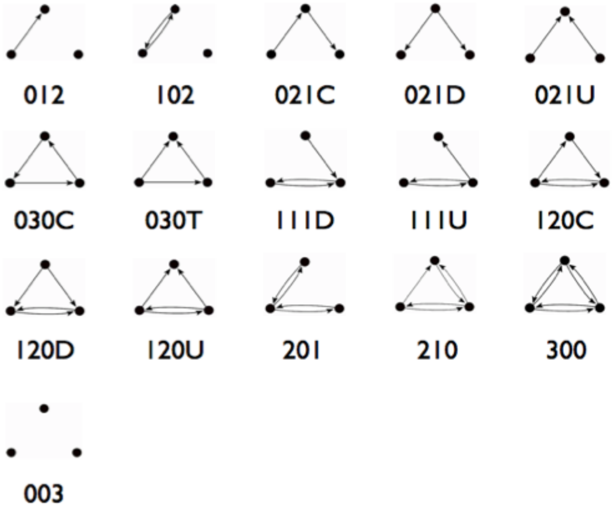
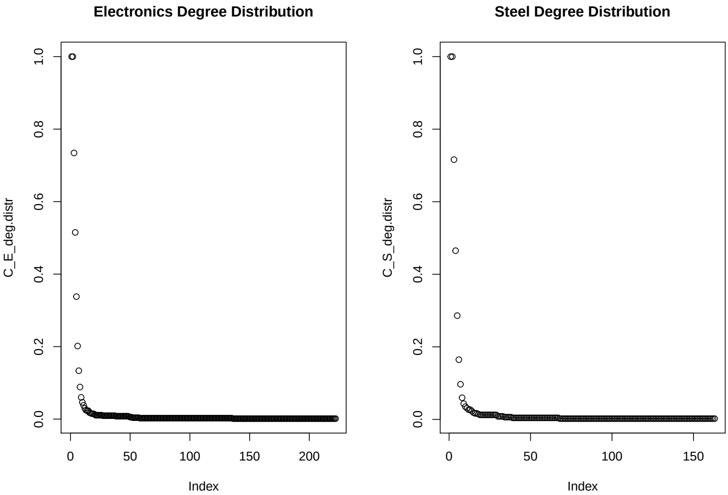
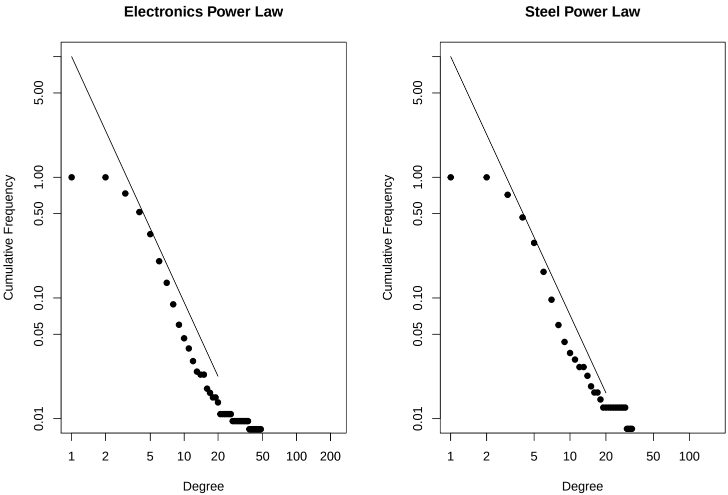



Figure 6: Configulation of Triad

# Distribution



# Power Law


Electronics Power Law
Cumulative Frequency
5.00
1.00
0.50
0.10
0.05
0.01
1
2
5
10
20
50
100
200
Degree
Steel Power Law
Cumulative Frequency
5.00
1.00
0.50
0.10
0.05
0.01
1
2
5
10
20
50
100
Degree

Power Law test

```
##          Electronics Steel
## alpha         3.036 3.142
## KS.stat       0.038 0.061
## KS.p          0.870 0.677
```

# TYPOLOGY

# Typology: Hub and Authority

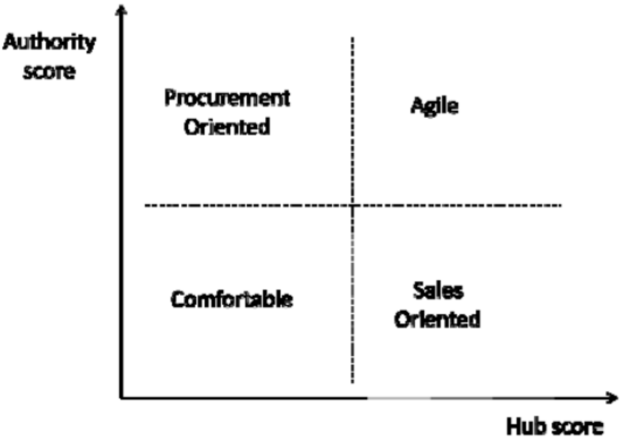



*Figure 5. Typology of firms based on hub and authority scores.*

Figure 7: From Borgatti and Li, 2009

- Hub Score (suppliers have many alternative customers)

$$u_i = \lambda \sum_j x_{ij} v_j$$

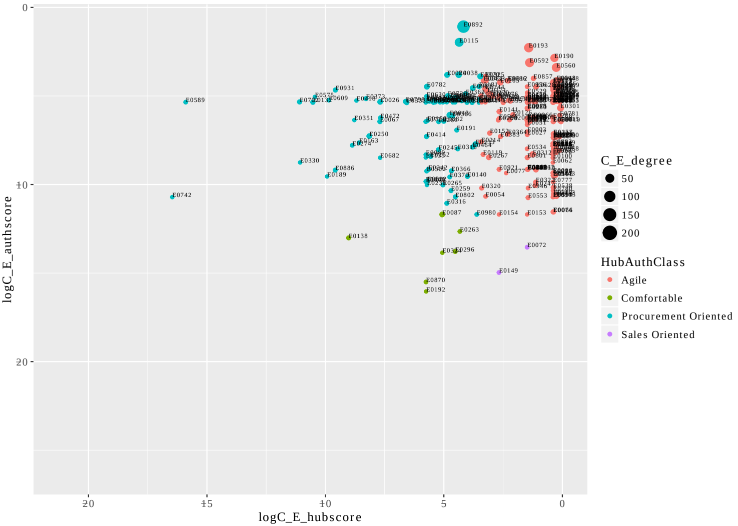
- Authority Score (buyers have many alternative suppliers)

$$v_i = \lambda \sum_i x_{ij} u_j$$

- Agile: firms that are both high hubs and authorities
  - These are firms that must be highly agile to survive.
- Sales-oriented: Firms that are hubs but not authorities
  - firms that face serious competition in selling their goods, but have a good situation with respect to their suppliers.
- Procurement-oriented: Firms that are authorities and less hubs
  - face relatively simple sales environments.
- Comportable: firms that are neither hubs nor authorities
  - Relatively calm waters on both fronts – an enviable position but also at risk of stagnation.

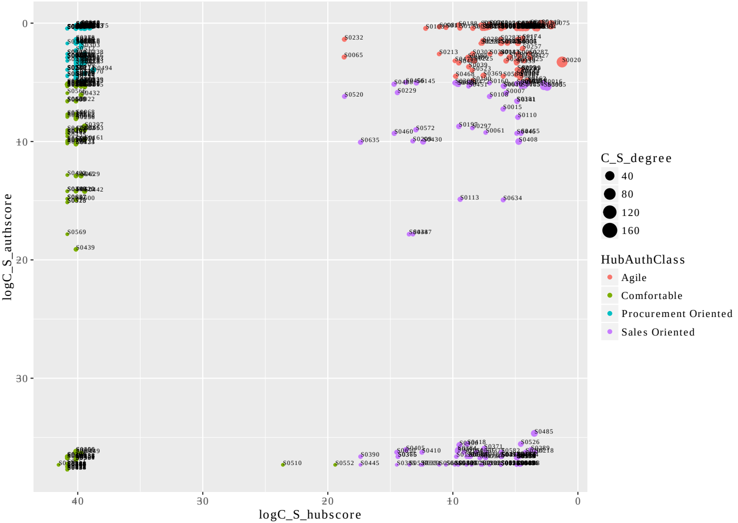
# Typology: Hub and Authority Electronics Industry

Median : Hub(0.0317), Authority(0.00000837)



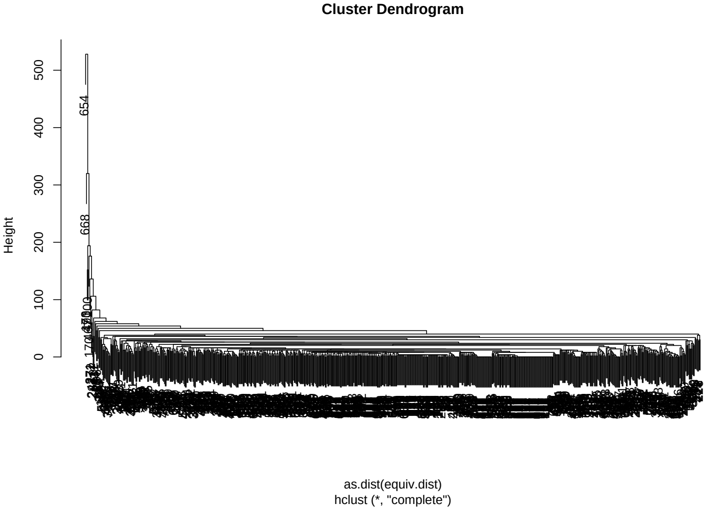
# Typology: Hub and Authority Steel Industry

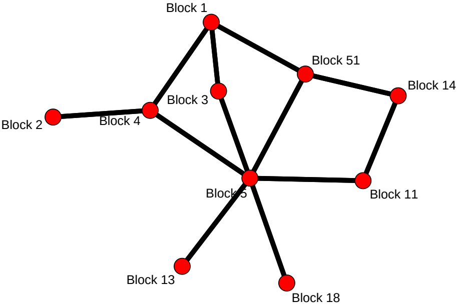
Median : Hub(0.00000000565), Authority(0.00685)



# STRUCTURAL EQUIVALENCE

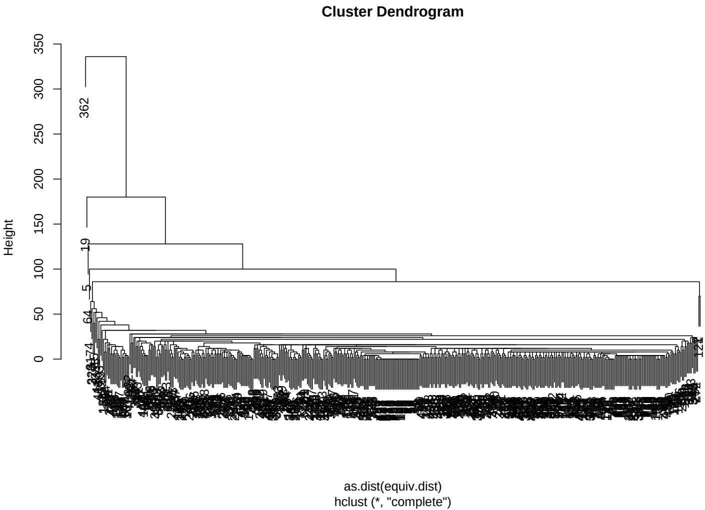
# Block modeling for electronics

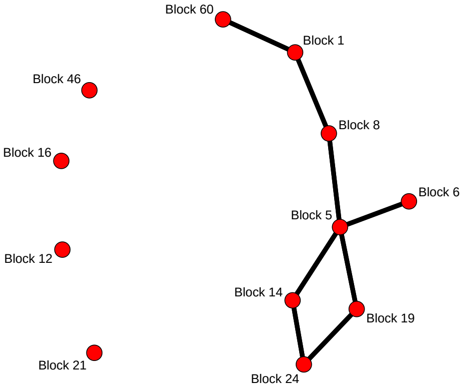



Block 1
Block 51
Block 14
Block 3
Block 2
Block 4
Block 5
Block 11
Block 13
Block 18

```
##                  1      2     3       4       5   8    11
## meanCAGR      9.526 -2.615 -5.0   0.333  -2.279  34 -12.8  6
## meanProfit    3.186  3.115  2.6   2.833   2.791   2  -6.4  1
## meanNofEmp   89.000 93.500 83.0 168.000 119.500 152 271.0 45
## meanAge      16.820 20.462 20.2  12.500  21.093  10  22.0 13
## NofNodes    534.000 26.000  5.0   6.000  43.000   1   5.0  5
##               51       NA
## meanCAGR     1.5    4.880
## meanProfit   3.5    1.280
## meanNofEmp  84.0  105.500
## meanAge     16.0   18.333
## NofNodes     4.0       NA
```

# Block modeling for steel




Block 60
Block 1
Block 46
Block 8
Block 16
Block 6
Block 5
Block 12
Block 14
Block 19
Block 21
Block 24

```
##                    1      5     6      8     12     14     16
## meanCAGR       2.285 -3.717  -8.8  4.571 -1.125 -4.059  0.143
## meanProfit     2.227  3.087   3.8 -3.857  4.750  1.647  3.143
## meanNofEmp    54.000 68.500 156.0 67.000 66.000 57.000 60.000
## meanAge       21.354 19.130  23.2 28.286 19.625 27.235 21.143
## NofNodes     277.000 46.000   5.0  7.000  8.000 17.000  7.000
##                  24     46     60     NA
## meanCAGR      9.909  0.812  -0.75 -0.232
## meanProfit    2.000  0.000   0.75  1.986
## meanNofEmp   91.000 66.500 138.00 51.000
## meanAge      27.545 16.750  36.50 23.072
## NofNodes     11.000 16.000   4.00     NA
```

# ADDITIONAL ANALYSIS

# Small World Test

Electronics

```
# Simulated Clustering Coefficient
summary(C_E_cl.rg)

##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## 0.001553 0.004180 0.005259 0.005355 0.006309 0.010220

# Observed Clustering Coefficient
C_E_inet_cluster_coefficient

## [1] 0.01697966
```

```
# Simulated Average Path Length
summary(C_E_apl.rg)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   4.809   4.879   4.899   4.898   4.917   4.986
```

```
# Observed Average Path Length
C_E_inet_average_path_length
```

```
## [1] 3.871656
```

Steel

```
# Simulated Clustering Coefficient
summary(C_S_cl.rg)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## 0.000000 0.005018 0.006964 0.007295 0.009009 0.016080
```

```
# Observed Clustering Coefficient
C_S_inet_cluster_coefficient
```

```
## [1] 0.02399863
```

```r
# Simulated Average Path Length
summary(C_S_apl.rg)

##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   4.776   4.900   4.935   4.933   4.964   5.104

# Observed Average Path Length
C_S_inet_average_path_length

## [1] 4.233117
```

# DISCUSSION

## Importance of study

Comparing electronics industry and steel industry is meaningful. Although there is gap between level of technology, both industries are regarded as Korea's foundational industry that sustain economical wealth. Moreover, each industries relational structure provides comparision criteria for each other.

## Embededness

Firms are inter-connected and embeded in their economical and contractual relationship.

## Implication

In a case that need to select firms for nurturing. In general, selection criteria for nurturing small and medium firms are limited in financial perspective.

## Limitation

- Cross-sectional data
- Binary network
- Limited relation

## Futher Research

- Social selection
- Social influence effect
- Peer effect
- Dynamics and evolution of network

# CONCLUSION

This study purposes to reveal distinctive structural characteristics between the electronics industry as a high-tech one and metallurgical industry as a low-and-medium-tech one, and to investigate the influence of the supply networks on company's innovation efforts and outcomes.

Each industry have showed distingitive struture that individual firm's behavior and performance is enhanced or constrained by individual firm's position in the supply network structure.

## Resource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# QUESTION and ANSWER


Figure 8: Question and Answer