

# **The Hard Sciences and the Soft: bibliometrical analysis of literature on the Internet of Things**

group 3(1), 2nd year

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# “The Hard Sciences and the Soft: Some Sociological Observations” by Norman Storer, 1967

HARD ← → SOFT

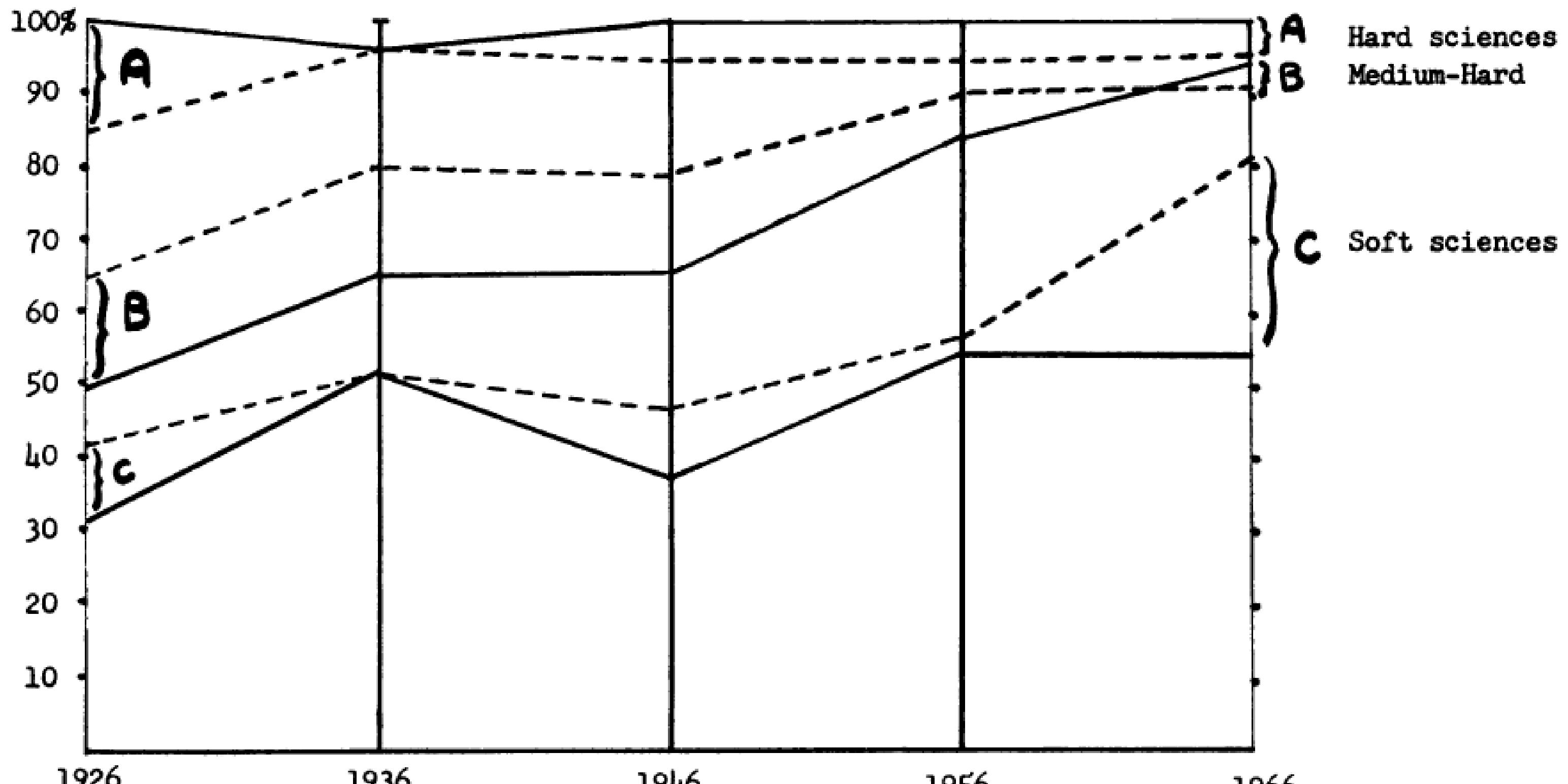
mathematical models

time and effort to attain knowledge

reproducibility of results

difficulty of contribution

attention and professional recognition



— Articles using initials-only footnotes.  
- - - Articles using tables.

**A. Hard sciences:**

- Physics (*Physical Review, Proceedings of the Royal Society*).  
Chemistry (*Journal of the Chemical Society, Journal of the American Chemical Society*).  
Biochemistry (*Journal of Biological Chemistry, Biochemical Journal*).  
Total articles (one issue of each journal for each year): 1926–86, 1936–89, 1946–84,  
1956–86, 1966–83.

**B. Medium-Hard:**

- Botany (*American Journal of Botany, Annals of Botany*).  
Zoology (*American Journal of Anatomy, Annals and Magazine of Natural History*).  
Economics (*The Economic Journal, American Economic Review*).  
Total articles: 1926–43, 1936–54, 1946–38, 1956–47, 1966–54.

**C. Soft sciences:**

- Psychology (*British Journal of Psychology, American Journal of Psychology*).  
Sociology (*American Journal of Sociology, American Sociological Review*).  
Political Science (*American Political Science Review, International Affairs*).  
Total articles: 1926–48, 1936–50, 1946–47, 1956–60, 1966–58.

# Internet of things

≡

The Internet of things (IoT) - physical objects (or groups of such objects) with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks

**Fields of application:**  
**economy, production,**  
**healthcare, Smart city and**  
**Smart home**

# Scientific consensus

agreement in the scientific community regarding the content of scientific knowledge, the consistency of points of view on the most significant issues of scientific activity



Core knowledge

Claims on  
knowledge

# **Aim of the study**

**Examine Internet of Things articles from different disciplines for scientific consensus**

## **Object:**

**scientific disciplines studying the Internet of things**

## **Subject:**

**structure of the scientific knowledge about the Internet of things in the disciplines**

Independent variable:

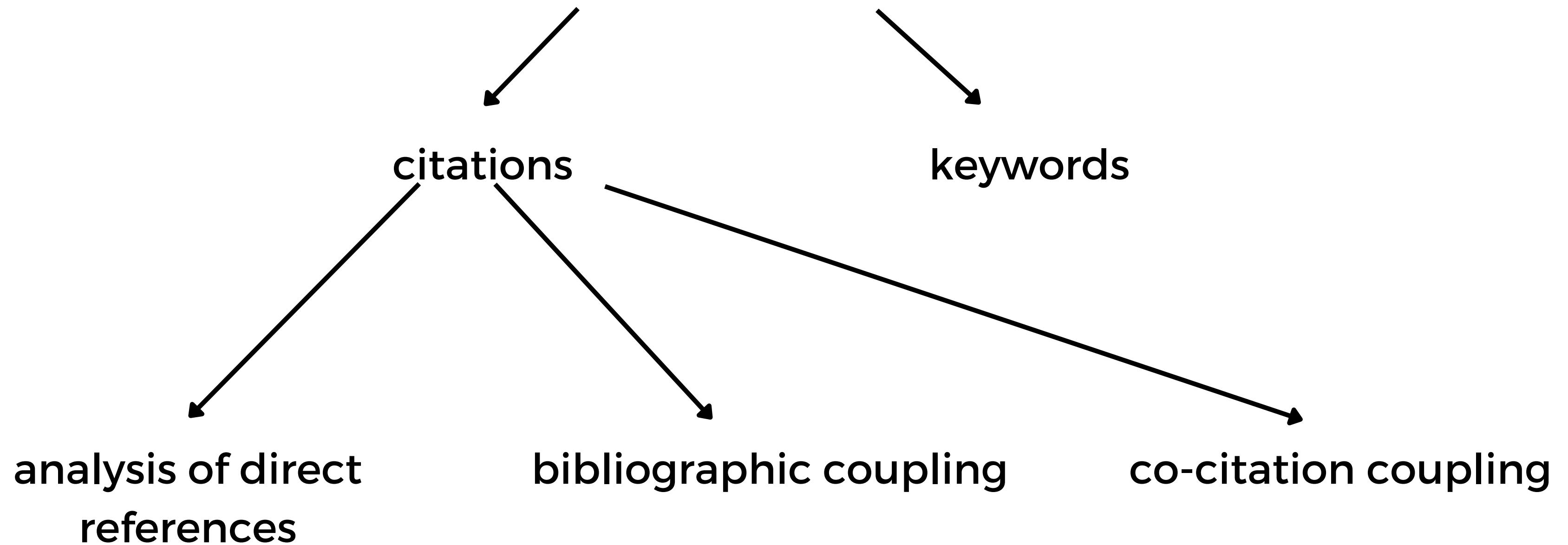
"hardness of discipline" (according to Storer)

Dependent variable:

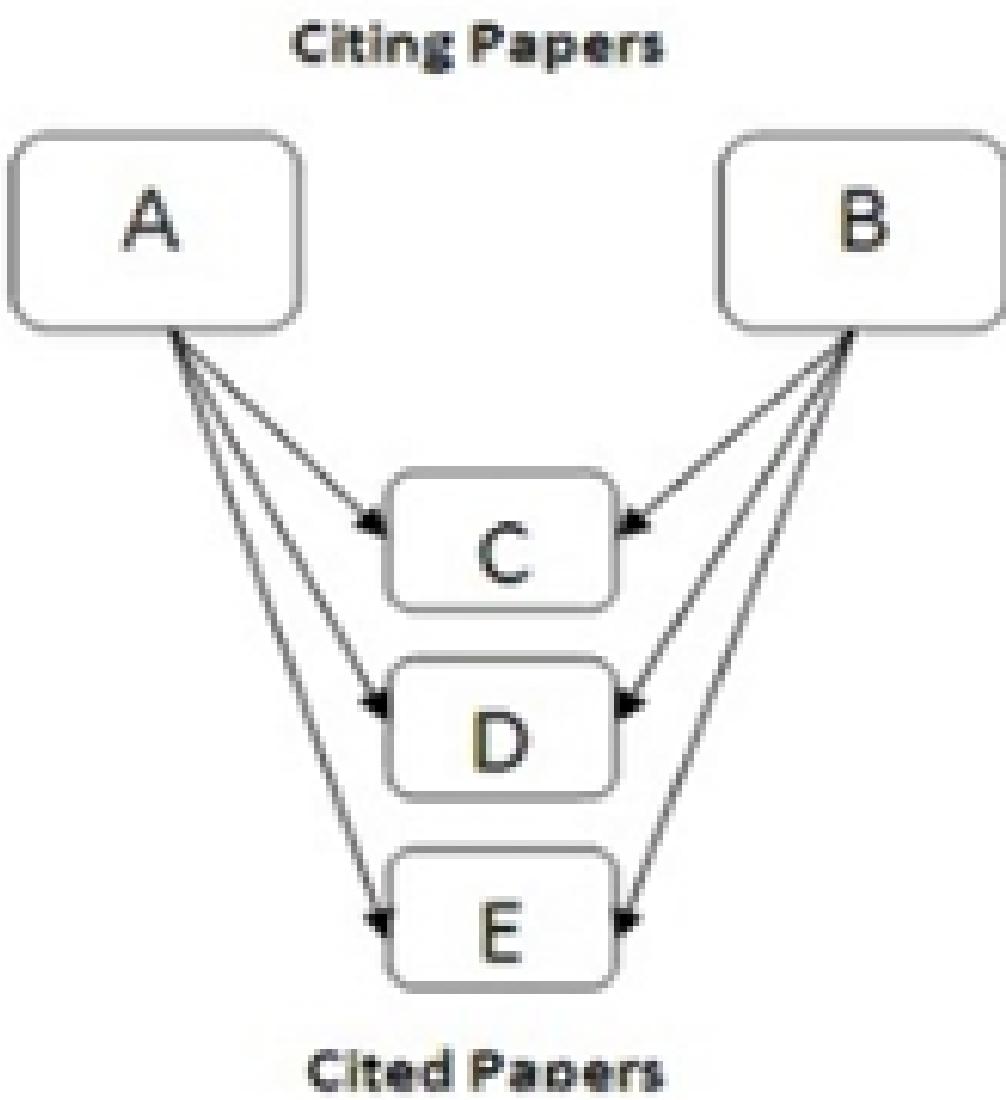
**scientific consensus on the topic "Internet of Things"  
within the discipline**

# **Bibliometrics**

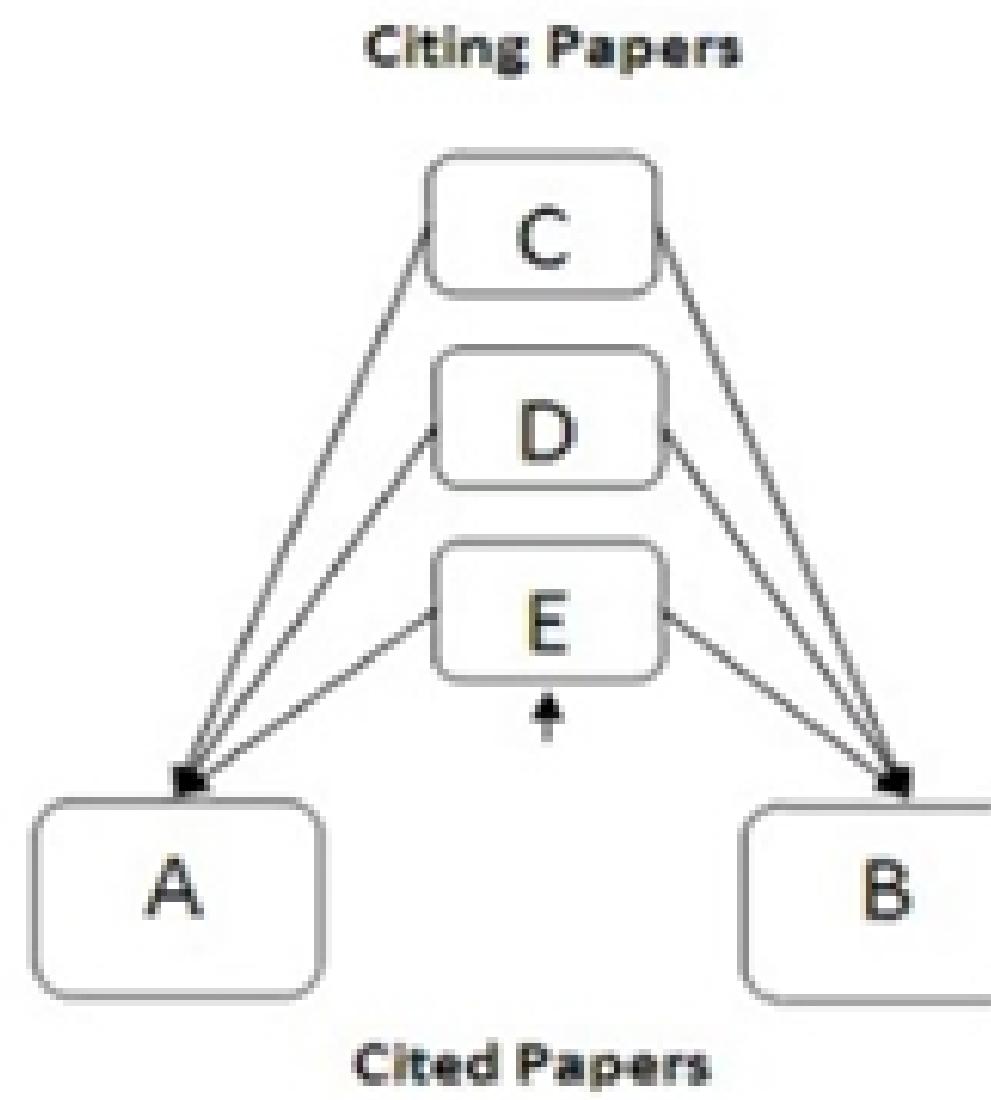
How to identify links between documents?



## Bibliographic coupling



## Co-citation coupling



Papers A and B are bibliographically coupled because they have cited papers C, D and E in their reference list.

Papers A and B are associated because they are co-cited in the reference list of papers C, D, and E.

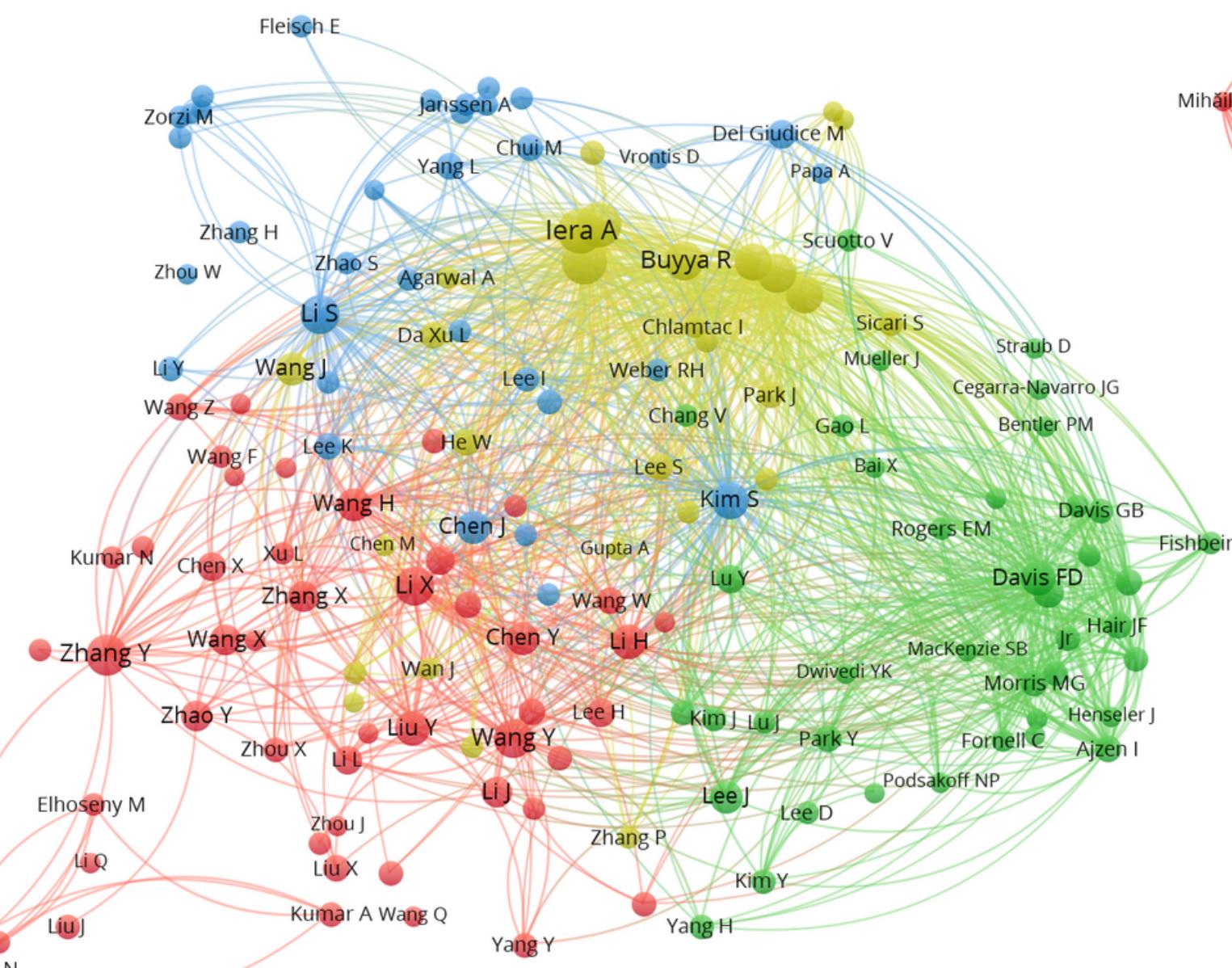
# Hypothesis:

**Works on the Internet of Things in hard disciplines have a greater degree of scientific consensus**

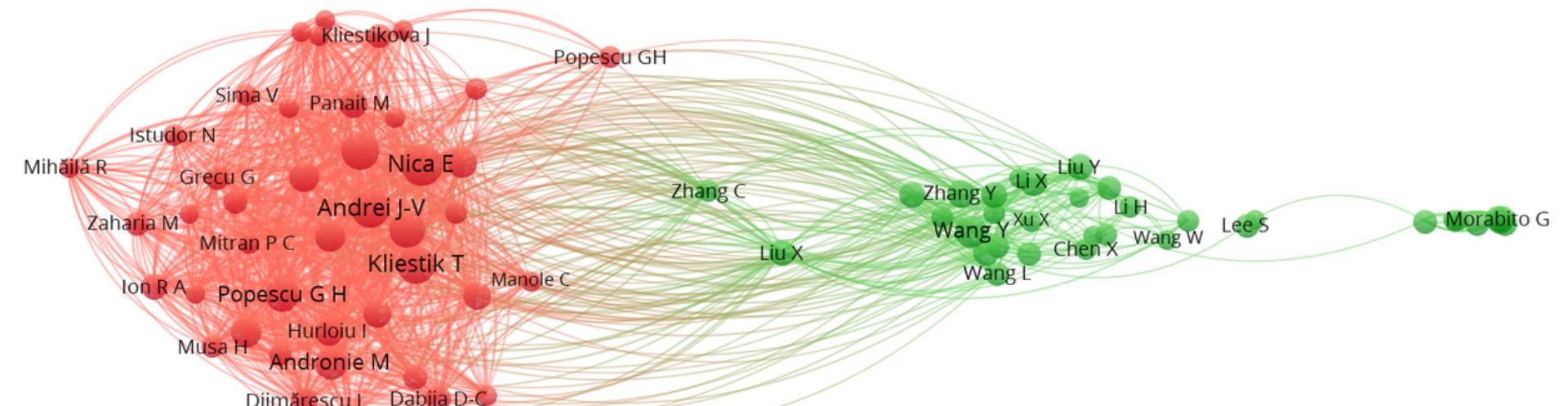
- Arts and Humanities
- Psychology
- Social Sciences
- Decision Sciences
- Economics (Energy, Business, Management and Accounting, Economics, Econometrics and Finance)
- Biology and Earth Sciences (Environmental Sciences, Earth and Planetary Sciences, Agricultural and biological sciences, immunology and microbiology)
- Medicine (Medicine, Biochemistry, Genetics and Molecular Biology, Health Professions, neurology, pharmacology, toxicology and pharmaceuticals, Nursing, Veterinary Medicine, Dentistry)
- Informatics (Informatics)
- Engineering (Engineering, Materials Science, Chemistry, Chemical Technology)

# Graphs' visualization

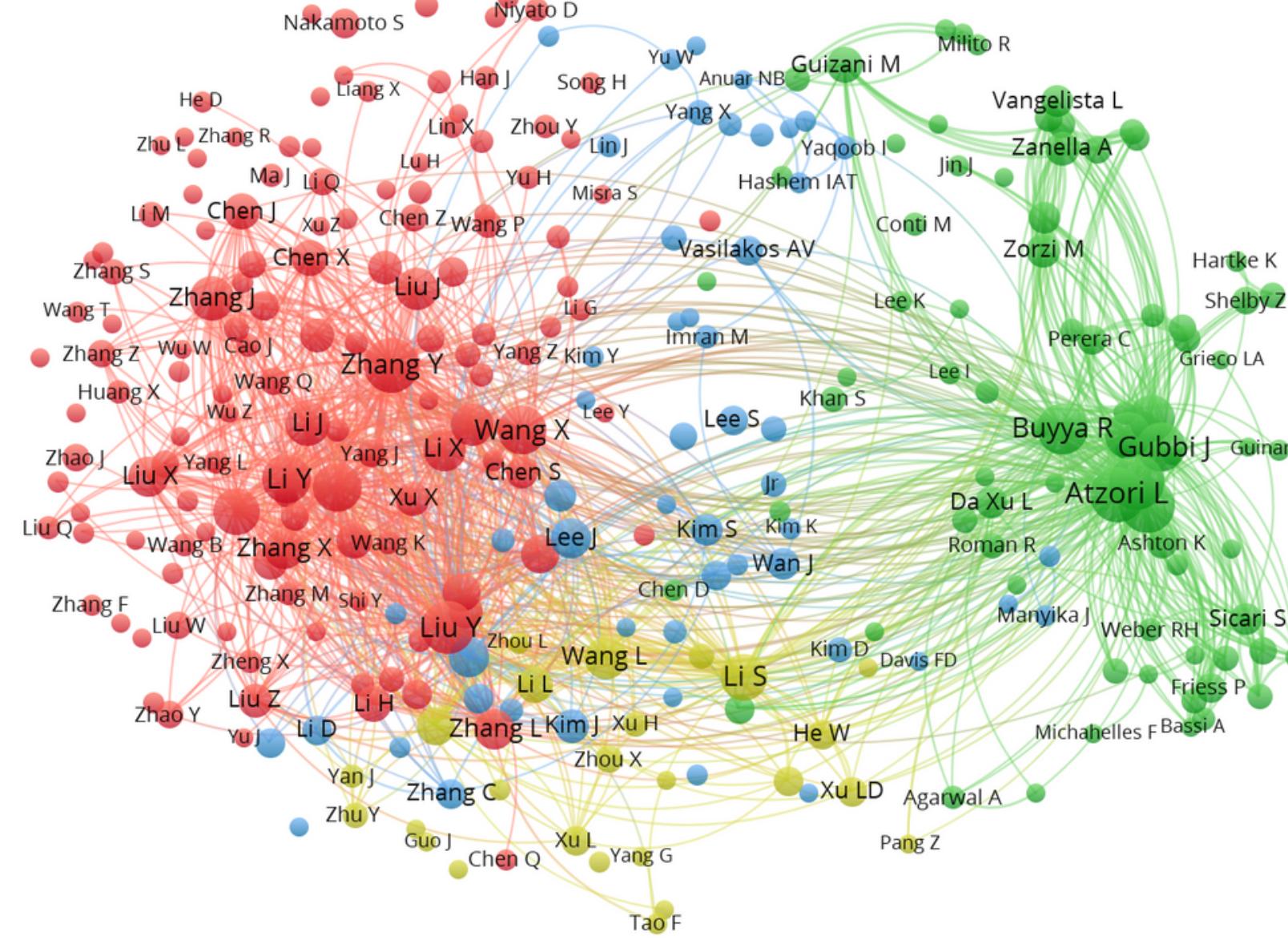
## Psychology



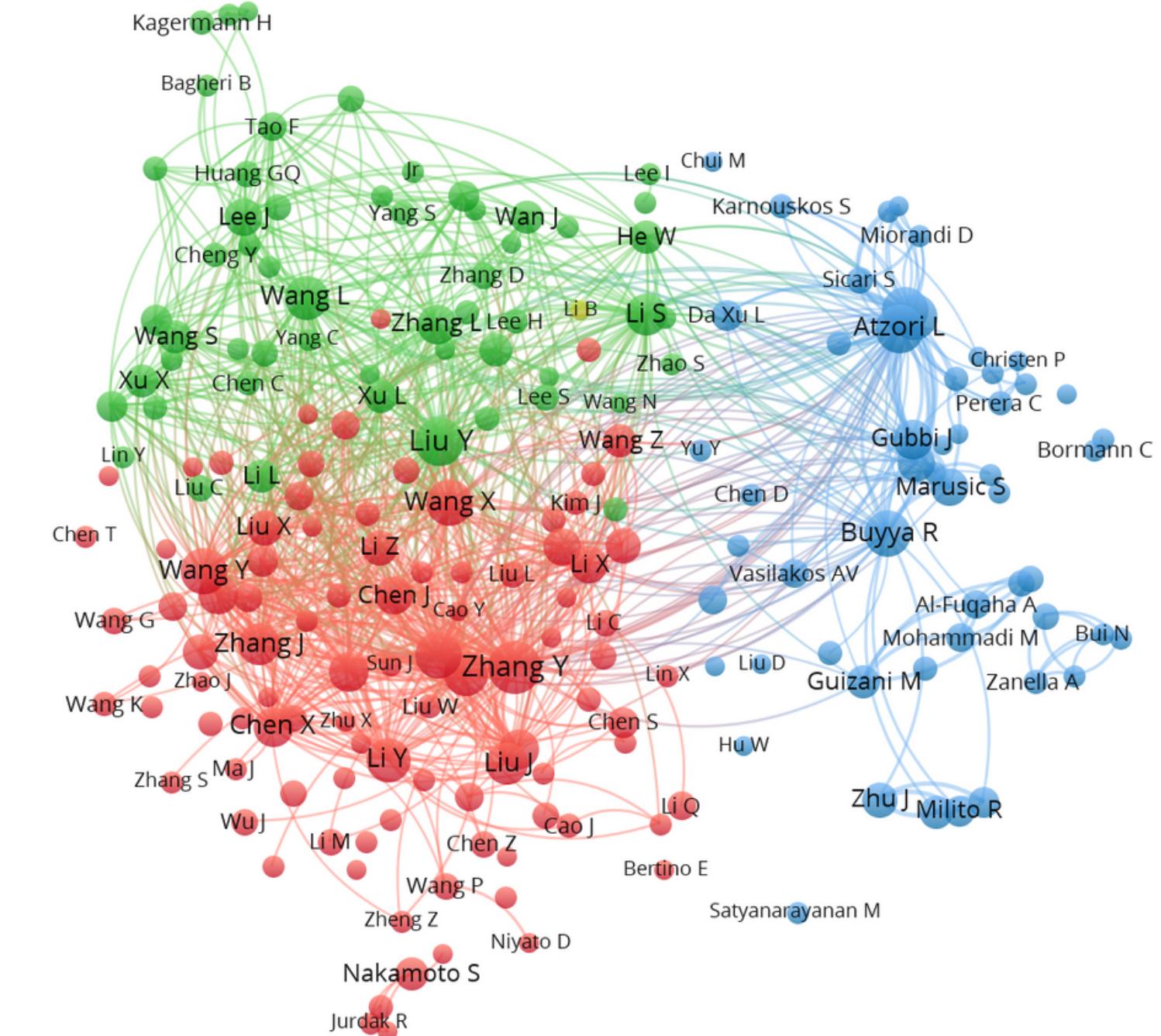
## Arts and Humanities



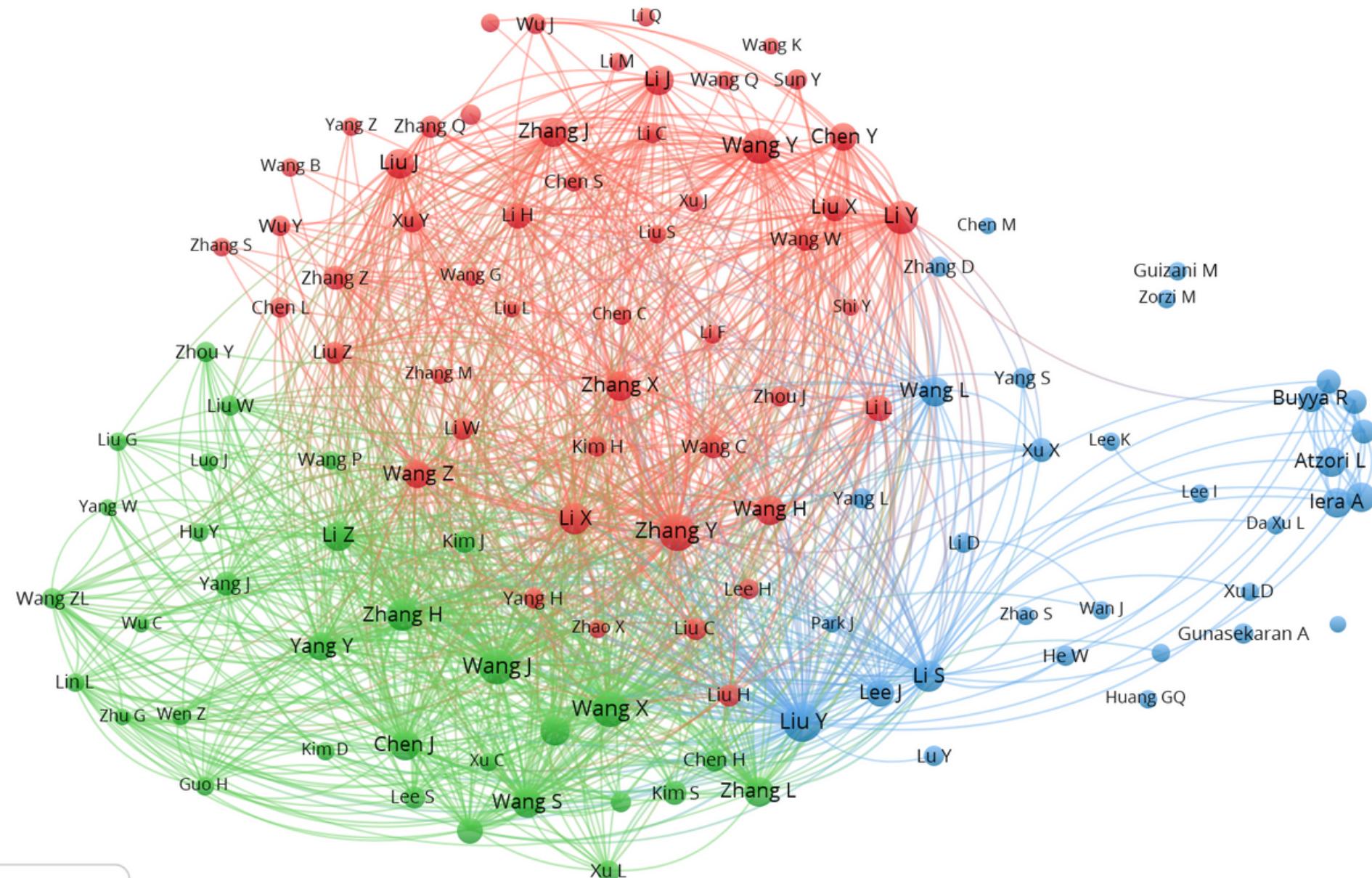
# Social Sciences



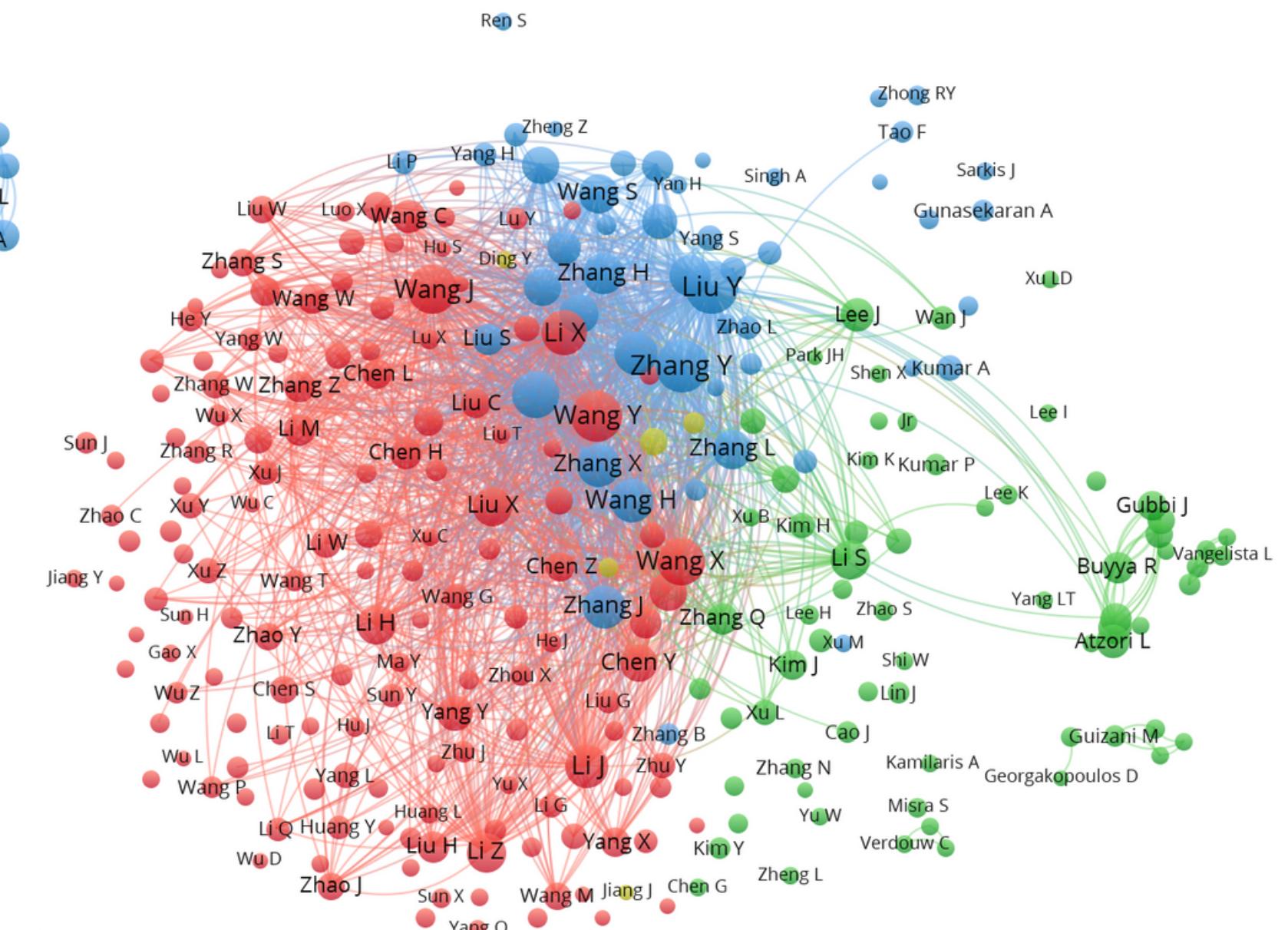
# Decision Sciences



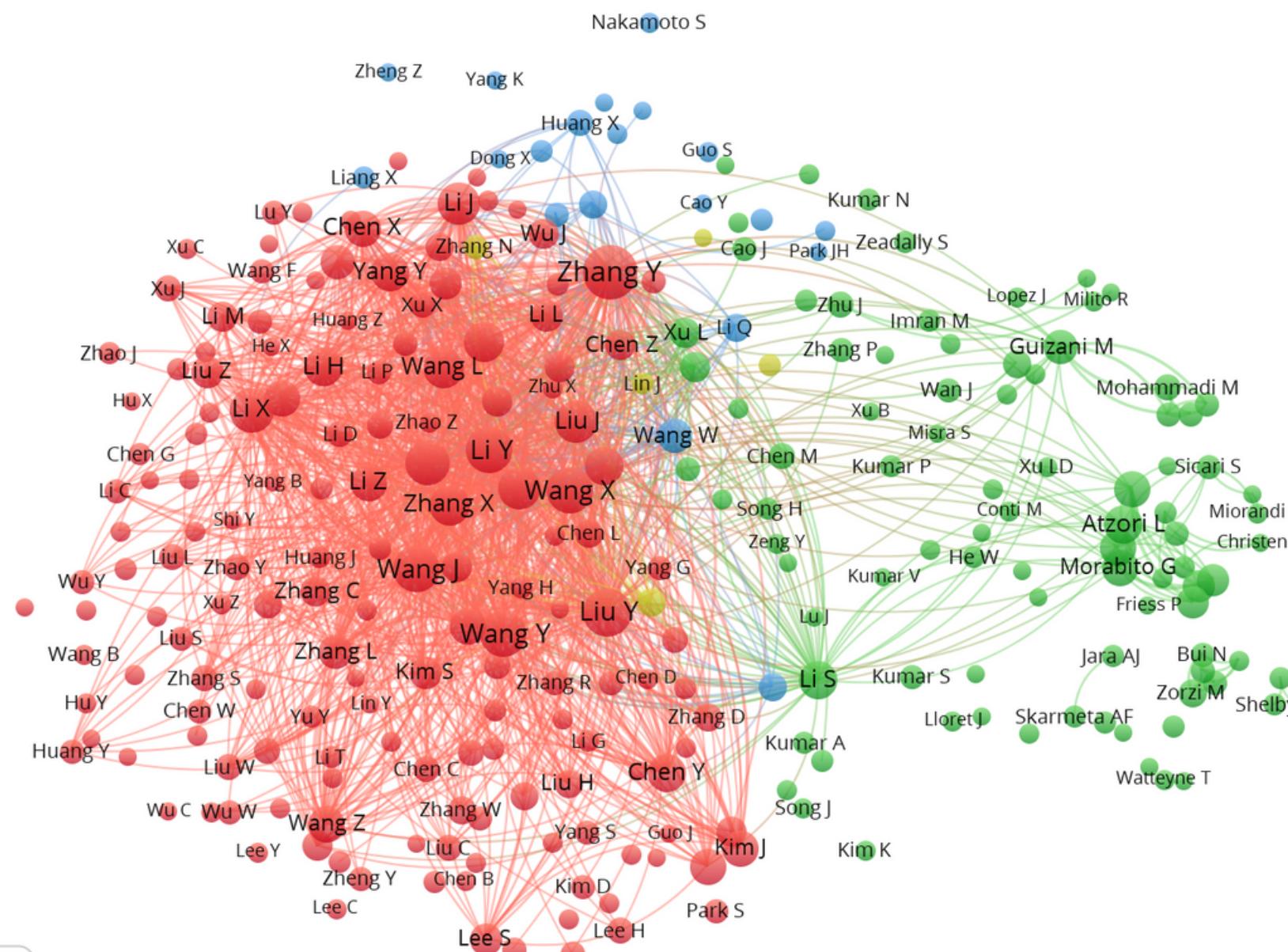
# Economy



# Biology and Earth Sciences

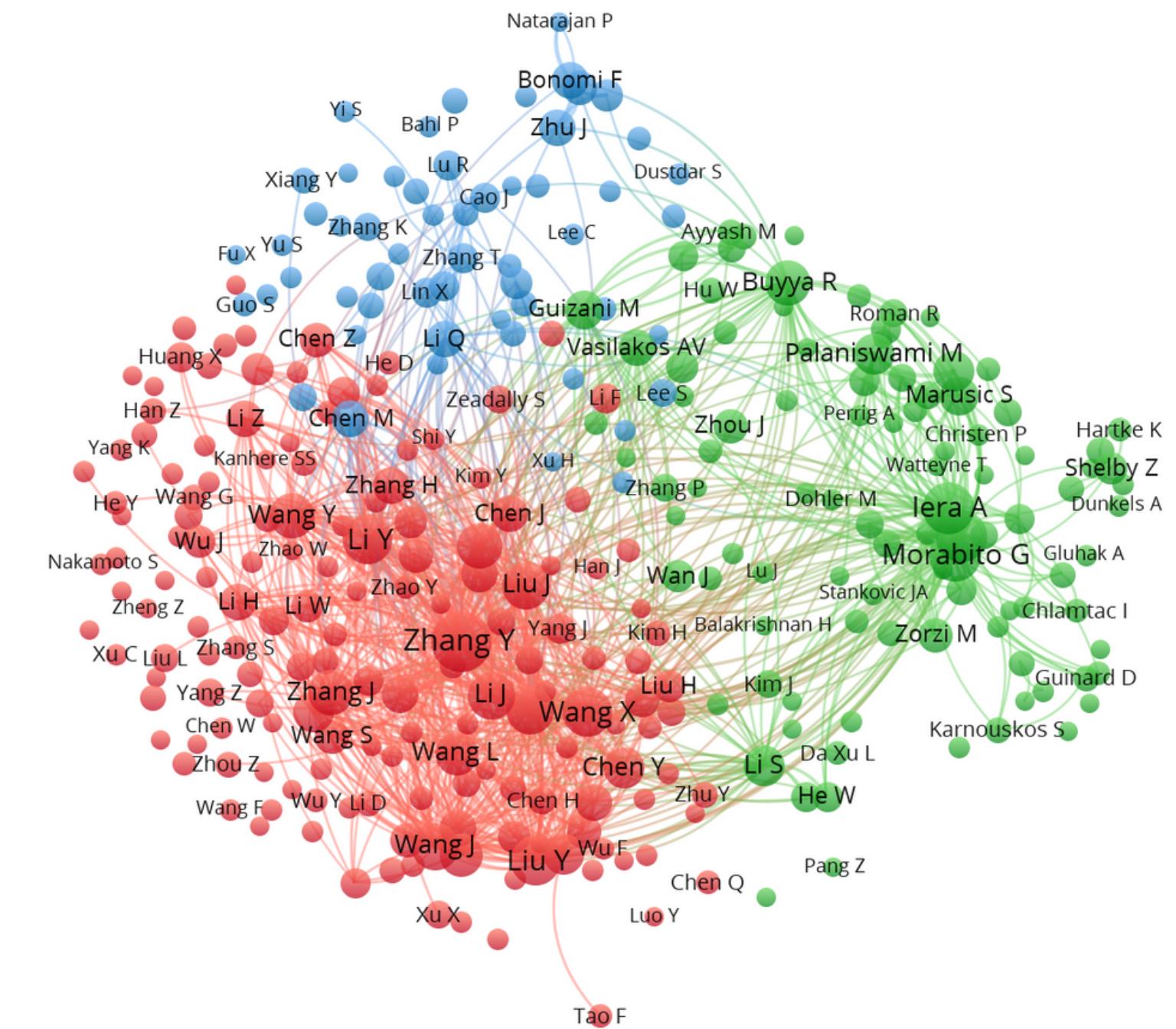


# Medicine

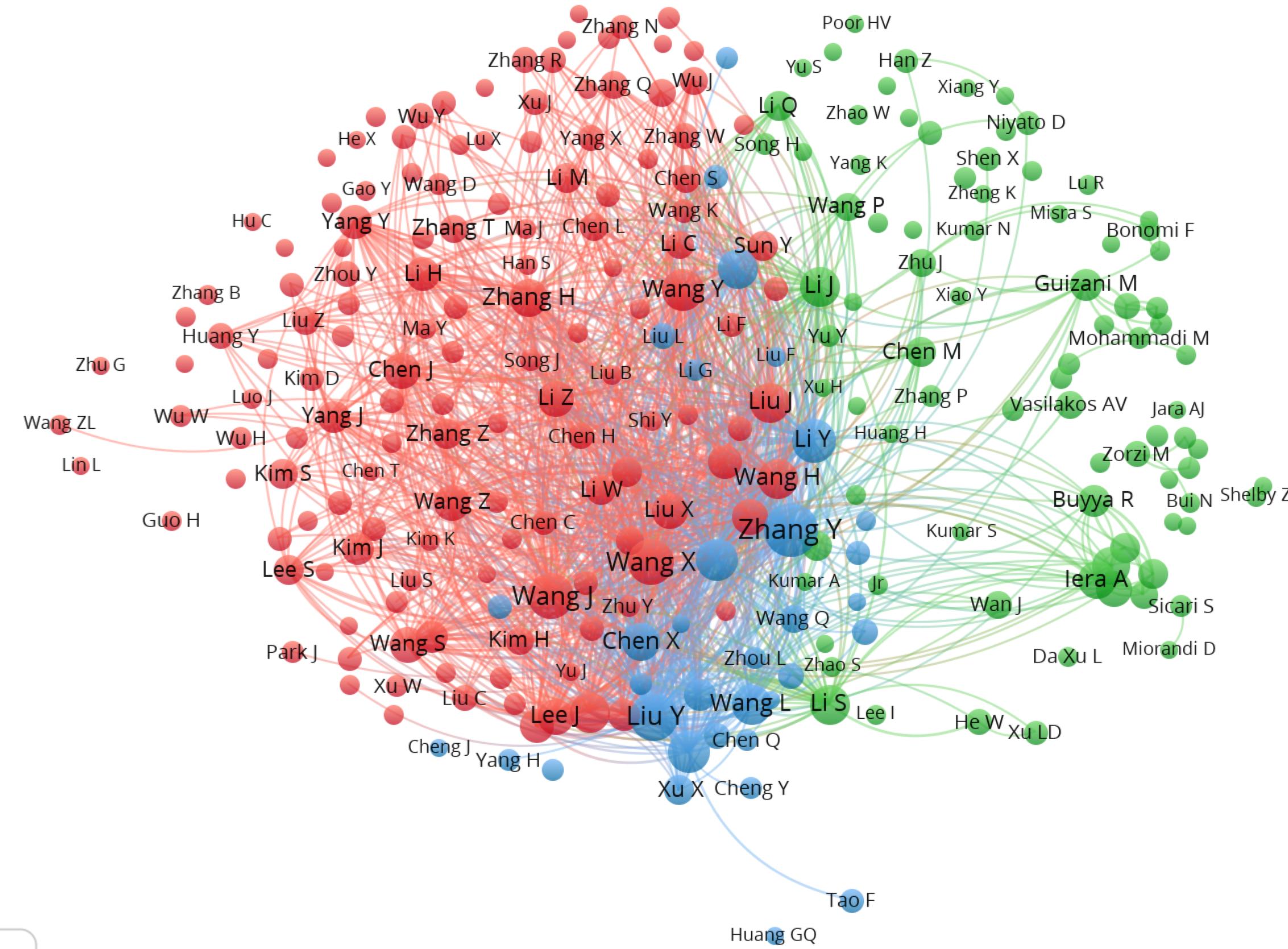


VOSviewer

# Informatics



# Engineering



# Data analysis in R

```
1 library(igraph)
2 decision_sciences_graph <- read.graph("c:/Project/decision_sciences_raw_copy.net", format = 'pajek')
3 decision_sciences_plot <- plot(decision_sciences_graph)
4
5 cluster_leading_eigen(decision_sciences_graph)
6
7 cluster_leiden(decision_sciences_graph)
8
9 cluster_louvain(decision_sciences_graph)
10
11 v(decision_sciences_graph)$degree <- igraph::degree(decision_sciences_graph)
12 E(decision_sciences_graph)$weight
13
14 sapply(decision_sciences_plot, function(x) mean(degree(x)))
15 which.max(degree(decision_sciences_graph))
16 assortativity.degree(decision_sciences_graph)
17 power_centrality(decision_sciences_graph)
18 d <- decompose.graph(decision_sciences_graph)
19 table(sapply(d, vcount))
20 sapply(d, vcount)
21 largest <- d[[1]]
22 plot(largest, vertex.label = NA)
23 power_centrality(largest)
24 closeness(decision_sciences_graph)
25 which.max(eigen_centrality(largest)$vector)
26
27 edge_density(decision_sciences_graph)
28 edge_connectivity(decision_sciences_graph)
29 max_cardinality(decision_sciences_graph)
30 transitivity(decision_sciences_graph)
31
32 |
33 cluster_fast_greedy(decision_sciences_graph)
34
35
```

32:1 (Top Level) #

Console ~/Учеба/Семестр 3/МиМСИ/проект/ ↵

```
> edge_density(decision_sciences_graph)
[1] 0.9487568
> edge_connectivity(decision_sciences_graph)
[1] 136
> transitivity(decision_sciences_graph)
[1] 0.9552174
> max_cardinality(decision_sciences_graph)
$alpha
```

# Results

Discipline	Edge density	Edge connectivity	Transitivity
Art and humanities	0.7642358	5	0.8835825
Psychology	0.7437528	22	0.8032914
Social Sciences	0.8566321	88	0.8837801
Decision Theories	0.9487568	136	0.9552174
Economy	0.9993898	110	0.9994053
Biology and Earth Sciences	0.9743938	196	0.9766815
The medicine	0.9816355	212	0.9831157
Informatics	0.9945893	287	0.9948
Engineering	0.9979819	243	0.9980697

**What else makes hard and soft sciences different?**