Network analysis in the field of law and international relations,

focus on graphs modeling the ratification of international treaties

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Outline

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II – Modelling

III – Results

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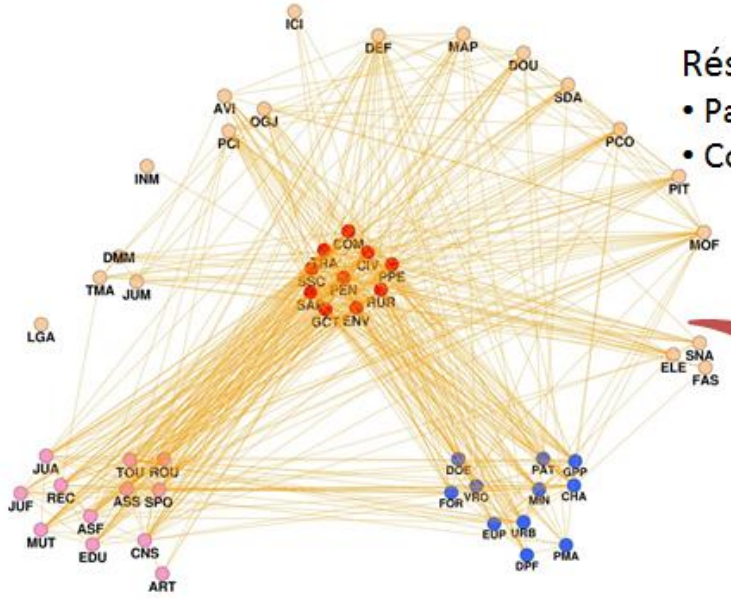
I – Introduction

Complexité juridique

- Several legal systems exist and develop
- Citations and interference within and between these various systems
- Two reports of the *Conseil d'Etat* (1991, 2006) criticize the complexity of French law.
- Decision of Conseil Constitutionnel of 29 December 2005

↪Study Law complexity

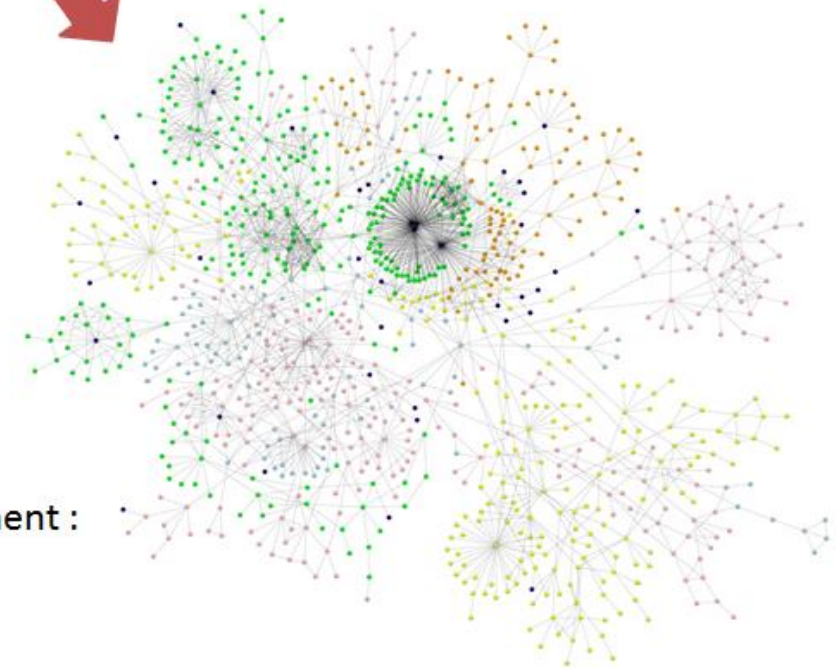
Previous works



Réseau des codes législatifs français :

- Pas un petit monde mais *un monde concentré*
- Communauté centrale influente (club huppé)

Changement d'échelle (zoom sur le code de l'environnement)



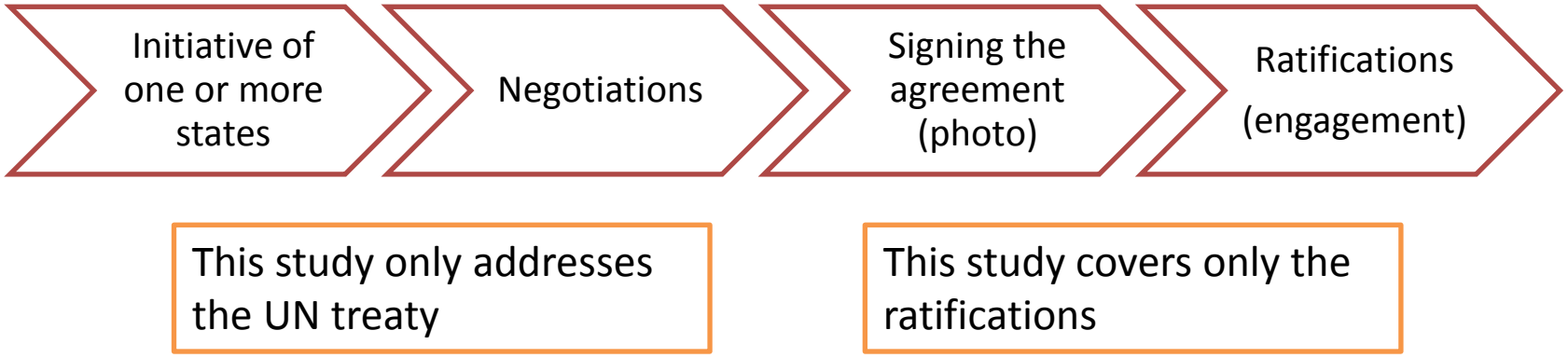
Réseau des articles du code de l'environnement :

- Effet petit-monde
- Pas de communauté centrale influente

References

- Mazzega P., Bourcier D., Boulet R., The Network of French Legal Codes, Twelfth International Conference on Artificial Intelligence and Law (ICAIL 2009).
- Mazzega P., Bourcier D., Boulet R., Code Communities in the French Legal System, Symposium on Courts and Mediations - New Paths for Justice, 2009.
- Boulet R., Mazzega P., Bourcier D. Network Analysis of the French Environmental Code, Artificial Intelligence approaches to the complexity of legal systems (AICOL 2009)
- Bourcier D., Mazzega P., Boulet R., (2010) Visualiser la Complexité du Droit, Les technologies de l'information au service des droits : opportunité, défis, limites sous la coordination de Daniel Le Métayer, Bruylant.
- Boulet R., Mazzega P. and D. Bourcier (2011) A Network Approach to the French System of Legal codes- Part I : Analysis of a Dense Network. Artificial Intelligence and Law.
- Boulet R., Mazzega P., Bourcier D., Réseaux normatifs relatifs à l'environnement : structures et changement d'échelles. Dans "Politiques Publiques Systèmes Complexes", Editions Hermann, (2012)

Ratification of international treaties (UN)



Modelling the successive ratifications

Study of the dynamic aspect through the introduction of a notion of temporality in a static representation

Environmental treaties and trade treaties

Environment

Trade

Two related fields (resource use, pollution, ...) with different interests

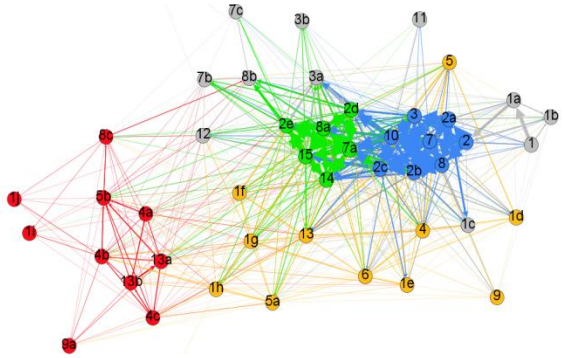
Two central areas for sustainable development of a country

Soft law (environment) vs. *hard law* (commerce)

Previous works

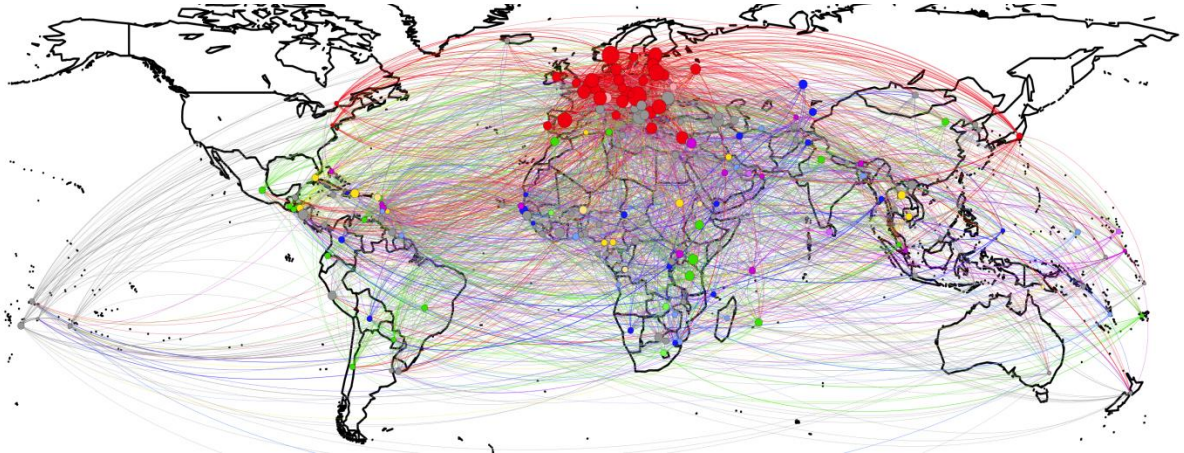
R. Boulet, A-F Barros-Platiau, P. Mazzega ,
35 years of Multilateral Environmental Agreements Ratification: a Network Analysis
(AI & Law 2016)

Network analysis between environmental treaties: highlight on a group of environmental treaties between countries of ratifications



R. Boulet, A-F Barros-Platiau, P. Mazzega ,
Country Communities Underlying the Ratification of Multilateral Environmental Agreements
(submitted)

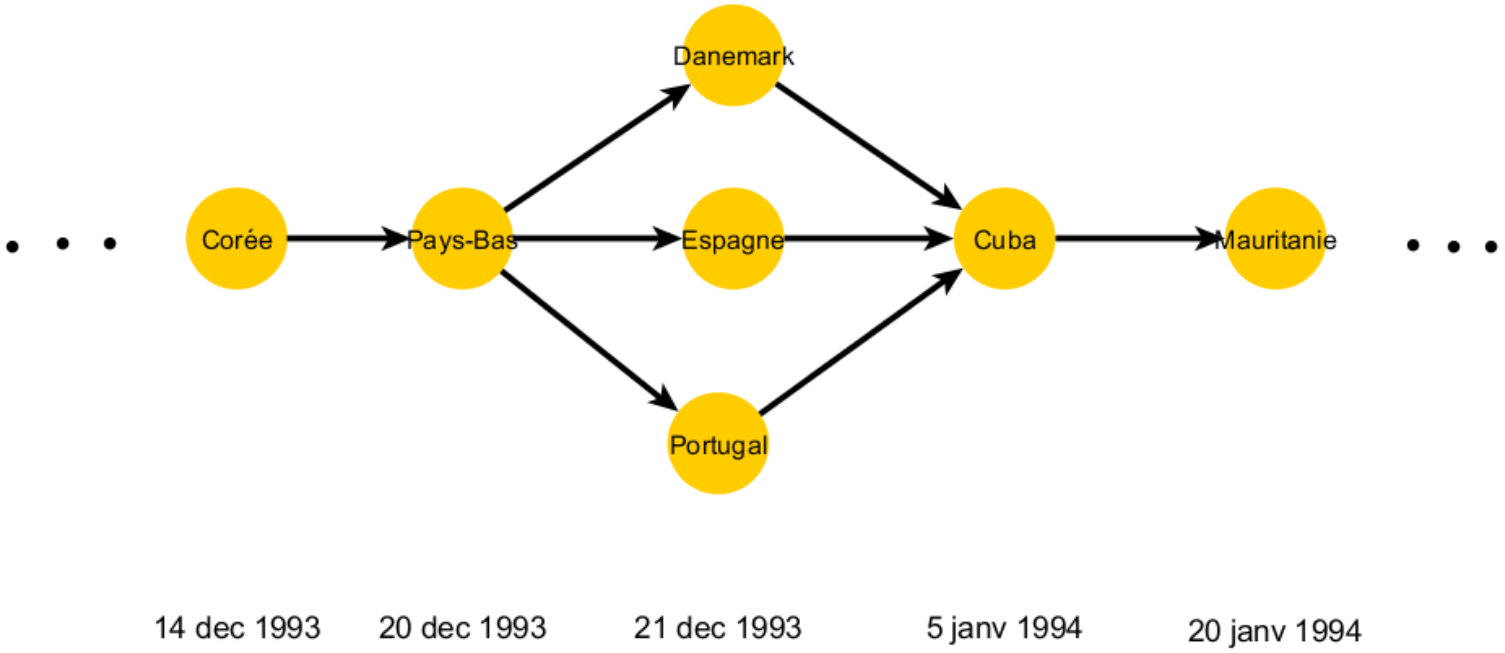
Network Analysis of the successive ratifications for the environment: highlighting the European leadership in the creation of a global environmental order since the 80s



II – Modelling

Directed graphs

Each treaty induces a "temporal chain" of ratifications:

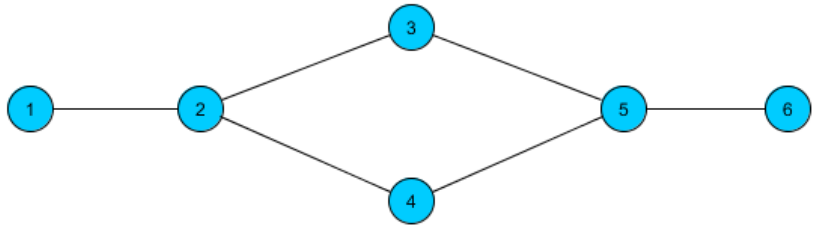


Extract from United Nations Framework Convention on Climate Change

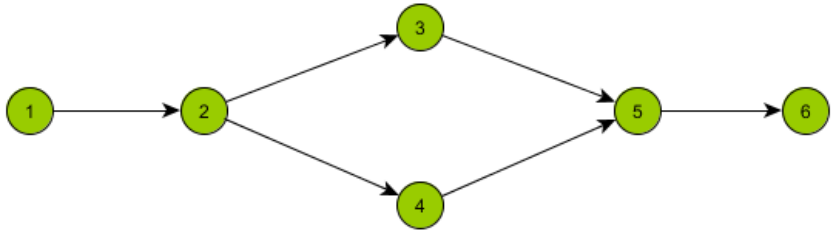
Limit: If simultaneous ratifications are too numerous

Directed hypergraphs : definition

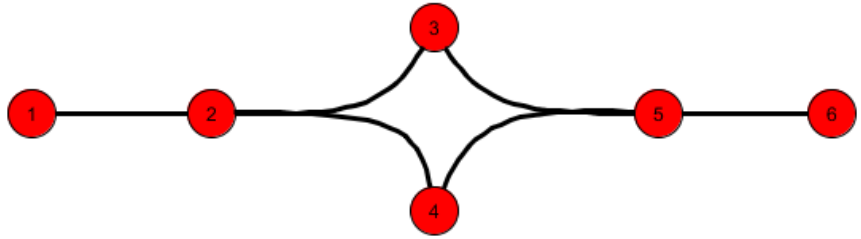
A graph is defined by:
- A set $V=\{v_1,v_2,\ldots,v_n\}$ of vertices
- A set E of edges, an edge is a subset of 2 vertices of V



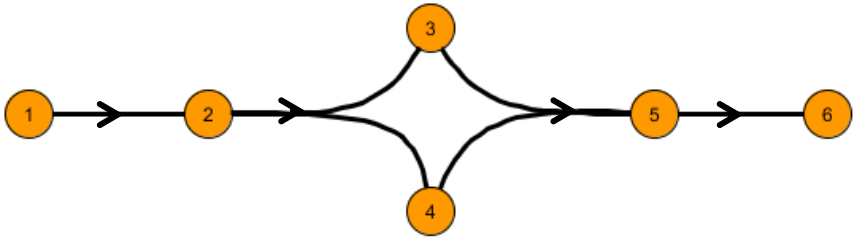
A directed graph is defined by:
- A set $V=\{v_1,v_2,\ldots,v_n\}$ of vertices
- A set E of directed edges (arcs), a directed arc being defined by one source vertex and one target vertex



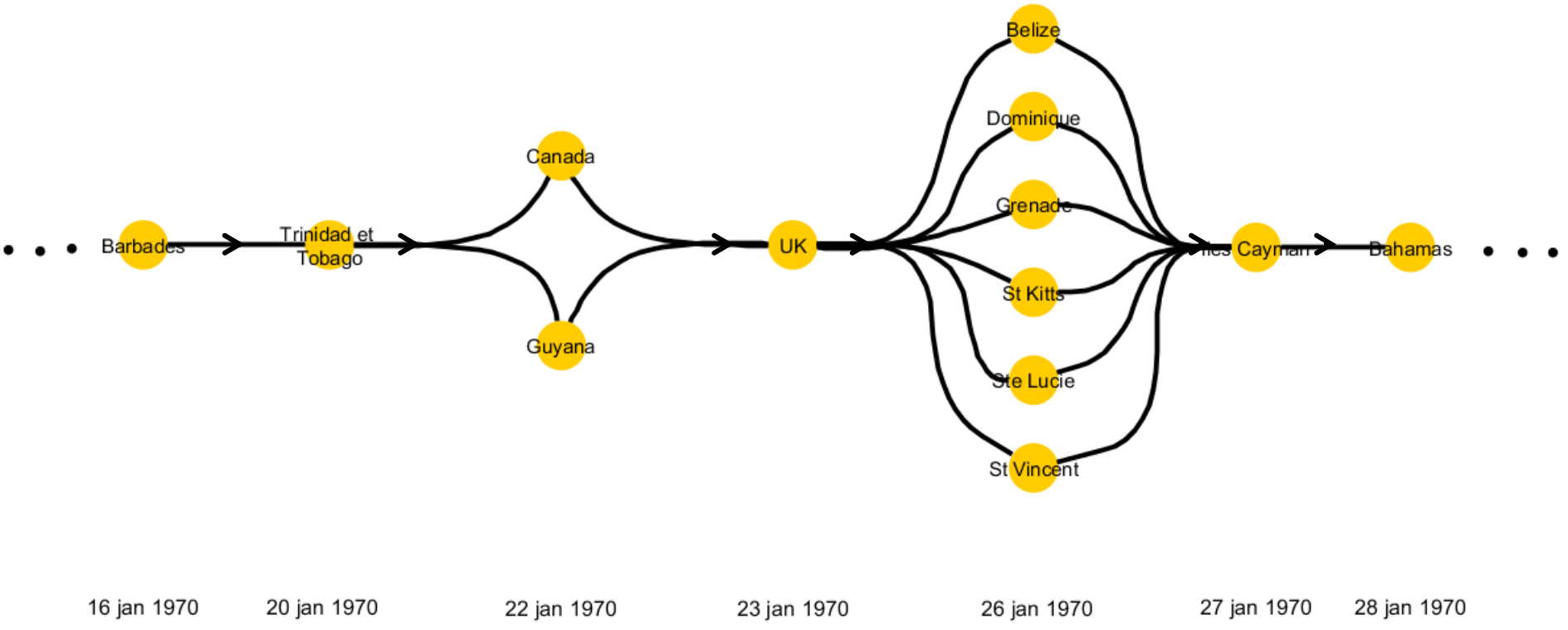
A hypergraph is defined by:
- A set $V=\{v_1,v_2,\ldots,v_n\}$ of vertices
- A set E of hyperedges, a hyperedge is a subset of several vertices of V



A directed hypergraph is defined by :
- A set $V=\{v_1,v_2,\ldots,v_n\}$ of vertices
- A set E of directed hyperedges, a directed hyperedge being defined by a set of source vertices and a set of target vertices



Directed hypergraphs



Extract of the agreement establishing the Caribbean Development Bank

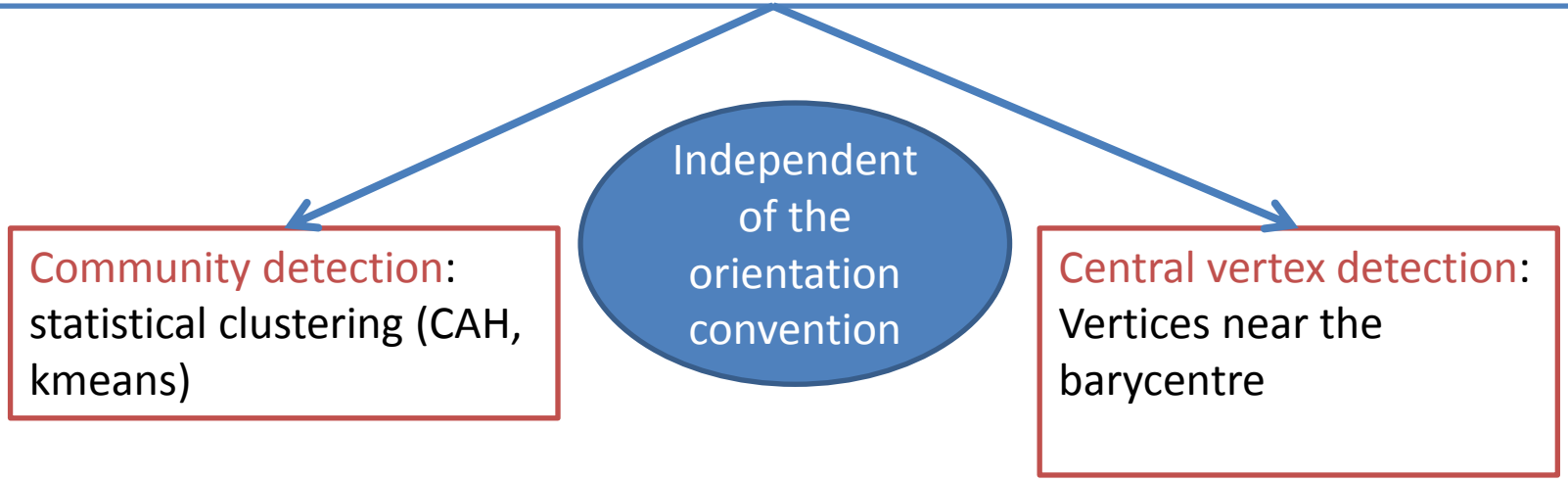
Methodology of analysis

The basic simple idea:

Writing the incidence matrix of the hypergraph

then

Embedding vertices in IR^n



III – Results

Environmental treaties

There is clearly a community that emerges:

```
"Albania"                 "Austria"
"Belarus"                 "Belgium"
"Bulgaria"                "Croatia"
"Cyprus"                  "Czech Republic"
"Denmark"                 "Estonia"
"European Union"          "Finland"
"France"                  "Germany"
"Greece"                  "Hungary"
"Ireland"                 "Italy"
"Latvia"                  "Liechtenstein"
"Lithuania"               "Luxembourg"
"Netherlands"             "Norway"
"Poland"                  "Portugal"
"Republic of Moldova"     "Romania"
"Serbia"                  "Slovakia"
"Slovenia"                "Spain"
"Sweden"                  "Switzerland"
"Ukraine"                 "United Kingdom of Great Britain
```

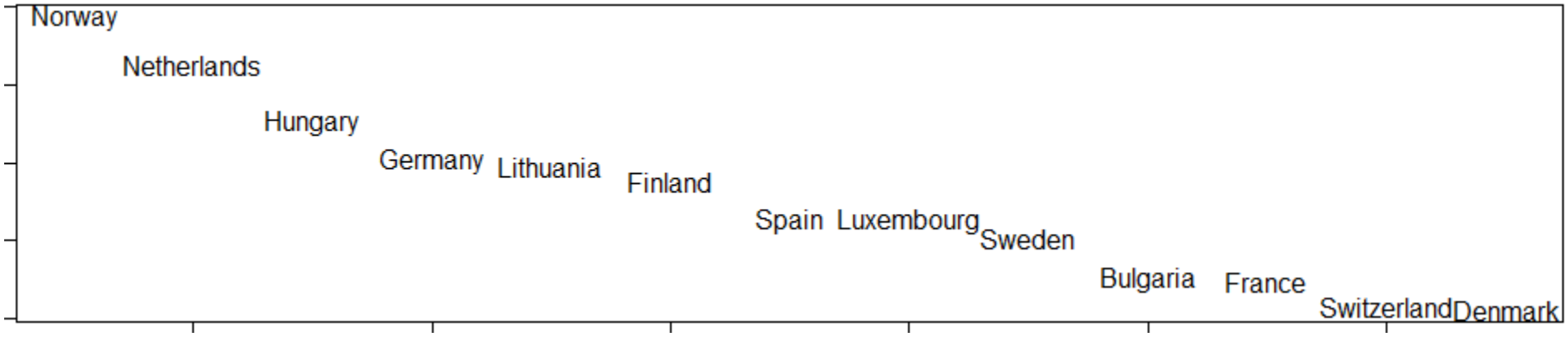
Community of European countries including 27 EU members

Europe (EU) constitutes a core.

There are no other communities corresponding to politico-economic groups

Environmental treaties

Central vertices are :



La période d'analyse est 1979 - 2014

The central countries are only European countries.
-> Europe Leadership (EU) in environmental treaties ratification process
Note the central position of the countries of northern Europe.

Comparisons of results between hypergraph directed graph

We find the community "Europe" (plus Japan, Russia, the United States in the case of directed graphs)

We recover the same central vertices (betweenness and closeness).

Closeness (Rank)		*Betweenness (Rank)*	
1	Norway	1	Hungary
2	France	2	Norway
3	Hungary	3	Lithuania
4	Luxembourg	4	Belgium
5	Spain	5	Austria
6	Netherlands	6	Spain
7	Finland	7	Estonia
8	Lithuania	8	Romania
9	Bulgaria	9	Netherlands
10	Denmark	10	Finland

Trade-related treaties

There is clearly a community that emerges:

"Antigua and Barbuda"	"Azerbaijan"	"Bahrain"
"Bolivia (Plurinational State of)"	"Bosnia and Herzegovina"	"British Virgin Islands"
"Brunei Darussalam"	"Bulgaria"	"Cayman Islands"
"Costa Rica"	"Croatia"	"Czech Republic"
"Eritrea"	"Estonia"	"Greece"
"Guatemala"	"Hong Kong"	"Iceland"
"Kiribati"	"Latvia"	"Lithuania"
"Malta"	"Marshall Islands"	"Micronesia (Federated States of)"
"Monaco"	"Montserrat"	"Nauru"
"Nicaragua"	"Niue"	"Oman"
"Palau"	"Portugal"	"San Marino"
"Serbia"	"Slovakia"	"Solomon Islands"
"South Sudan"	"Timor-Leste"	"Turkmenistan"
"Turks and Caicos Islands"	"Tuvalu"	"United Arab Emirates"
"Vanuatu"		

There is no top 10 world economic powers

Trade-related treaties

We have also these two other communities

```
"Belgium"                    "China"                    "Denmark"                  "Egypt"
"Gabon"                      "Guinea"                   "Japan"                    "Liberia"
"Libya"                      "Malaysia"                 "Republic of Korea"        "Thailand"
"United States of America" "Zambia"
```

There are three leading economic powers

```
"Comoros"  "Gambia"   "Honduras" "Iraq"     "Lesotho"  "Malawi"   "Niger"    "Qatar"    "Samoa"
"Senegal"  "Viet Nam" "Yemen"
```

Trade-related treaties

Central vertices are :

La période d'analyse est 1963 - 2014

Central position of African countries (there are five treaties related to Africa)

USA, China: economic power

Several central countries in the same community

Comparison of some environmental and trade networks measures

Fact :
the number of countries involved is similar

Measures :
The hyper graph for the environment has 197 vertices
The hypergraph for Trade has 198 vertices

Interpretation :
All countries of the world have ratified at least one treaty on environment and one on trade.

Comparison of some environmental and trade networks measures

Fact :
The (hyper)graphe related to environment is 4,5 times more dense

Measures :
Density of 17% against 3.5%. Furthermore :

There are 48 environmental treaties and 23 trade agreements
The hypergraph for the Environment has 3286 hyperedges (68 / treaty)
The hypergraph for Trade has 694 hyperedges (30 / treaty)

Interpretation , explanation:
Environmental treaties generate more signatures as trade,
Soft law

Comparison of some environmental and trade networks measures

Fact :

There are more simultaneous ratifications in the field of trade

Measures :

The hypergraph for the Environment (for 48 treated) has 3286 hyperedges and 3550 ratifications (6% of simultaneous ratifications)
The hypergraph for Trade (for 23 treaties) has 694 hyperedges and 834 ratifications (14% of simultaneous ratifications)

Interpretation , explanation

National and international pressure
Trade-related treaties are very well negotiated before

Comparison of some environmental and trade networks measures

Fait :
Between trade and environment central vertices (countries) differ

Mesures :
The 10 countries the most central (near barycentre) are not the same

Interpretation , explanation :
Hope of South countries to change the international order through law

IV – Conclusions

Synthesis

- Modeling via directed hypergraphs
  - More suitable than directed graphs
  - But difficulty of adapting classical network tools
  - There are similar structuring elements for the environment

- The "dynamics of ratification" trade side is different from the environment side.

Outlooks

- Model other chapters of the United Nations (Health, ...)
- Take into account the WTO
- Modeling perspective: introduce multiplexity (one network but several types of links).

Merci pour votre attention !