The Global Network of Environmental Agreements: A Preliminary Analysis

Caterina Gennaioli

Queen Mary University of London

(Joint with Stefano Carattini, Sam Fankhauser, JianJian Gao and Pietro Panzarasa)

June 18th, 2019

ABCDE Conference, World Bank

Motivation

- Cooperation b/w sovereign states is key to deal with global environmental problems, i.e. ozone depletion and climate change.

- Cooperation requires each state to internalize the negative externalities of emissions.

- Typical prisoner's dilemma game: incentive to free-ride => inefficiently high level of emissions.

- States attempt to negotiate agreements to solve global or transboundary environmental issues.

Motivation Cont’

- Since the late 1800s, almost 2000 international environmental agreements signed by more than 200 countries.

- Little is known about the global system of IEAs that has emerged.

Some of the questions that remain answered:

- Who are the (countries) leaders, able to spur participation of other countries?
- Who are the frontrunners and who the followers in signing agreements?
- Is there a core group of countries that tend to cooperate more among themselves than others?
- How does international cooperation on environmental issues relates to cooperation on other sectors, e.g. trade, migration?
- Does environmental cooperation between countries stimulate flows of information and in turn climate policy diffusion?

This Paper

Focus on the network of countries signing IEAs over the period 1950-2015.

An *International Environmental Agreement* is an intergovernmental document intended as legally binding with a primary stated purpose of preventing or managing human impacts on natural resources (Mitchell, 2003)

- Apply network theory to characterize the system of IEAs looking at its main topological properties.

- The structure of a network *per se* can be illuminating and provide useful insights beyond those found in other political and economic characteristics (Jackson, 2008)

This Paper Cont'

- Very detailed database by Ecolex.
- One-mode projection of a bipartite network-> network of countries that co-sign IEAs.
- Descriptive approach; we compute various network measures which capture different aspects of network structure.
- We look both at the evolution of the network over time and at its static features in 2015.

Main network measures under analysis:

- Shortest path length, global clustering coefficient, closeness and betweenness centrality, etc.

This Paper Cont’

Main Results

- Network more dense over time -> countries increasingly interact.
- Decreasing weighted shortest path length over the past decades-> information diffuses more efficiently.
- France at the top of both rankings of betweenness and closeness centrality-> stimulate diffusion of information and influence adoption by other countries.

First step of a research agenda which aims to study questions about:

- Factors influencing the structure of the network.
- Is the structure of the network conducive to policy diffusion?
- Relationship between this network and other networks between countries.

Outline

- Literature Review
- Data and Methodology
- Results
- Concluding Remarks

Literature Review

- **Theoretical papers**. Participation in treaties as a self-enforcing non cooperative game. Predictions on the size of a stable coalition (**Carraro and Siniscalco, 1993; Barrett, 1994**)**.** Subsequent work allows for richer dynamics and strategies. **Wagner (2016)** develops a model of timing of ratification, with strategic interaction between country players.

- **Empirical studies**. Reduced form estimations, eg. on trade openness/political regime and multilateral environmental agreements (**Congleton, 1992; Fredriksson and Gaston, 2000; Neumayer, 2002**)

- **Networks studies**. **Kim, 2013**: Complex (citation) network of treaties. Polycentric legal structure of the environmental system.

=> Different approach: topology of the network of countries that signed multilateral environmental agreements

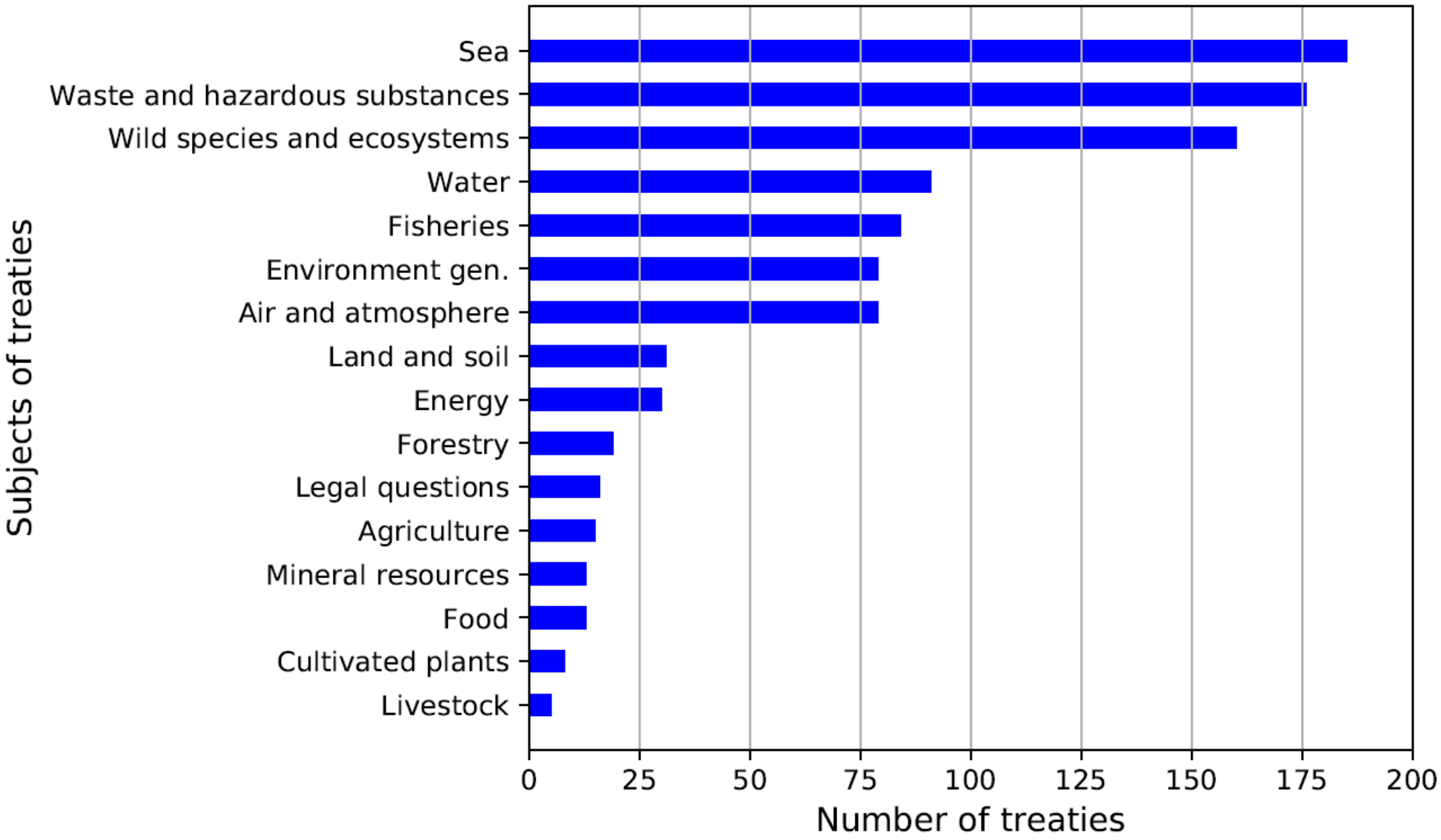
Data and Methodology

- Unique dataset from Ecolex (UNEP, FAO, World Conservation Union)
- 1,998 treaties signed by 238 jurisdictions over the period 1868-2015
- Information of: signatory countries, dates, subjects, abstracts, amendments, etc.

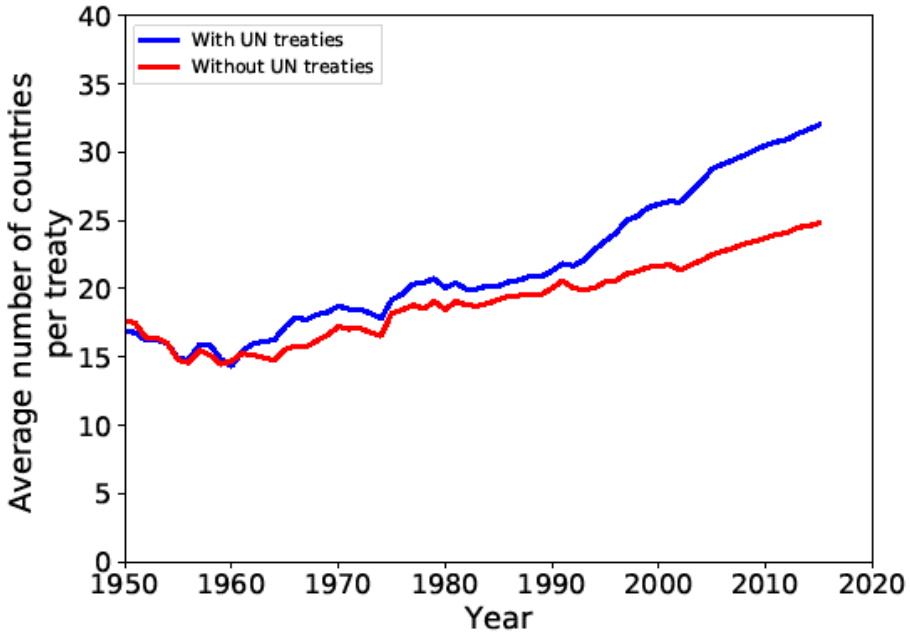
Final sample

- 559 treaties signed by 200 countries over the period 1950-2015

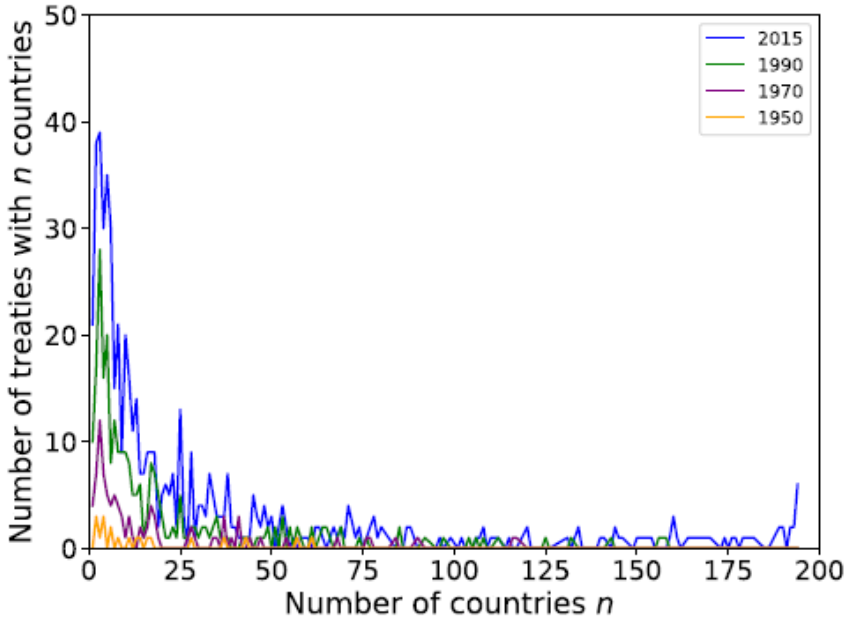
Treaties by Subjects



Number of Countries Signatory over Time

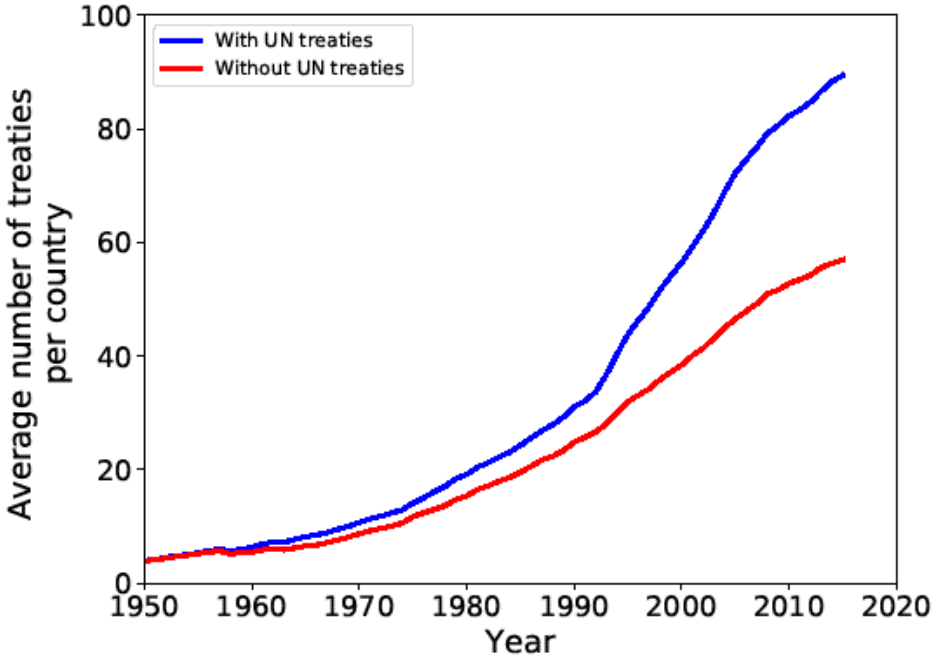


Average number of countries per treaty (1950-2015)

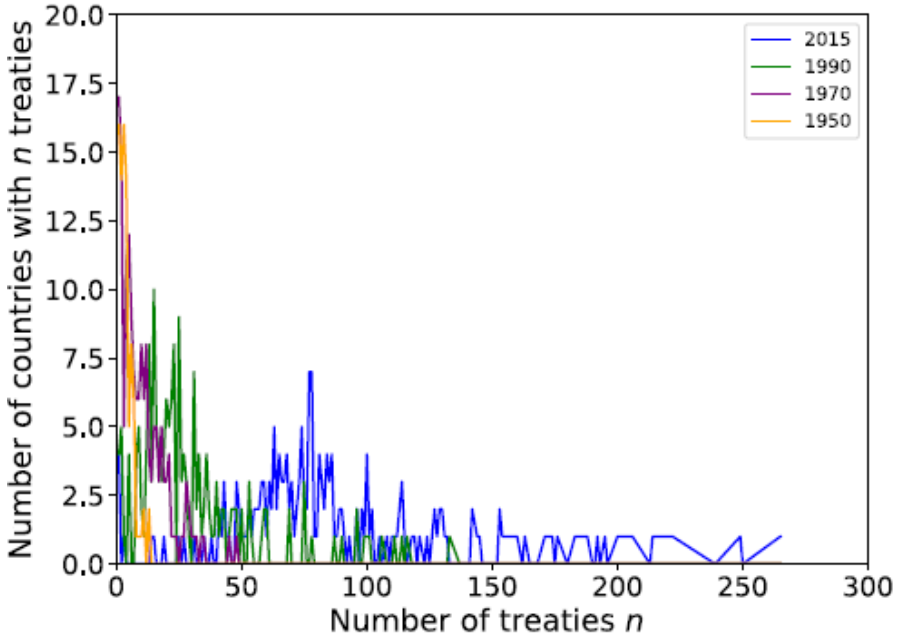


Distribution of n countries per treaty in different years

Number of Treaties per Country over Time



Average number of treaties per country (1950-2015)

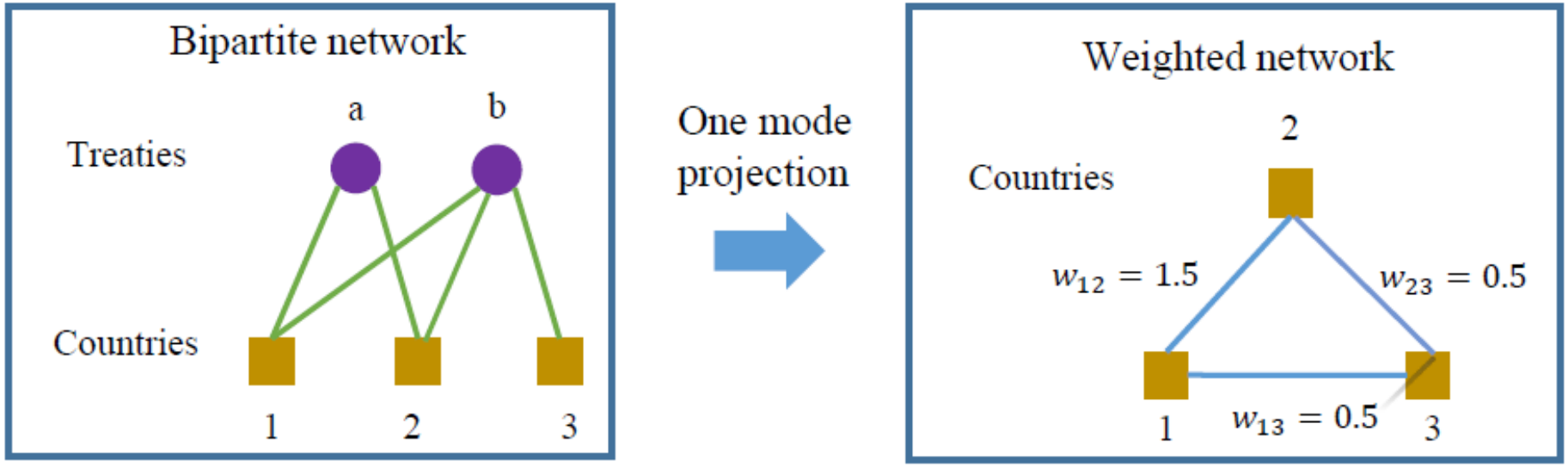


Average number of treaties per country (1950-2015)

Methodology

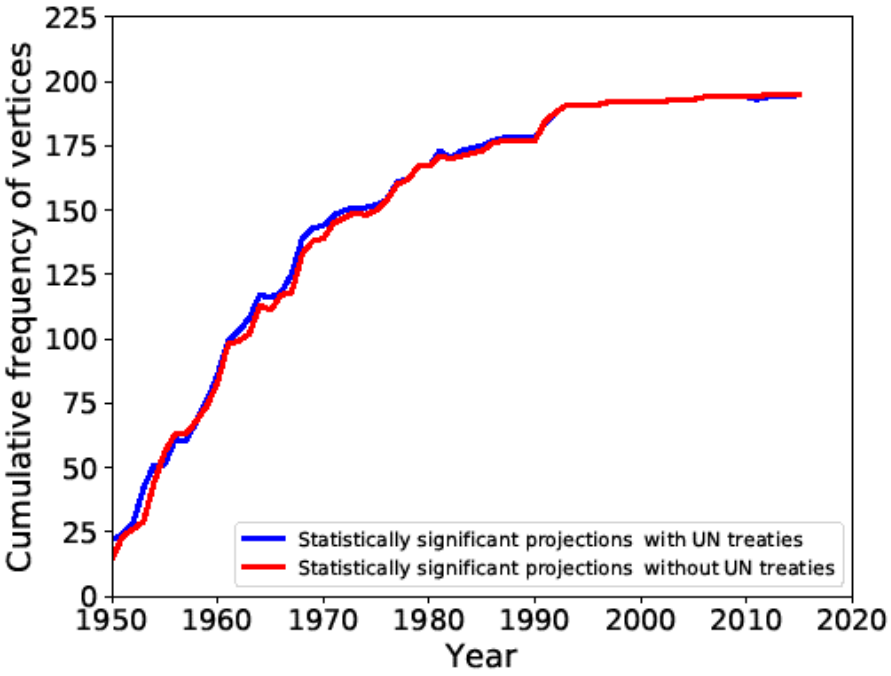
Aim: study the relationship between countries that co-sign treaties

1) Bipartite network of countries and treaties;
2) One mode projection of the bipartite network.
3) Weighted links according to Newman (2001): intensity of the interaction
4) All the results are validated against a null model which maintains the degree of the nodes.

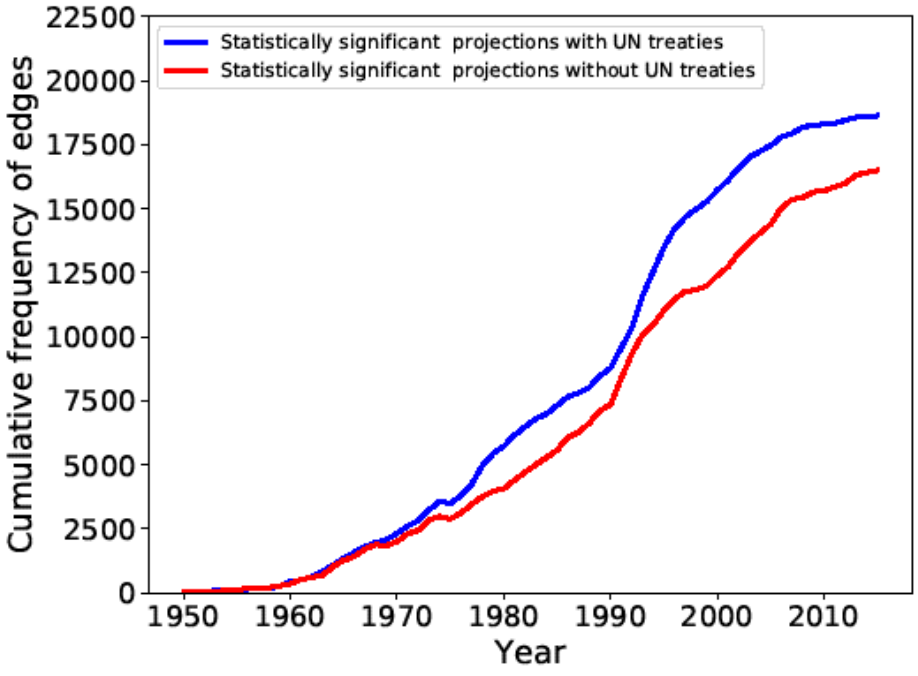


Dynamics of the Network (1950-2015)

- The number of countries joining the global environmental system increased linearly since 1950 and reach 195 in 2015.
- Collaboration (links) between countries intensified in the 60s and grew rapidly between 1990 and 1996.



Cumulative frequency of vertices

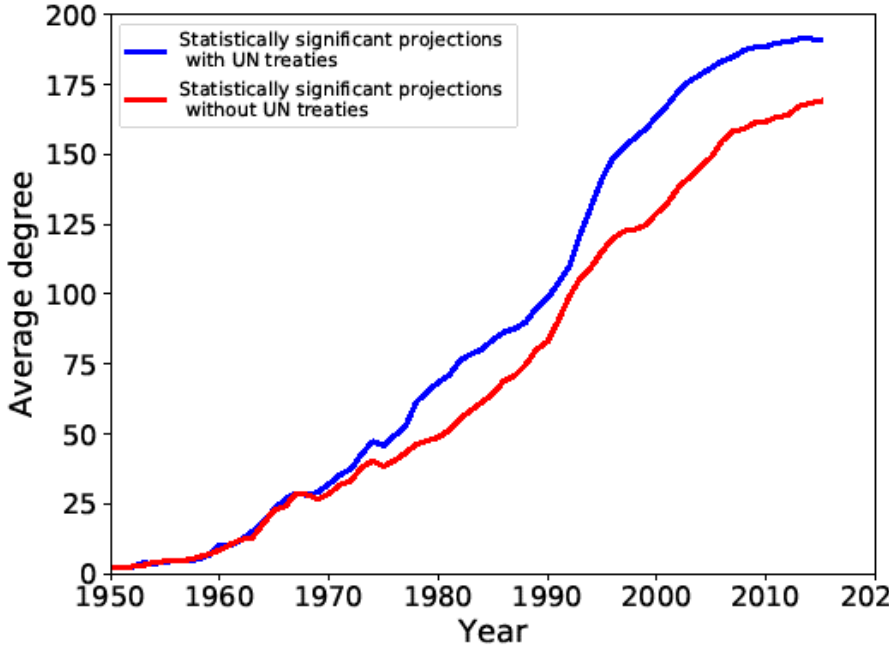


Cumulative frequency of edges

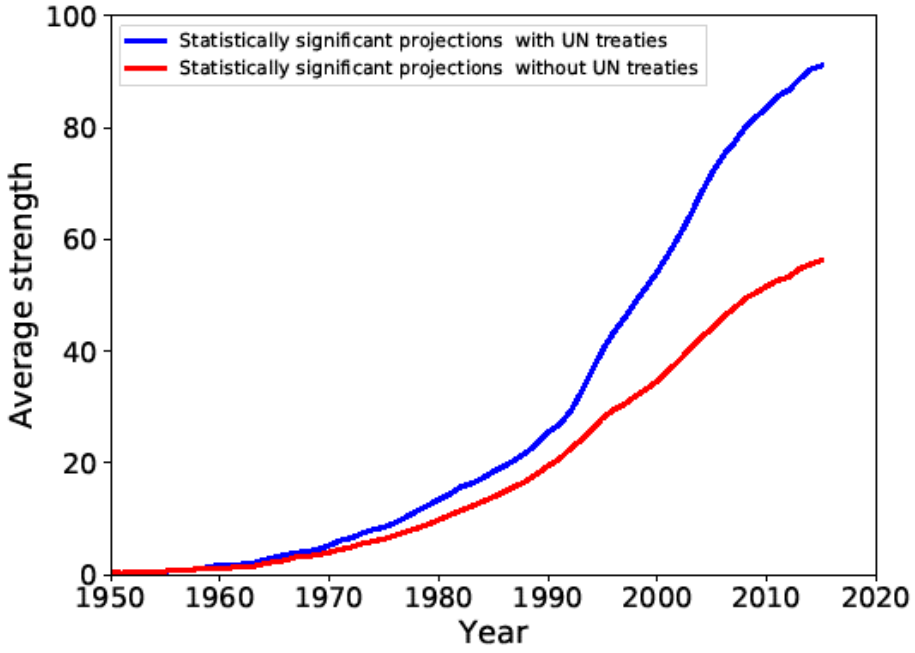
Dynamics of the Network (1950-2015)

- Less fragmented system over time: since 1979 the network is organised in one giant component, i.e. all countries can reach another either directly or indirectly.

- Each country collaborated with an increasing number of other countries and the intensity of their collaboration increased over time.



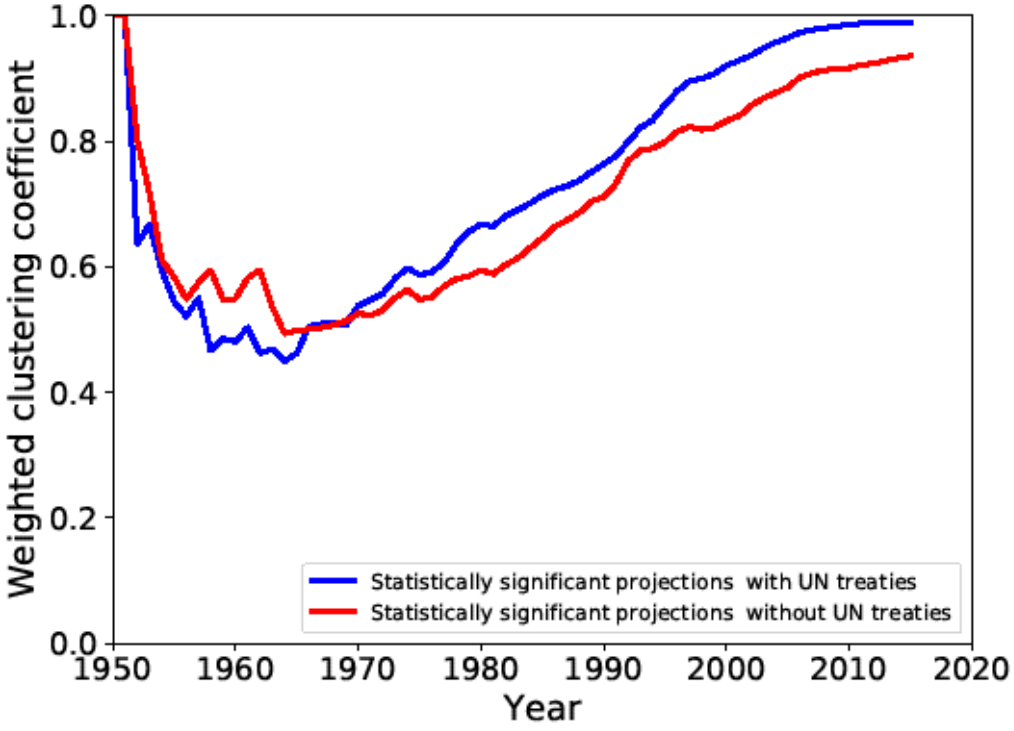
Average degree



Average strength

Dynamics of the Network (1950-2015)

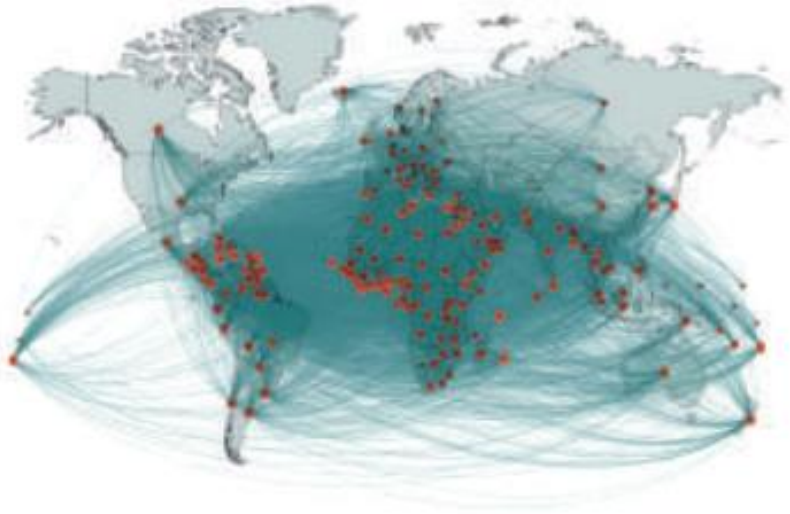
- Global clustering coefficient captures the extent of transitivity in the system, i.e. to which extent if countries A and B are each connected to C, they are connected themselves.



- Increase in cooperation associated with the presence of common partners who helped countries to establish new relationships.

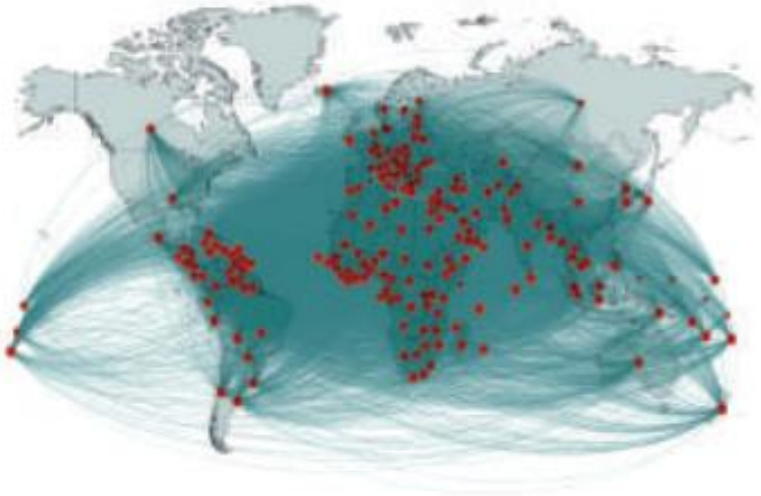
Dynamics of the Network (1950-2015)

(c) 1970

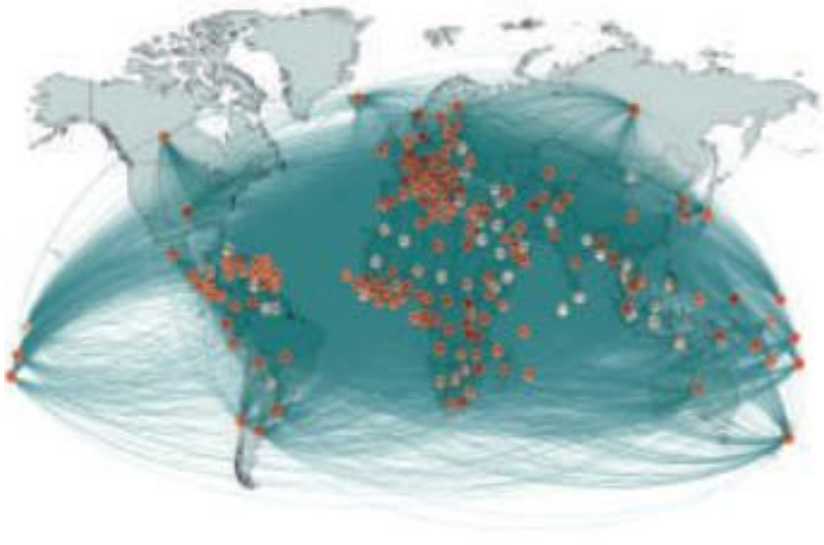


(e) 1990

Dynamics of the Network (1950-2015)



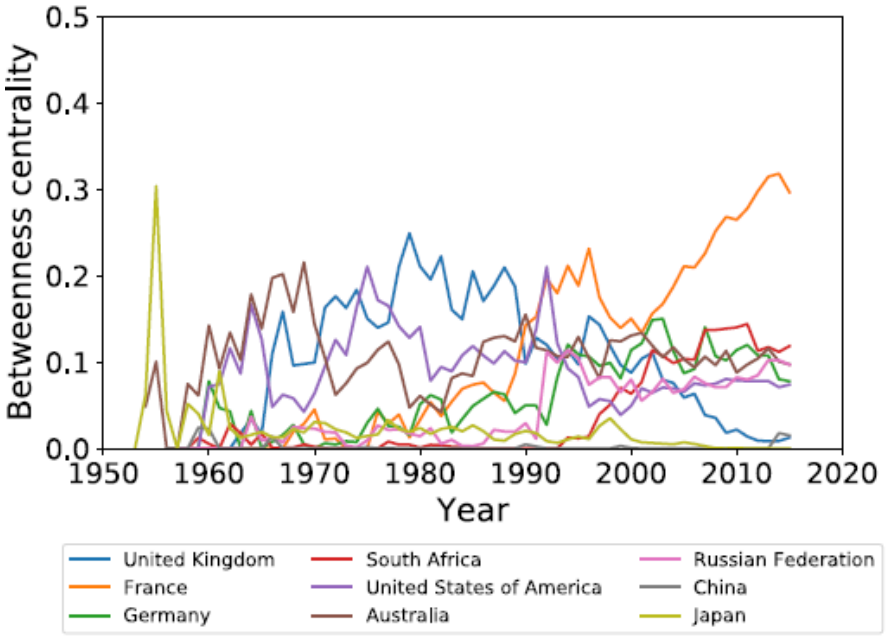
(f) 2000



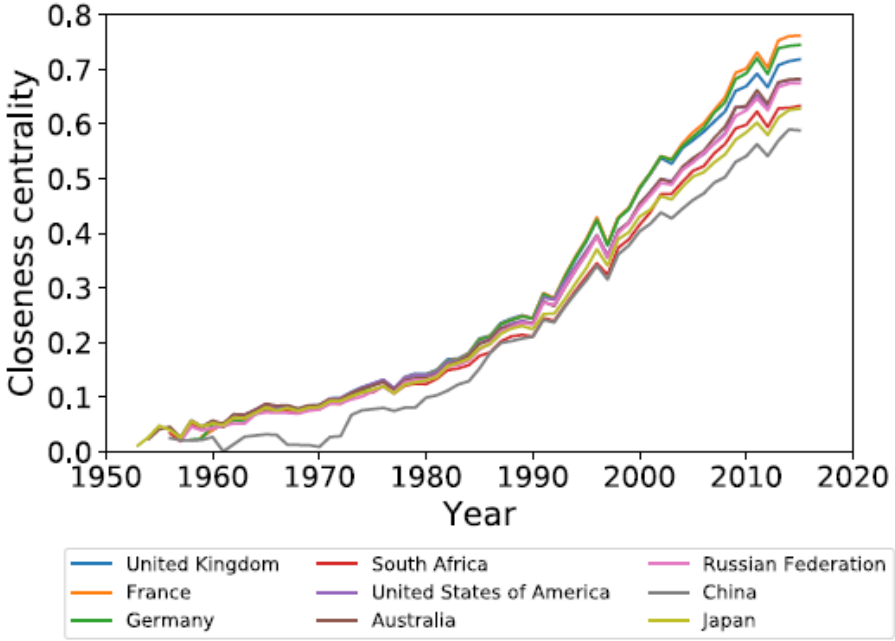
(h) 2015

Role of Individual Countries (1950-2015)

- Betweenness centrality: associated with a role of intermediary, who control the flow of information and can influence the network.
- Closeness centrality: associated with being in the position to reach all other nodes quickly.



(a) Betweenness centrality of countries



(b) Closeness centrality of countries

Topological Properties in 2015

Centrality measures

Ranking	Betweenness centrality		Closeness centrality	
	Real network	Statistically significant network	Real network	Statistically significant network
1	France	France	France	France
2	Germany	South Africa	Germany	Germany
3	Australia	Australia	Netherlands	Netherlands
4	Russian Federation	Russian Federation	Italy	Italy
5	South Africa	Germany	Spain	Spain
6	America	America	United Kingdom	United Kingdom
7	Morocco	Morocco	Belgium	Belgium
8	Tanzania	Spain	Luxembourg	Luxembourg
9	Spain	India	Switzerland	Switzerland
10	India	Tanzania	Norway	Norway

Summing Up

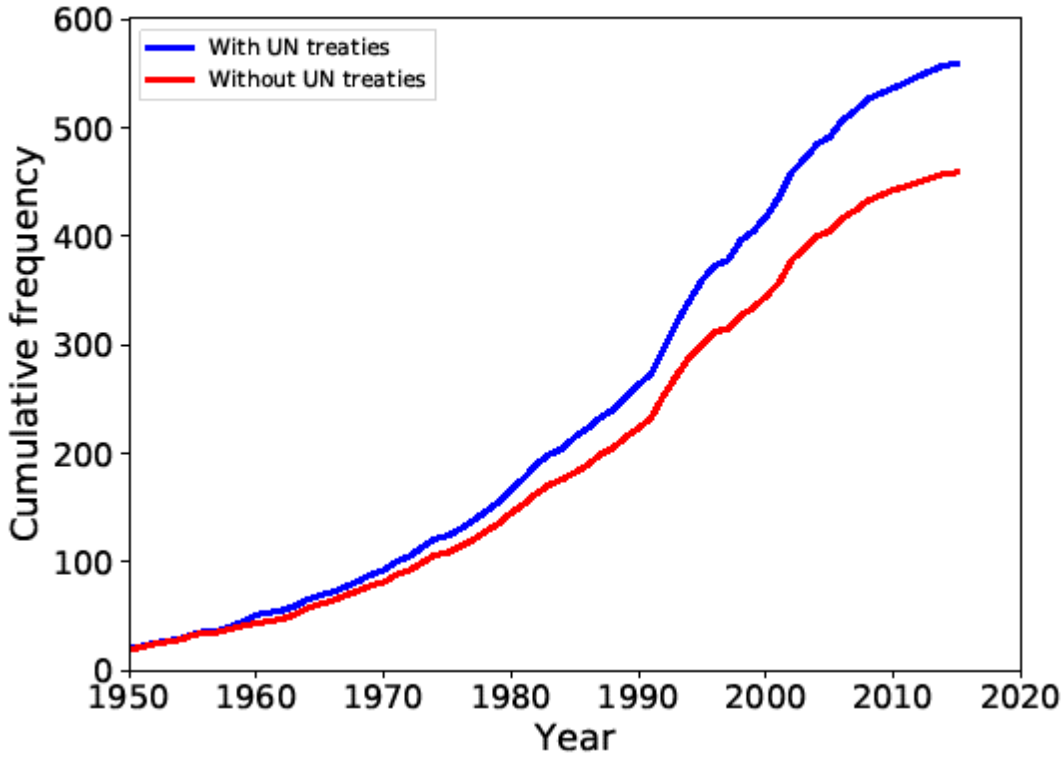
- Dense system; countries interact with each other more intensively.
- Countries are not isolated.
- Since the last decades information can travel more efficiently between countries
- France seems to play a crucial role in the system. Its position is associated with a higher possibility to influence other countries and control the diffusion of information.

=> First step of a broad research agenda.

THANK YOU!

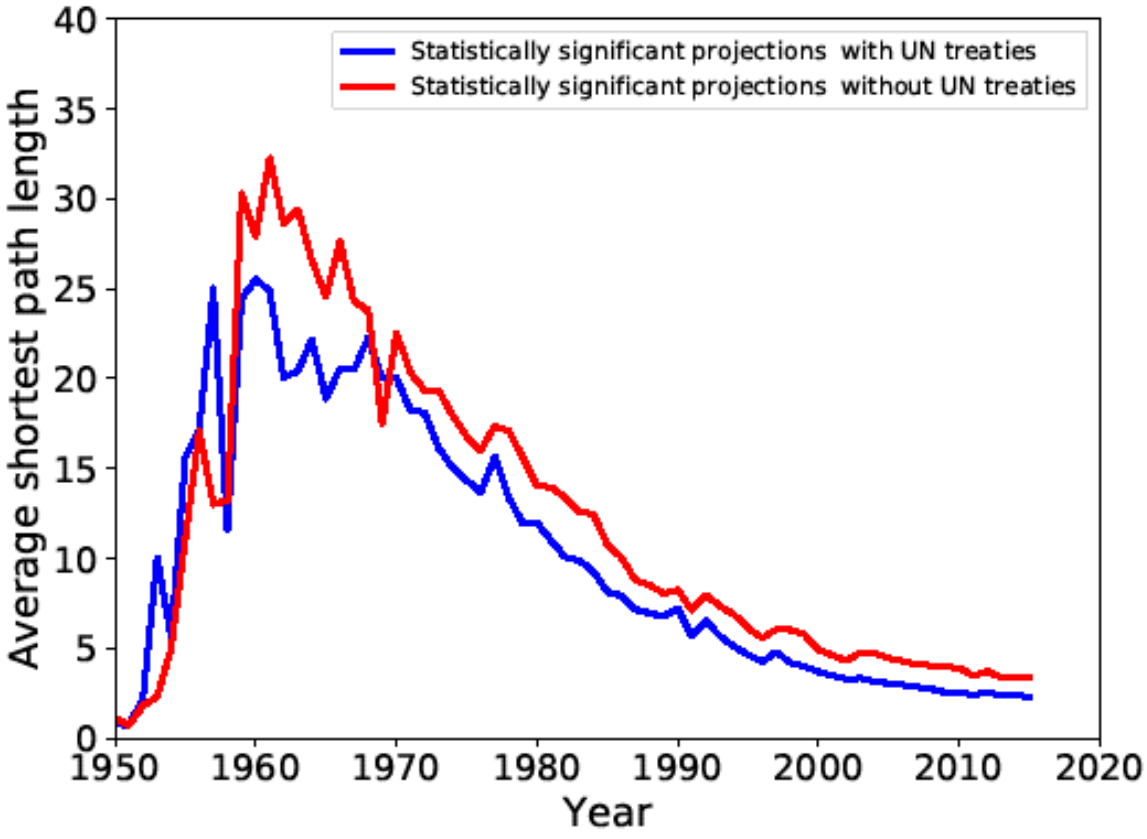
Appendix

- Cumulative frequency of treaties involved from 1950 to 2015



Dynamics of the Network (1950-2015)

- Circulation of information between countries became more efficient, as the interaction became less costly.



Topological Properties in 2015

- Weighted local clustering coefficient: extent to which a node's neighbours cooperate with each other.