

Enforcing Compliance in IEA: Investments, Instruments, and Participation

Alessia Russo

PhD minicourse - EAERE Summer School - Graz

June 2025

Some Facts on International Environmental Agreements

1-6. Sources of data

- ▶ **International Environmental Agreements Database Project**, available at: <https://www.iea.ulaval.ca>
- ▶ **What We Know (and Could Know) About International Environmental Agreements.** (Mitchell R., et al., 2020.) *Global Environmental Politics* 20:1: 103-121. https://doi.org/10.1162/glep_a_00544

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- ⇒ Not only Kyoto Protocol or Paris Agreement!

1-6. Definition of IEA

Type of Treaties	Number of Treaties
BEA (Bilateral Environmental Agreement)	1920
MEA (Multilateral Environmental Agreement)	1307

- ▶ Sample period: 1960-2023

1-6. History of IEA

- ▶ The **1969 Vienna Convention on the Law of Treaties** defines a treaty and sets procedures for adopting protocols and amendments.
- ▶ The **1972 UN Conference on the Human Environment (UNCHE)** is seen as a milestone in international environmental law.

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- ▶ Numerous BEAs were negotiated around UNCHE, and both MEAs and BEAs around the **1992 UN Conference on Environment and Development**.

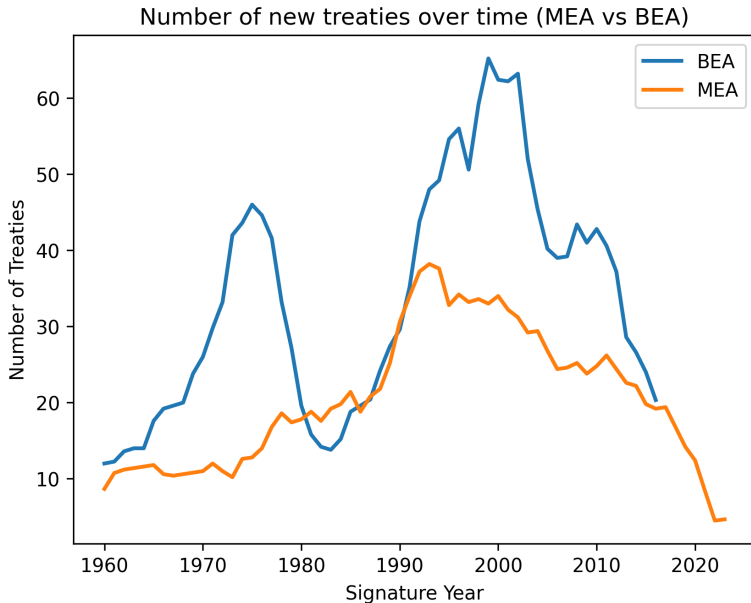
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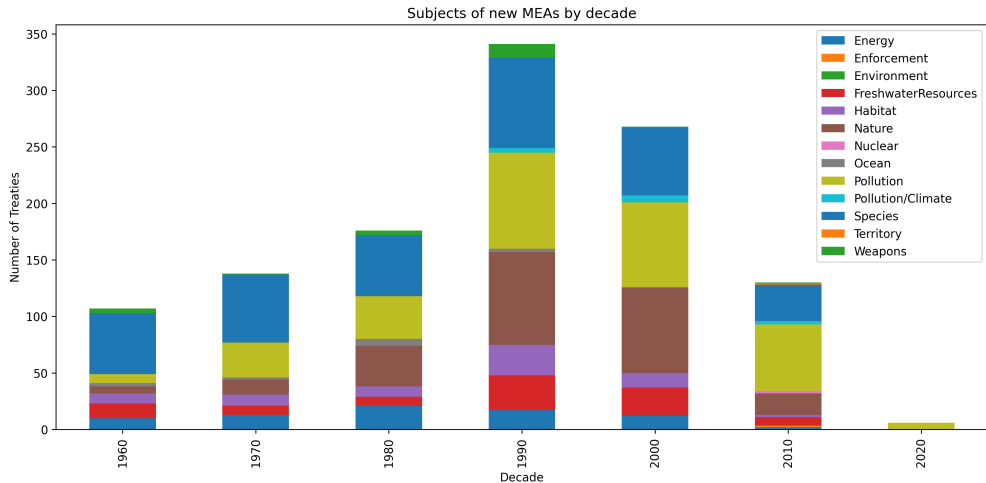
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- ▶ Rising IEA membership reflects more treaties, more states (UN members rose from 51 in 1945 to 193 in 2019), and broader state participation in MEAs.

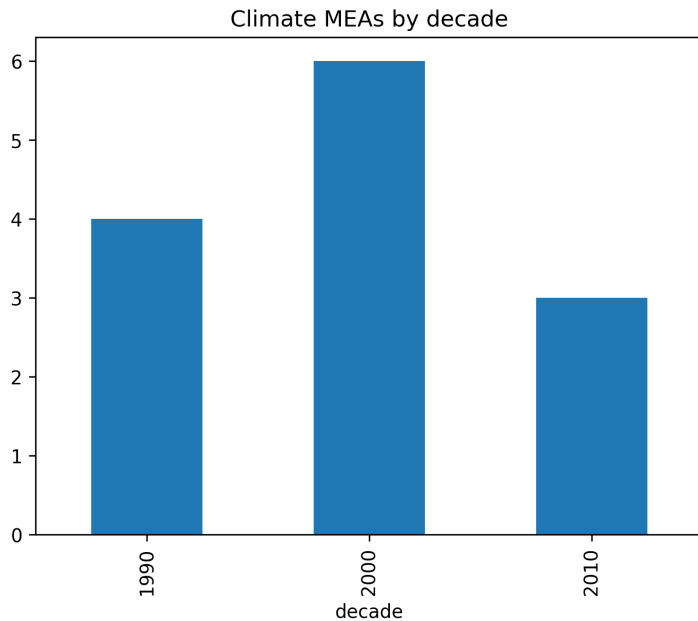
1-6. Treaties over Time



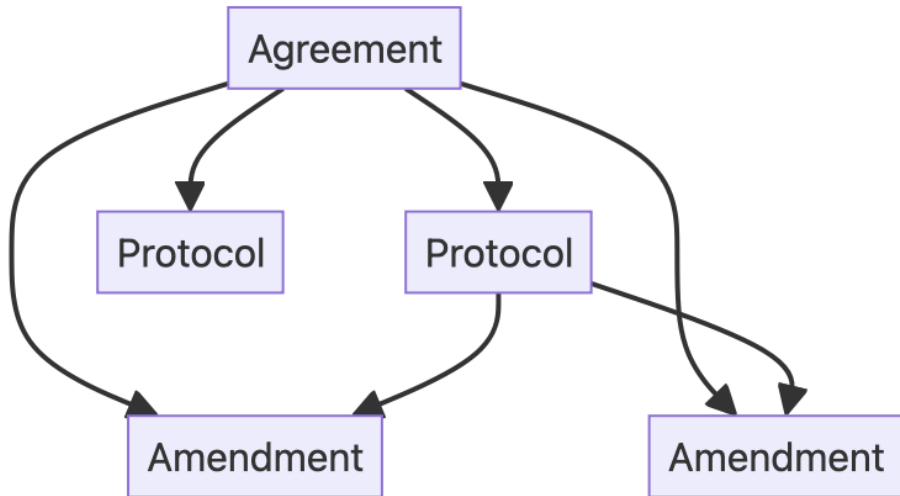
1-6. Treaties over Time by Subject



1-6. Climate Treaties over Time



1-6. Treaties as a Hierarchy



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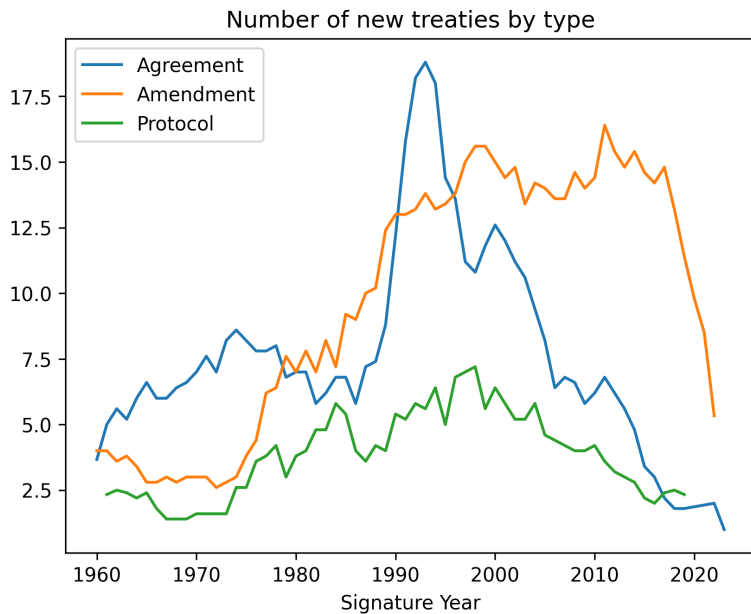
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Amendment	It refers to the formal modification of a treaty's provisions by its parties, and it must follow the same procedures required for the original treaty's adoption.

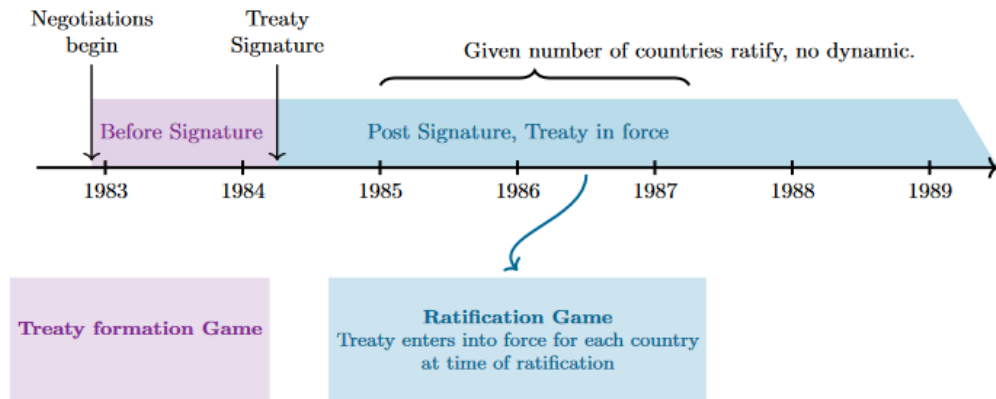
1-6. Treaties as a Hierarchy

Agreement Type	Number of Treaties by type
Agreement	2175
Protocol	312
Amendment	735

1-6. Treaties as a Hierarchy over Time



1-6. Timing of Negotiations



1-6. Delay of Entry into Force

- Many treaties have **an entry into force (EIF) condition**
- Hence, they do not enter into force just after a country ratifies it
- For example:
 - Kyoto Protocol (1997):** Enters into force *90 days after* at least 55 *Parties* to the UNFCCC ratify, and These Parties account for at least 55% of CO₂ global emissions
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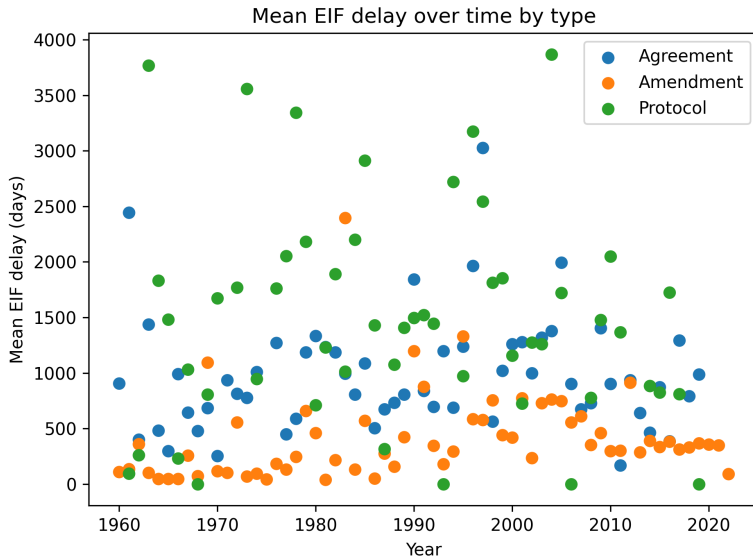
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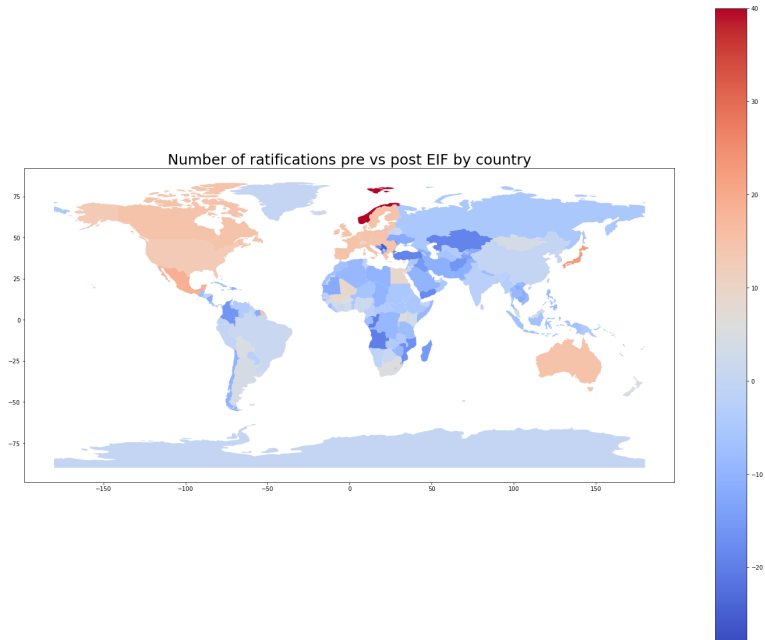
Paris Agreement (2015): Enters into force *30 days after* at least 55 *Parties* to the UNFCCC ratify, and These Parties account for at least 55% of global CO₂ emissions

→ Entered into force on 4 November 2016, less than a year after adoption.

1-6. Delay of Entry into Force



1-6. Delay of Ratifications across Countries



1-6. Three Key Theoretical Aspects on IEA

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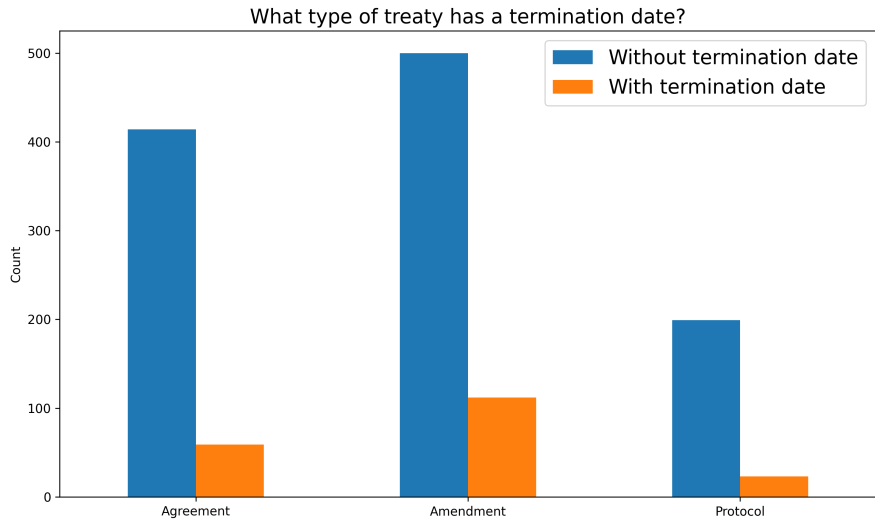
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- ▶ **Duration:**
 - ⇒ How long the agreement remains in force.
- ▶ **Size:**
 - ⇒ The number of participating countries.
- ▶ **Depth:**
 - ⇒ The extent of stringency and ambition of the agreement.

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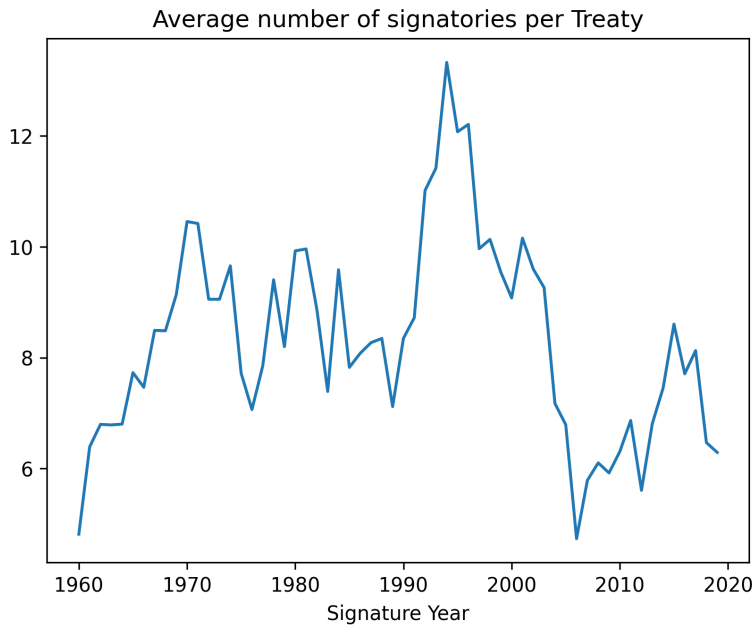
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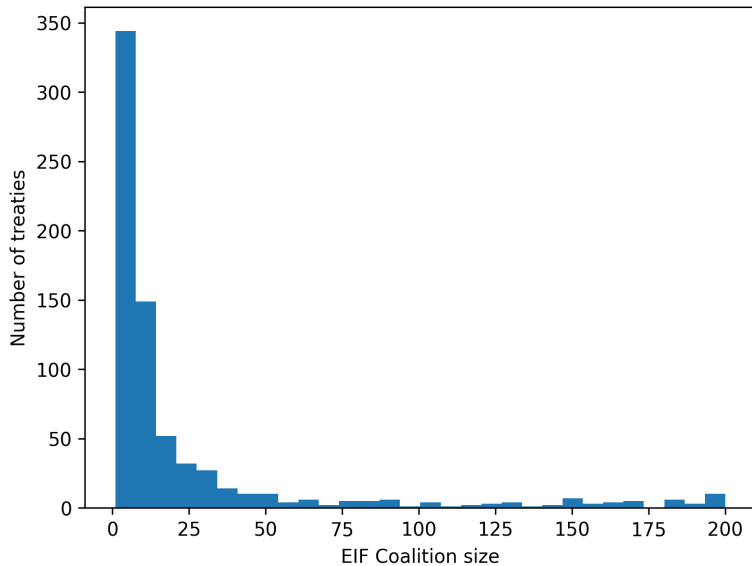
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 - **Climate Change Lineage:** UNFCCC (1992) → Kyoto Protocol (1997) → Paris Agreement (2015)
 - **Biodiversity Lineage:** Convention on Biological Diversity (1992) → Cartagena Protocol (2000) on Biosafety → Nagoya Protocol (2010) on Access and Benefit-Sharing

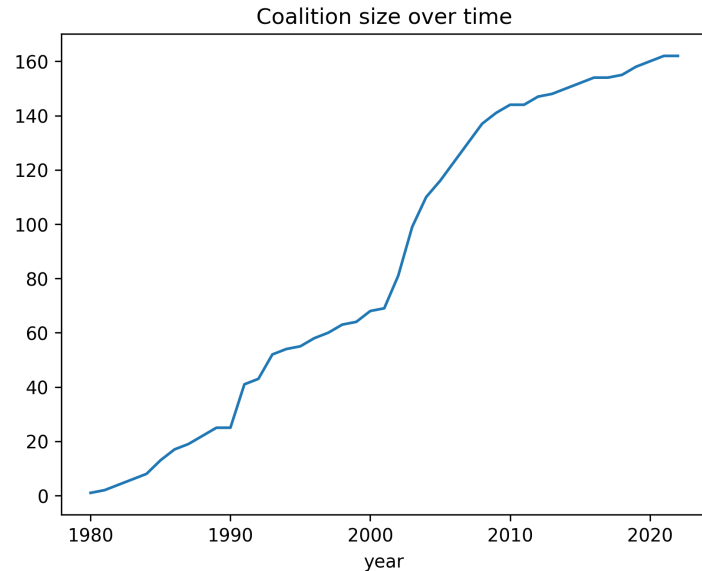
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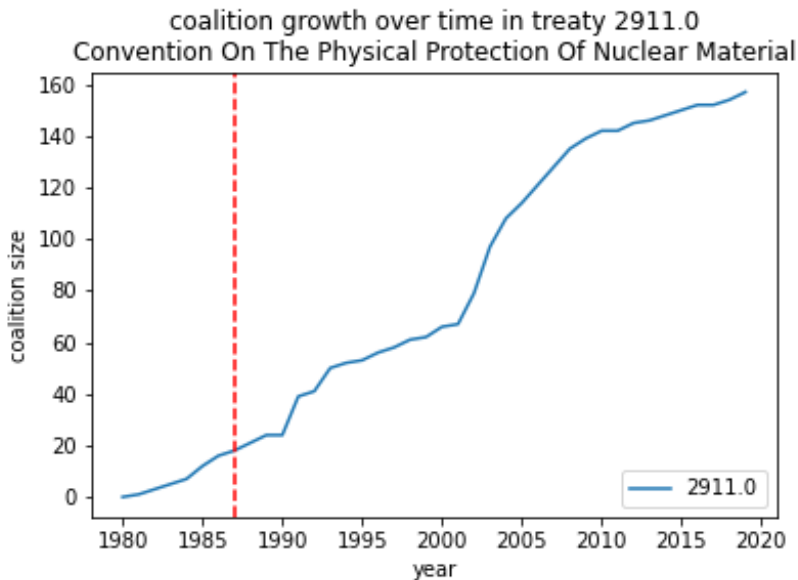
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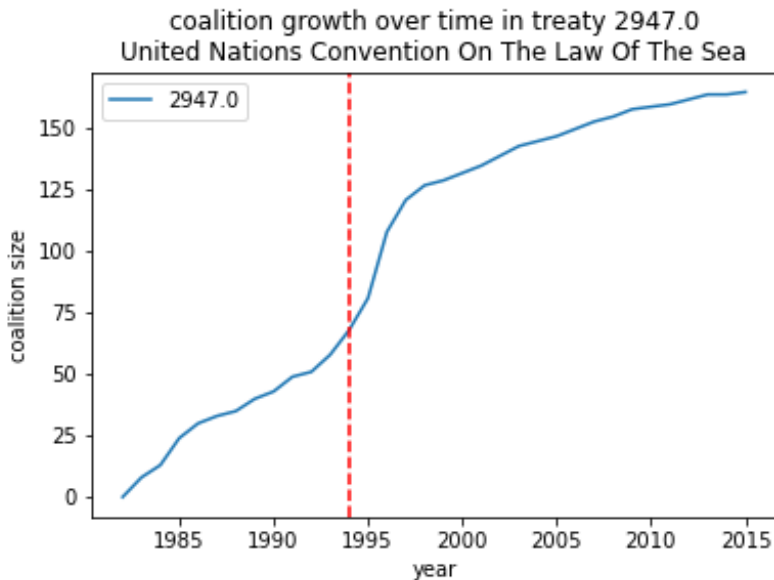
1-6. Size: Convention On The Physical Protection Of Nuclear Material - mitch_id 2911)



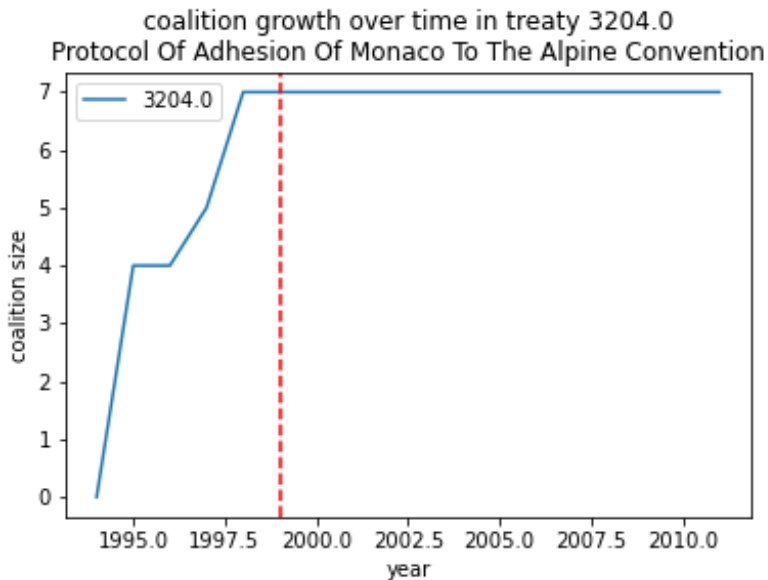
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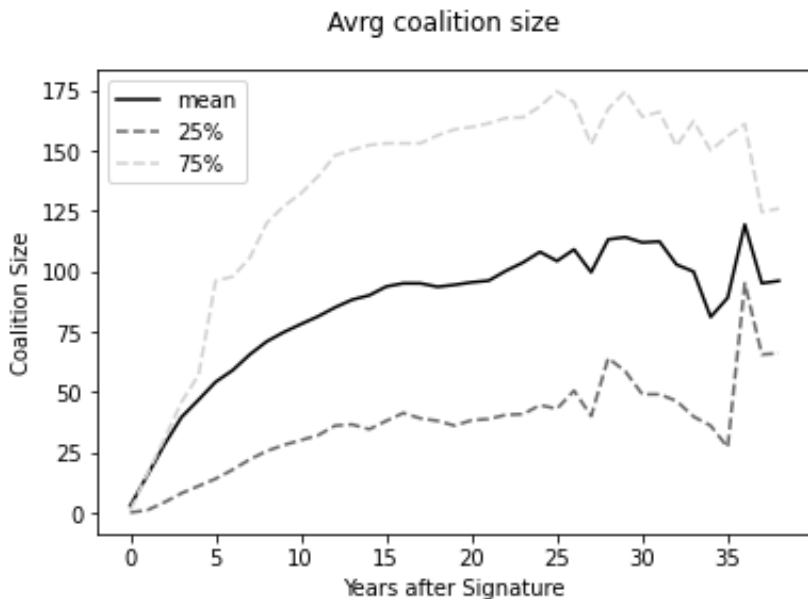
1-6. Size: United Nations Convention on the Law of the Sea - mitch_id 2947



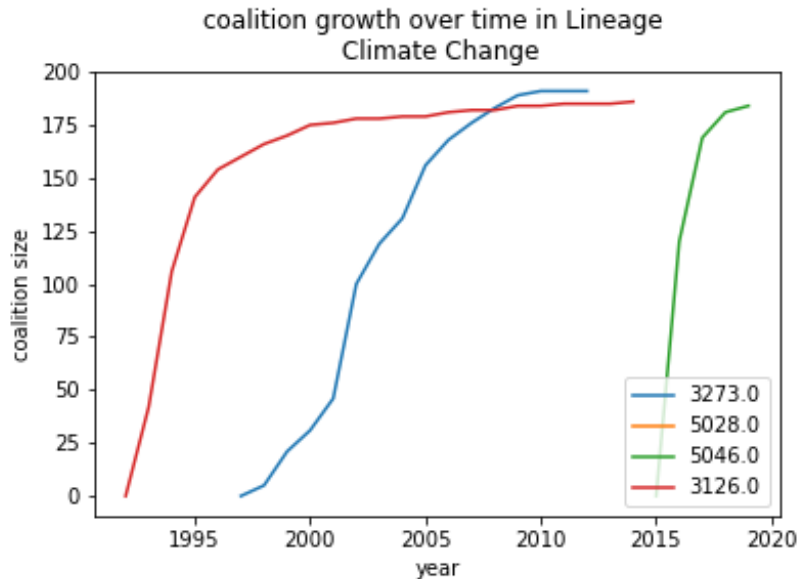
1-6. Size: Protocol of Adhesion of Monaco to the Alpine Convention - mitch_id 3204



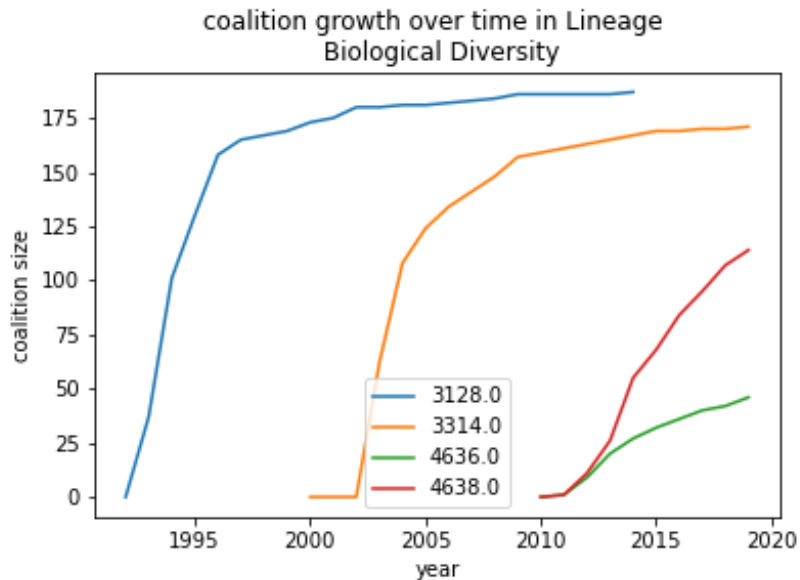
1-6. Size: Average Membership Dynamics



1-6. Size: Climate Change Lineage



1-6. Size: Biodiversity Lineage



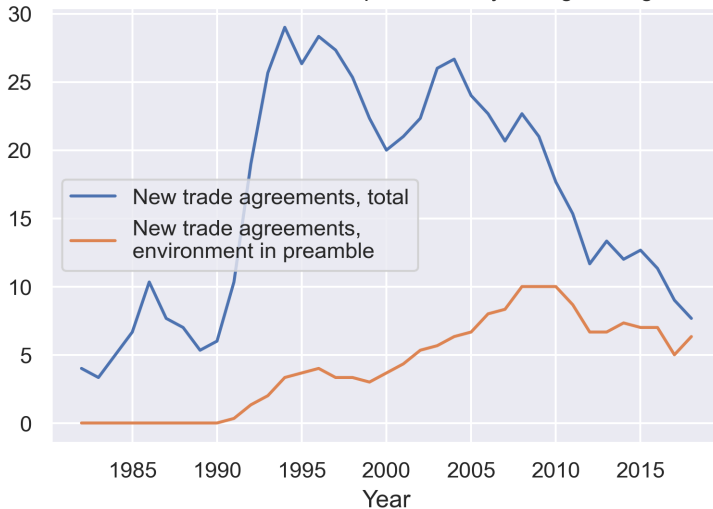
1-6. Depth

Tabela 1: Treaty depth by subject: depth variable takes values $\{0; 1; 2; 3\}$ given by the sum of dummy variables encoding **monitoring** and **enforcement provisions** and **quantifiable targets**

Subject	count	mean	std	min	50%	max
Climate	2.0	2.000	1.414	1.0	2.0	3.0
Energy	3.0	1.667	1.155	1.0	1.0	3.0
Freshwater	2.0	0.000	0.000	0.0	0.0	0.0
Habitat	11.0	2.455	0.688	1.0	3.0	3.0
Human sphere	7.0	1.857	1.464	0.0	3.0	3.0
Other	7.0	1.714	0.951	0.0	2.0	3.0
Pollution	50.0	2.000	0.969	0.0	2.0	3.0
Species	38.0	1.974	0.885	0.0	2.0	3.0

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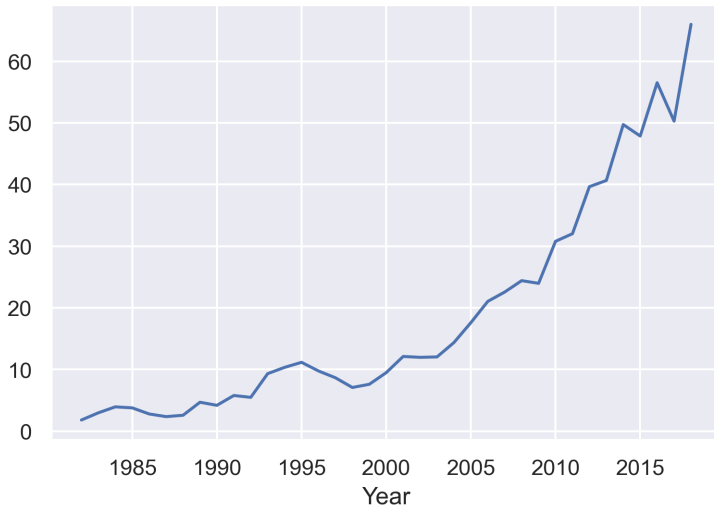
Signature of new trade agreements that refer to the environment in their preamble, 3y rolling average



Data a from TREND

1-6. Depth

Average number of environmental provisions per trade agreement



Data a from TREND

A Discrete Choice Model of Dynamic Ratifications

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- Key facts:
 - * Some countries — primarily G20 members — tend to lead the ratification process by ratifying early, even before the entry-into-force conditions are met [▶ Timing](#)
 - * Ratifications occur in a staggered fashion; withdrawals are rare (e.g., the U.S. from Paris, Canada from Kyoto) and, over time, many global agreements gravitate toward broad participation or a “grand coalition”

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 - McEvoy et al. (2015)
- ▶ Why are some treaties eventually ratified by all countries, while others are not? What explains the pace of ratification?
 - Wagner (2015); Russo, Sanches, and Werth (2025)

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1-7. Dynamic Ratification

- ▶ We distinguish between two types of countries: **Leaders** and **Followers**

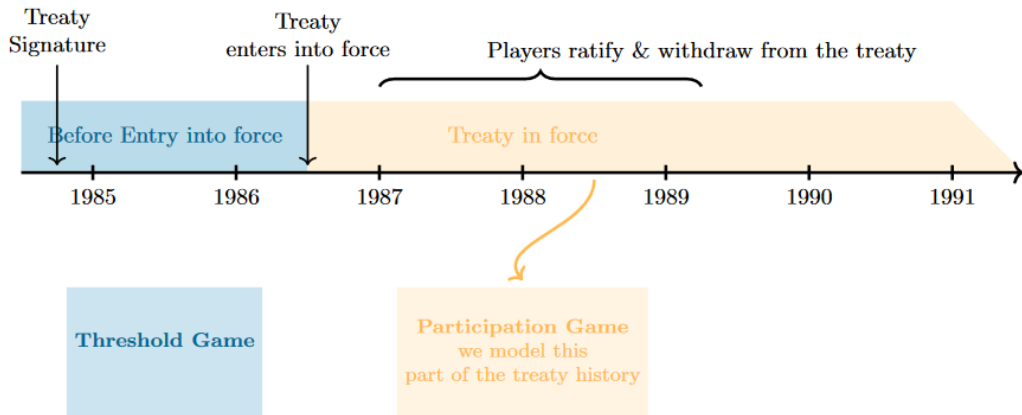
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- ▶ Leader countries ratify *before* EIF conditions are met, while Follower countries ratify *after*
- ▶ Our focus is on the **Follower Ratification Game**, taking the outcome of the Leader game as given
 - * The game we model begins *after* the treaty has entered into force
 - * Accordingly, the empirical analysis is restricted to ratification decisions made after that date

1-7. Institutional Setting



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- ▶ Ratification **benefits are uncertain**
- ▶ Once a country ratifies a treaty, it cannot withdraw (in practice, withdrawals are rare and excluded from the analysis)
 - * A **discrete time dynamic choice model under uncertainty with absorbing state**

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- ▶ ε_i^t is a **private information** payoff shock drawn from $\Psi(0, 1)$ independent from the state variables

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- * If club good, then $\phi_1 > \phi_0, \Rightarrow$ **Strategic Complementarity**

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- * If club good, then $\phi_1 > \phi_0, \Rightarrow$ **Strategic Complementarity**

- ▶ $\phi \equiv \phi_1 - \phi_0$, $\gamma \equiv \gamma_1 - \gamma_0$, and $\mu \equiv \mu_1 - \mu_0$ can be estimated for each treaty using variations in ratifications dates across countries!

1-7. Timing of the Game

For each treaty j , the **timing of the game** in each period is as follows:

- i. All countries observe the current **state** and their idiosyncratic **payoff shock**
- ii. Countries simultaneously choose actions $a_{ij}^t \in \{0, 1\}$ to maximize their expected sum of future payoffs discounted at a common factor $\beta < 1$
- iii. After actions are taken, all countries observe the actions of every other country and beliefs are updated; the game then proceeds to the next period

1-7. Equilibrium Concept

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- ▶ Each country forms beliefs $\sigma_i(\mathbf{a}_{-i}|\mathbf{s})$ about other countries' actions, conditional on state \mathbf{s} , and chooses its action accordingly.
- ▶ After actions are taken, the state evolves according to a Markov transition function $g(\mathbf{s}'|\mathbf{s}, \mathbf{a})$ with:

$$\sum_{\mathbf{s}'} g(\mathbf{s}'|\mathbf{s}, \mathbf{a}) = 1$$

Value Function

Fixed-Point Problem

- ▶ Let $V_i^1(\mathbf{s}, \varepsilon_i | \sigma_i)$ denote country i 's value if it chooses $a_i = 1$ today.
- ▶ Let $V_i^0(\mathbf{s}, 0 | \sigma_i)$ denote its value if it chooses $a_i = 0$.

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- ▶ Given $\varepsilon_i \sim \Psi(0, 1)$, the probability that i chooses $a_i = 1$ in state \mathbf{s} is:

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- ▶ Let \mathbf{P} and $\boldsymbol{\sigma}$ be the vectors of choice probabilities and beliefs across all i , and let $\boldsymbol{\theta} = (\gamma, \phi, \mu)$ collect the treaty parameters. Then:

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- ▶ Beliefs match behavior \Rightarrow **fixed point of choice probabilities:**

$$\mathbf{P} = \Psi(\mathbf{P}, \boldsymbol{\theta})$$

1-7. Algorithm

- ▶ **Two-Step Algorithm**

(Hotz & Miller, 1993; Aguirregabiria & Mira, 2007; Bonet & Pesendorfer, 2003; Pesendorfer & Schmidt-Dengler, 2008; Sanches et al., 2016)

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- ▶ **Step 1 — Reduced Form:** Estimate countries' conditional choice probabilities (CCPs) from observed ratification behavior as a function of state variables.
- ▶ **Step 2 — Structural:** Recover model parameters by exploiting the fixed-point condition linking beliefs and CCPs.

1-7. Sample Selection

- ▶ **Country Selection:** Post-EIF Ratification Game
 - Most G20 countries ratified **before** entry into force (EIF).
 - Focus on 10 **middle-income countries** with highest GDP growth.

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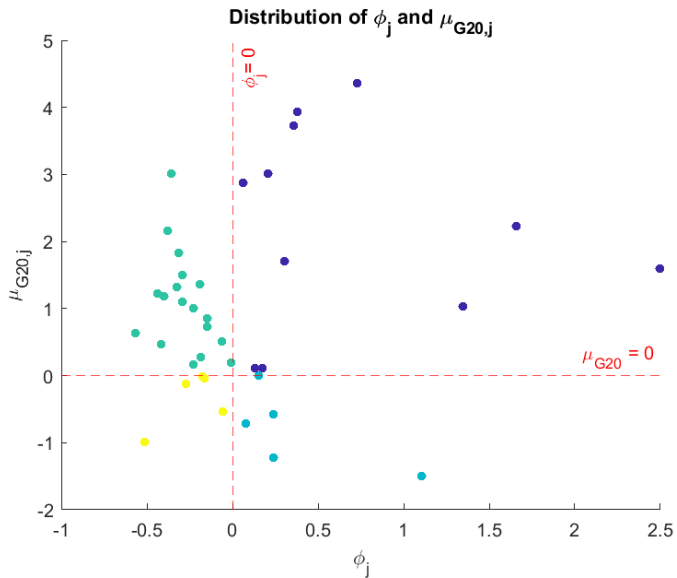
▶ **Treaty Selection**

→ Treaties signed between 1980–2019

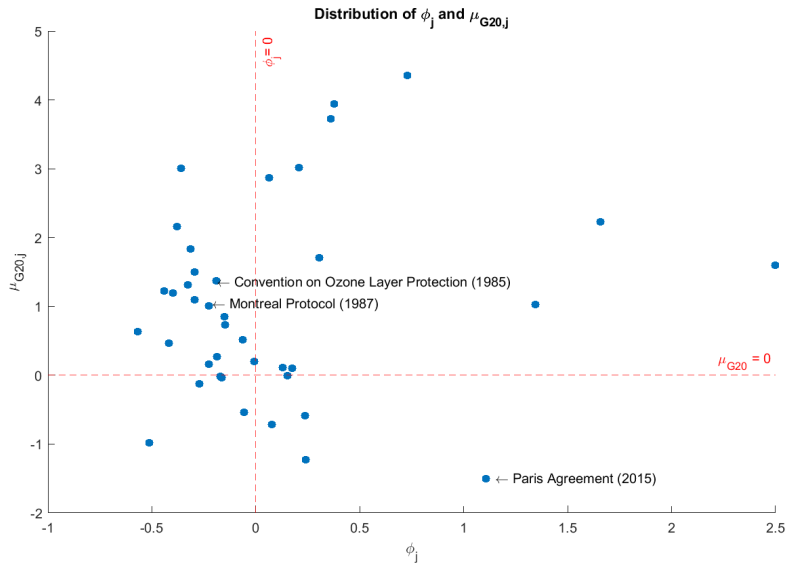
→ Open to **global ratification** (excluding regional agreements)

→ Final sample: $J = 46$ treaties

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 - Use of **text-as-data** to quantify **treaty depth** (Lancia, Russo, Werth, ongoing work)
- ▶ The **Coordination Game of Leadership** is crucial for understanding international climate cooperation.
- ▶ Interdependence between **environmental treaties and trade agreements** offers a promising direction for future research.
 - A similar structural approach can be applied, though dimensionality challenges must be addressed.

1-7. Simple Code for Numerical Simulations

Thank you for the attention!
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