Jan, 2026
GRINS DISCUSSION PAPER SERIES DP N° 80/2026 ISSN 3035-5576

GRINS

The Architecture of Environmental Cooperation: Size, Duration, Depth, and Trade Linkages

DP N° 80/2026

Authors:
Alessia Russo, Jonas Werth

Jan, 2026
GRINS DISCUSSION PAPER SERIES DP N° 80/2026 **ISSN 3035-5576**

The Architecture of Environmental Cooperation: Size, Duration, Depth, and Trade Linkages

Alessia Russo, Jonas Werth

KEYWORDS

Duration | Environment | Size | Trade | Treaty

JEL CODE

D86, F53, H87, Q54

ACKNOWLEDGEMENTS

This study was funded by the European Union - NextGenerationEU, in the framework of the GRINS - Growing Resilient, INclusive and Sustainable project (GRINS PE00000018). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them.

CITE THIS WORK

Author(s): Alessia Russo, Jonas Werth. Title: The Architecture of Environmental Cooperation: Size, Duration, Depth, and Trade Linkages. Publication Date: 2026.

This paper documents new stylized facts on the formation, design, and participation of international environmental agreements using data from the International Environmental Agreements Database Project (IEADB) for the period 1980–2023. We describe trends in treaty formation, coalition size, duration, and depth, highlighting a shift from new agreements toward the amendment and expansion of existing treaty lineages. Treaty characteristics vary systematically across environmental domains and geographic scope, with regional agreements exhibiting deeper commitments but more limited participation.
A central contribution of the paper is to link environmental treaties to international trade agreements. Combining IEADB data with information on preferential trade agreements and their environmental provisions, we document a growing integration of environmental objectives into trade policy. The results provide a data-driven foundation for future research on treaty effectiveness and policy interaction.

The Architecture of Environmental Cooperation: Size, Duration, Depth, and Trade Linkages*

Alessia Russo[1] and Jonas Werth[2]

[1] *University of Padua and CEPR*

[2] *BI Norwegian Business School*

Abstract

This paper documents new stylized facts on the formation, design, and participation of international environmental agreements using data from the International Environmental Agreements Database Project (IEADB) for the period 1980–2023. We describe trends in treaty formation, coalition size, duration, and depth, highlighting a shift from new agreements toward the amendment and expansion of existing treaty lineages. Treaty characteristics vary systematically across environmental domains and geographic scope, with regional agreements exhibiting deeper commitments but more limited participation. A central contribution of the paper is to link environmental treaties to international trade agreements. Combining IEADB data with information on preferential trade agreements and their environmental provisions, we document a growing integration of environmental objectives into trade policy. The results provide a data-driven foundation for future research on treaty effectiveness and policy interaction.

Keywords: Duration, Environment, Size, Trade, Treaty

JEL classification: D86, F53, H87, Q54

* This study was funded by the European Union- NextGenerationEU, Mission 4, Component 2, in the framework of the GRINS- Growing Resilient, INclusive and Sustainable project (GRINS PE00000018-CUP C93C22005270001). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them.

1 Introduction

We provide a description of data related to the "International Environmental Database Project" (IEADB, Mitchell et al., 2023) and illustrate how the data can be used to answer questions surrounding the formation of international environmental agreements, the processes that lie behind their ratification, and their interaction with other areas of international cooperation.* In the last years there have been a series of papers that describe the IEADB in some depth and many aspects of the data have already been discussed in the literature (Mitchell et al., 2020, Mitchell 2003, Aftab et al., 2023). The IEADB was initiated in 2002 to provide researchers, students, and negotiators with a reliable list of both historic and current international environmental agreements of both bilateral (two countries) and multilateral (three or more countries) inclusion (Mitchell et al. 2023). The IEADB covers historical as well as more contemporaneous treaties with more than 3000 international environmental treaties at this point (Mitchell et al., 2020). We focus on the sample of treaties that were signed between 1980 and 2023. One of the advantages of the IEADB over comparable databases (CESIN, SEDAC ENTRI) is the clear definition of an environmental treaty that is used. International documents have to fulfill two conditions to be included, the intend to be legally binding and a stated environmental purpose. The requirement is that "an intergovernmental document **intended as legally binding** with a **primary stated purpose of preventing or managing human impacts on natural resources**" (Mitchell et al., 2023). This is a functional requirement and leads to the inclusion of treaties that are often overlooked when analyzing international environmental policy-making such as the "Agreement Establishing The World Trade Organization", "Convention On Nuclear Safety", or "World Health Organization Framework Convention On Tobacco Control". The IEADB catalogs signature, ratification, and entry into force dates of countries that are collected from national sources and combine them with treaty texts and metadata on treaty subjects, lineages, and other treaty-level information.

*Data from Ronald B. Mitchell. 2002-2023. International Environmental Agreements Database Project (Version 2020.1). Available at: http://iea.uoregon.edu/ Date accessed: 14 December 2023

2 Organization of the IEADB

The IEADB organizes treaties hierarchically into agreements, protocols, and amendments. Agreements introduce new policy areas, protocols extend existing agreements by adding further regulation, and amendments are used to change or update certain aspects of existing agreements or protocols. Therefore, there is always a relationship between agreements, protocols, and amendments. A group of related environmental treaties are nested in lineages. A lineage is defined as a "set of legally-related agreements that are linked by the fact that they modify, replace, extend or otherwise constitute agreements that have a legal relationship to each other. " (Mitchell et al., 2023). This concept allows to track policy efforts over longer periods and study how initially shallow environmental legislation gains depth as further treaties are added to the lineage.

3 Trends in international environmental policy-making

3.1 Signature of new treaties and lineages over time

International environmental agreements are subject of public debates and events like the conference of parties meetings of the "United Nations Framework Convention on Climate Change" (UNFCCC) are covered by media outlets all over the world. This gives the impression that countries continuously negotiate and sign new environmental treaties. If we look at the signatures of new environmental treaties over the past forty years we see that this is not the case. There has been a strong downward trend in the signature of new environmental agreements since new signatures peaked in the early to mid-1990s. For some time this reduction in agreement signatures was partially offset by signatures of new amendments. From the mid 2010s onward the signature of new amendments has dropped significantly too. Much of the change that happened in international environmental policy-making has happened in the form of amendments to existing treaties instead of through the negotiation and signature of new agreements and protocols. Thereby amendments are signed on average 20 years after the treaty (agreement or protocol) that

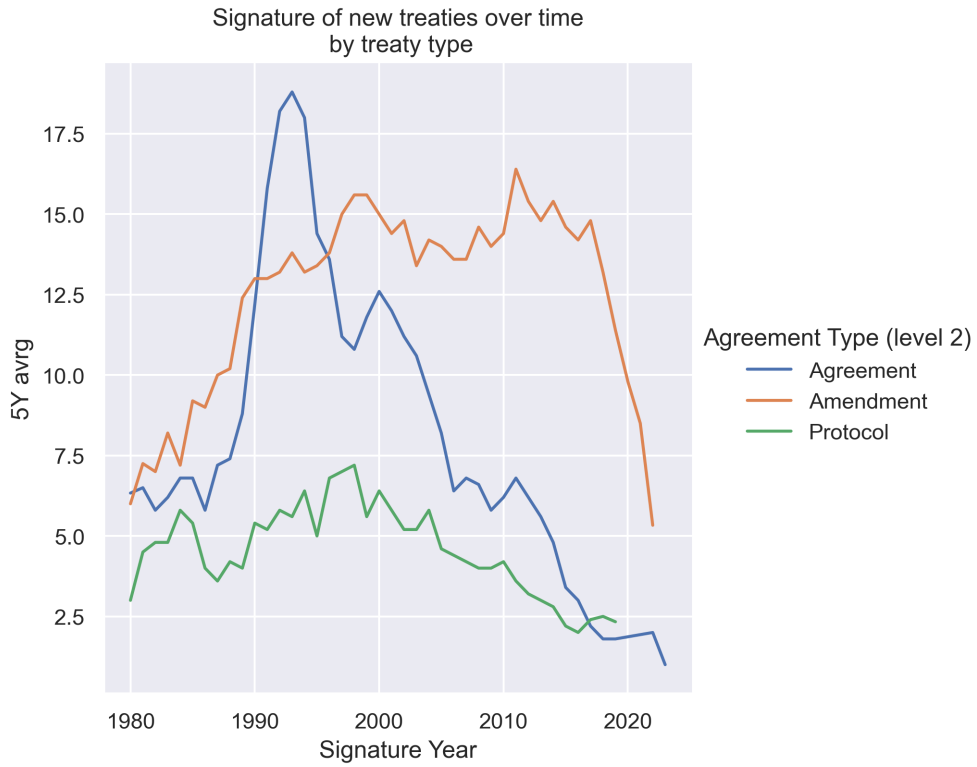


Figure 3.1: New signatures over time (5-year rolling average) by treaty type.

they are amending. This indicates that States update existing treaties with some time delay to maintain the relevance of these documents and adjust the legal framework to new scientific findings and technological standards. This is interesting from the standpoint of dynamic models of treaty formation because the possibility to adjust some of the treaty content without the need for full renegotiation can influence the holdup problem between member states investment in clean technologies and treaty participation that has been discussed in the literature (Battaglini & Harstad, 2016). Above we plot the average time that has passed between the signature of the amended treaty and the signature of the corresponding amendment. The upward trend is the result of continued work on the treaties that states signed in the early to mid-1990s. We can look at the distribution of amendments across lineages in the data and find that amendments are highly concentrated in a couple of lineages. Most notably "MARPOL" (International Convention for the Prevention of Pollution from Ships) with around 20% of all amendments in our data set, and the lineage on "Rhine Pollution" (Central Commission for the Navigation on the Rhine), "International Whaling" (International Whaling Comission), and "Conservation of Migratory Species" (UNEPS) with 5.5%-7.8% of all amendments each (the full table is provided in the appendix). To better understand how much of the dynamics in figure

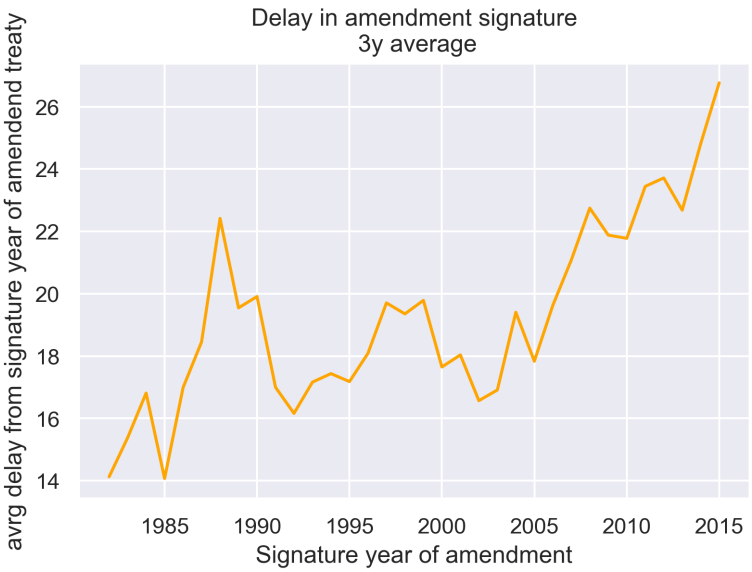


Figure 3.2: Time delay between treaty signature and signature of the amendment to the treaty (3-year rolling average)

3.1 is due to continued work in existing lineages or if new lineages drive the dynamic we plot the signature of first agreements in lineages over the sample period. In fact, most of the agreements signed between the early 1990s and 2000 initiated new lineages and only a few of them extended existing lineages. This suggests that states sought to contract new environmental policies in the 1990s that did not fit the existing cosmos of lineages and much of the international environmental policy making that happens today can be attributed to those lineages.

3.2 Subjects of international environmental agreements

Humans impact many different natural resources so naturally the IEADB includes treaties with a broad set of stated subjects. We follow Mitchell et al. (2020) and group treaties into 7 subjects and one residual group. The IEADB uses an explicit definition of what constitutes and international environmental agreement and includes intergovernmental treaties accordingly. Part of that definition is that the treaty has to have "a primary stated purpose of preventing on managing human impacts on natural resources" (Mitchell et al., 2023). By focusing on the interaction between human activity (most often economic activity) and it's impact on natural resources instead of simply focusing on the presence of the term "environment" the IEADB includes a wide range of treaties. Each treaty is assigned a series of subject codes with the primary subjects of newly signed multilateral

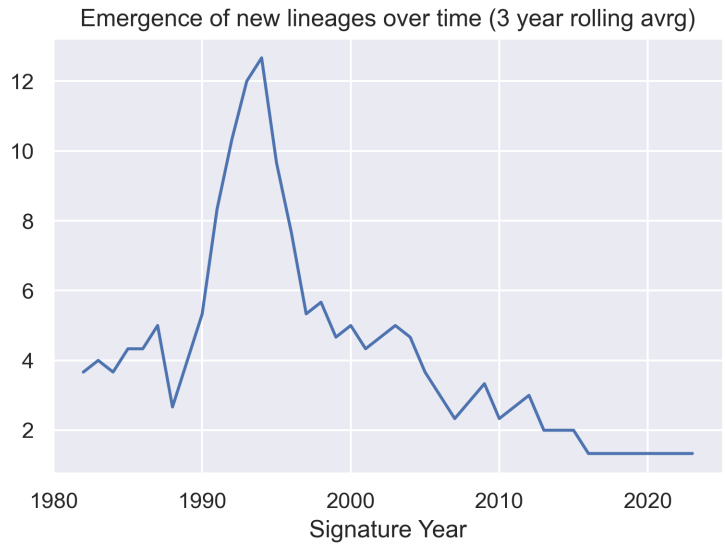


Figure 3.3: New lineages being started over time, (3-year rolling average)

environmental treaties plotted below Treaties that seek to manage or mitigate the human impact on species and biological diversity play a major role throughout the sample period with a share that ranges between roughly 40% in the 1980s to around 32% in the 2010s. The second most prominent subject is "Pollution". This subject nests a broad range of issues that span from the control of transboundary movement of hazardous wastes, the protection of the marine environment from oil and other harmful substances, long-range transboundary air pollution, nuclear accidents and safety, to the protection of the ozone layer. The most famous subject of international environmental policy "climate" has only started in the 1990s and plays a minor role from the perspective of newly signed treaties. To better understand how the relevance of subjects has changed we can further look at the emergence of new lineages of a given subject over time. We again group treaties by signature decade and subject but restrict the treaty sample to those that started a new lineage and plot the count instead of shares. Surprisingly, the trends from figure 3.4 appear relatively well preserved. Overall, new lineages are most commonly targeted towards pollution and species with freshwater resources and energy-related lineages playing an important role in the 1990s and 2000s.

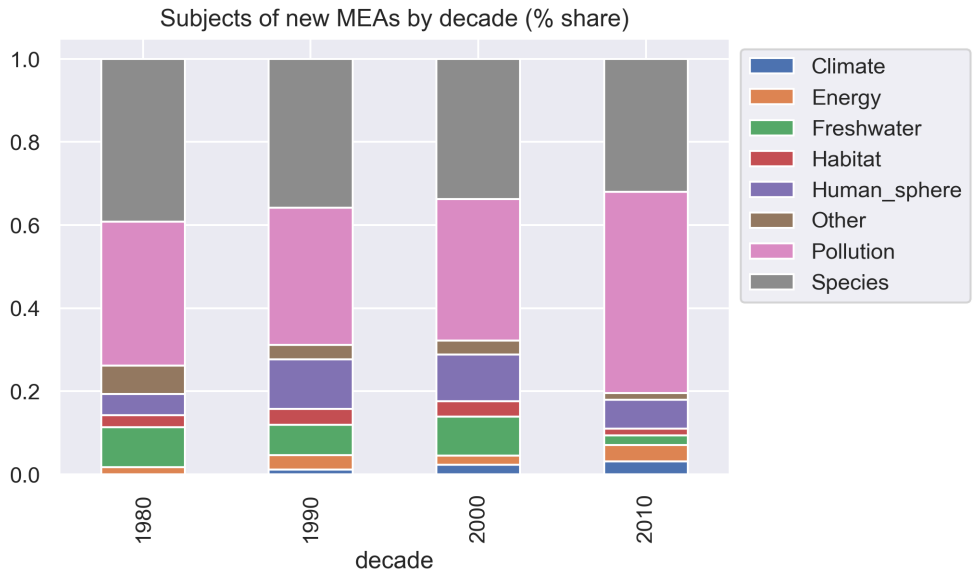


Figure 3.4: Distribution of subjects in newly signed treaties over time

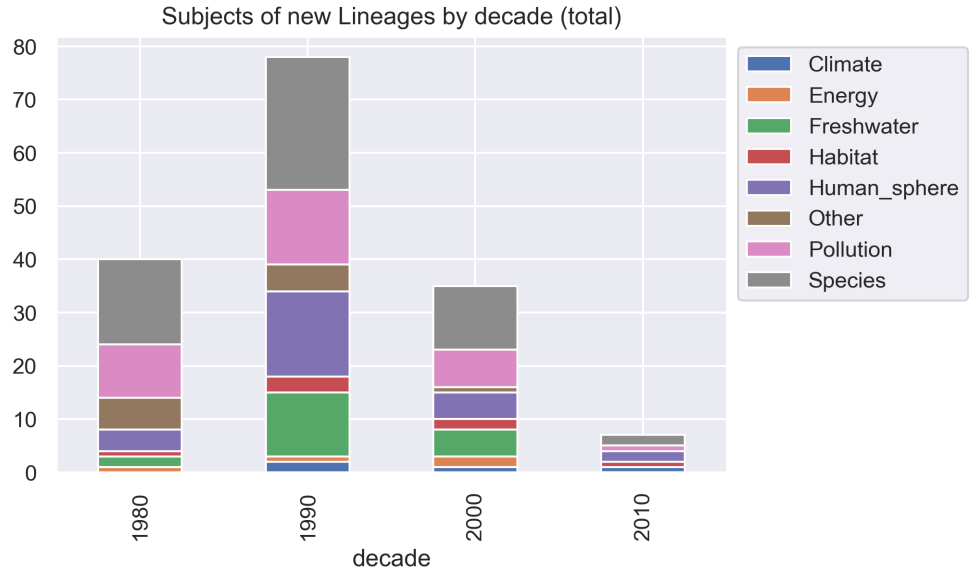


Figure 3.5: Emergence of new lineages and their subjects over time.

Table 4.1: Size of the signature coalition by decade of signature.

Decade	count	mean	std	min	50%	max
1980	107.0	12.794	18.475	0.0	7.0	154.0
1990	213.0	16.296	29.258	0.0	7.0	186.0
2000	137.0	13.964	25.620	0.0	7.0	167.0
2010	68.0	15.985	31.927	0.0	6.0	194.0
2020	2.0	0.000	0.000	0.0	0.0	0.0

4 Dimensions of IEAs

Below we illustrate how the IEADB data can be combined with other publicly available data sources to build a base for empirical evaluations of the theory models that are used to analyze the formation of treaty coalitions and the treaties that are signed in equilibrium.

4.1 Environmental treaties and their size

The size of an environmental treaty is an important indicator of the impact that treaty can have. Bigger treaties are more likely to bring all stakeholders to the table and result in a coordinated policy response. When we talk about the size of a treaty we refer to the size of its coalition. As we discussed in the beginning, treaties are a multistage process. First, countries sign a treaty, then they ratify it and it eventually enters into force. After the treaty has entered into force it often remains open to accession (ratification without prior signature) to other countries. So the size of a treaty can be measured by the size of its signature coalition (the number of countries that signed the treaty initially), or the number of ratifications/accessions by countries in a given treaty at a given point in the treaty's' life span. Let's first discuss differences in the signature coalition size of agreements and protocols. We exclude amendments here because they often do not require the deposit of a ratification or accession instrument. We find that the average size of the signature coalition for treaties signed within the same decade is very stable across decades. This suggests that even though the number of newly signed treaties peaked in the 1990s, the initial size of those treaties is not significantly different from that of earlier or later treaties. If we group treaties by subject instead this picture changes. Climate treaties are on average the

Table 4.2: Size of signature coalition by treaty subject.

Subject	count	mean	std	min	50%	max
Climate	8.0	62.750	75.367	6.0	23.5	194.0
Energy	23.0	19.435	34.768	3.0	6.0	162.0
Freshwater	59.0	6.017	5.746	2.0	4.0	36.0
Habitat	25.0	13.760	22.979	3.0	8.0	114.0
Human sphere	59.0	24.034	40.409	1.0	9.0	186.0
Other	33.0	14.758	28.720	2.0	7.0	154.0
Pollution	128.0	15.555	20.718	1.0	9.0	151.0
Species	143.0	13.497	23.778	1.0	7.0	167.0

biggest by quite some margin, followed by treaties focusing on human sphere and energy topics.[†] We recover the same order when looking at the size of the median treaty instead of the average. These differences make intuitive sense, smaller public goods like rivers (freshwater) have fewer stakeholders, and we would expect smaller signature coalitions. But how do countries coordinate to sign environmental treaties in the first place? To better understand this we can further dissect the signature coalition into neighboring states and broader connected regions. The average number of neighbors (that is neighboring dyads in the set of signature dyads) in the signature coalition is 32.3%. When we group treaties by subject as we have done before this increases to over 50% for treaties on energy, freshwater, and habitat and still around 9% for treaties on climate. The intuition of smaller treaties and their focus on local public goods from before carries through. We can classify the signature coalition as a "connected region" if there exists a walk through the network of countries that connects all countries that have signed the treaty. Unsurprisingly, the share of neighboring dyads in signature coalitions that are a connected regions is much higher (65% on average) than that in non-connected coalitions (12.4%) and a total of 37% of all agreements and protocols in the sample are signed within a geographical region which reemphasizes the relative importance of regional and local policy coordination. The next "size" of a treaty that we directly observe in the data is the largest coalition size (in terms of ratifications and accessions) that a treaty has reached in the sample. For the median treaty, the two coalition sizes perfectly coincide. Around 28% of treaties have more members (countries for whom the treaty became legally binding) than signatories.

[†]Human sphere contains treaties that focus on environment and development, the establishment of country communities, and environmental monitoring bodies.

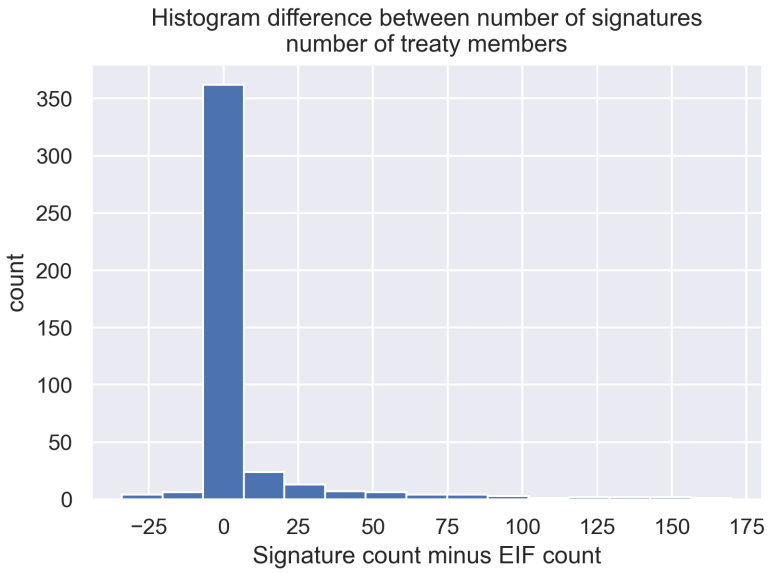


Figure 4.1: Difference between the number of countries that have signed a treaty and the total number of countries that became treaty members.

Table 4.3: Worst performing treaties in terms of difference between the number of signatures and the number of treaty members in 2019.

mitch_id	Agreement Name	difference in size	Signature Year	Entry into force (EIF) Date
4609	Agreement on the Establishment of the Internati...	-34.0	1991	1991-10-09
4445	African Convention On The Conservation Of Natur...	-26.0	2003	2016-07-23
4998	Agreement For The Establishment Of The African ...	-23.0	2012	2020-04-15
8507	Treaty on the Prohibition of Nuclear Weapons	-23.0	2017	2021-01-22
8808	Regional Agreement on Access to Information, Pu...	-11.0	2018	2021-04-22

Also, roughly 18% of all treaties' coalition size falls short of the number of signatures the treaty reached before entering into force, indicating that success as measured by the number of treaty participants varies across treaties. Further, this highlights the relevance that "membership by accession" has in international environmental policymaking and the need to better understand what motivates non-signatory countries to participate in an environmental treaty. If we were to focus only on the countries that have signed the treaty when studying treaty participation we would miss a significant part of the overall picture. The worst-performing treaty ("Agreement on the Establishment of the International Plant Genetic Resources Institute") fell 34 members short. Some of the other poorly performing treaties have been signed more recently, so the coalition in those treaties might outgrow the number of signatures over time. Conversely, most treaties achieve bigger coalitions than the initial number of signatures suggested. The best-performing treaties here are the global treaties on the protection of the ozone layer ("Convention For The Protection

Table 4.4: Best performing treaties in terms of difference between the number of signatures and the number of treaty members in 2019.

mitch_id	Agreement Name	difference in size	Signature Year	Entry into force (EIF) Date
2982	Convention For The Protection Of The Ozone Layer	170.0	1985	1988-09-22
3021	Montreal Protocol On Substances That Deplete Th...	152.0	1987	1989-01-01
2946	Protocol To Amend The Convention On Wetlands Of...	149.0	1982	1986-10-01
3042	Convention On The Control Of Transboundary Move...	137.0	1989	1992-05-05
3145	Protocol To Amend The International Convention ...	135.0	1992	1996-05-30

Of The Ozone Layer" and "Montreal Protocol On Substances That Deplete The Ozone Layer") and other global treaties from the mid-1980s and early 1990s. There is a positive correlation (0.29) between the size of the signature coalition and the number of excess members a treaty attracts. This can mostly be attributed to differences in treaty subjects between treaties with smaller and bigger signature coalitions.

Further, there is a negative correlation (-0.22) between the share of neighboring dyads in the group of signatories and the difference between the size of the signature coalition and the number of countries for whom the treaty became legally binding. This holds also when we look at the absolute difference instead but drops to around -0.09 if we use the difference relative to the number of signatory countries. Still, treaties that are started among neighboring countries tend not to outgrow the initial signatory countries. Either, because they already include all the necessary stakeholders at the signature stage or because they fail to create the incentives needed to attract more members after the treaty has entered into force.

4.2 Duration of treaties

The duration of a treaty is defined as the period the treaty is intended to be legally binding before being upended or replaced by a new treaty. Duration is an important determinant because it defines the time horizon for which a given environmental regulatory framework is locked in, and in theory, affects the policy commitment countries are willing to make. The IEADB does not code duration directly but offers information on the termination of environmental treaties. In total, around 10% of the treaties in our sample are of some limited duration. Below we report the number of treaties with limited duration as coded by the IEADB for treaty types agreement, protocol, and amendment.

Most treaties that were of limited duration (i.e. terminated at some point in time) are

Table 4.5: Limited duration by treaty type.

Treaty Type	Limited Duration	Counts	Share of treaty type
Agreement	False	321	0.927
	True	25	0.072
Amendment	False	461	0.861
	True	74	0.138
Protocol	False	171	0.955
	True	8	0.044

Table 4.6: Distribution of treaties with limited duration across lineages

Lineage	Treaties with limited duration in lineage	Total number of treaties in lineage
International Whaling	36	37
Baltic Sea Marine Environment	14	21
Rhine Pollution	10	47
International Tropical Timber	5	8
North Pacific Ocean Fisheries	4	5
Oslo-Paris Marine Pollution	4	8
Norway-Iceland-Greenland Capelin	3	4
Belarus-Kazakhstan-Russia Customs Union	3	4
CIS Environmental Agreements	3	36
Senegal River Basin	2	8
sum	84	178

amendments (13.8%), followed by agreements (7.2%) and protocols (4.4%). To better understand if termination of treaties is a rare but uniformly used tool across different lineages and subjects or if this is a very specific instrument that is heavily used in a couple of lineages we group treaties in their lineages. Table 4.6 displays the top ten lineages in terms of the absolute number of treaties with limited duration, as well as the total number of treaties in those lineages. We find that limited-duration treaties are highly concentrated in a handful of lineages with 64% and 78% of all limited-duration treaties in 5 and 10 lineages respectively. The most common reason reported in the IEADB for terminating a treaty is that the subsequent amendment replaces the treaty (in this case the amendment). For the lineage on international whaling for example amendments are adopted at annual meetings and adjust catching quotas for subspecies of whales in different regions which were set in the initial schedule as part of the 1946 "International Convention For The Regulation Of Whaling". Thereby, the scope of change that can be introduced through an amendment is regulated by the respective agreement.[‡] There is a difference between treaties that are ex-ante of limited duration and those that happen

[‡]See Article V of the International Convention For The Regulation Of Whaling, in appendix.

to be terminated ex-post. When countries commit to amending an existing agreement or protocol they generally know the minimum duration that this amendment will be in place for. However, because it is unsure if they will be able to find consensus during the next scheduled meeting of the contracting parties the actual duration of the treaty is not known ex-ante. Therefore, even in lineages that frequently replace amendments the assumption of limited-duration treaties can be questioned. The empirical relevance of limited-duration treaties has not been explored yet.

4.3 Depth of treaties

What matters for the impact that an environmental treaty has on the world? One important aspect of a treaty's impact is the size of the coalition, so the number of countries that are directly affected and commit to some degree of behavioral change, and the period for which the behavioral change is in place. The other important aspect is how far this behavioral change is going. This is also called the depth of a treaty. Downs et al. (1996) define depth as "The extent to which a provision requires a change in behavior from the counterfactual". The literature has discussed the existence of a depth-participation trade-off. The idea is that participation should shrink, as more countries find it costly to comply with a more demanding agreement (Downs et al., 1996; Barrett 2005; Battaglini & Harstad, 2016). The depth of a treaty is not directly observable in the data and to quantify it some counterfactual of country behavior in the absence of a treaty is needed. While the counterfactual is difficult to compute the treaty provisions can be used as a proxy for depth. The IEADB provides text data for most agreements and there have been efforts to manually identify and code differences in treaty provisions that add to treaty depth. Bernauer et al. (2013) have coded a total of 200 global treaties (agreements & protocols) from the IEADB to study the depth-participation dilemma. Besides coding treaty paragraphs on open-membership and entry-into-force provisions, the authors provide three codes on treaty depth using the existence of monitoring provisions, enforcement provisions, and if the treaty states quantifiable targets. The dataset by Bernauer and co-authors spans from 1946 to 2002 and we can merge 120 (around 55% of their treaty sample) with the sample we have discussed using treaty names and further information

Table 4.7: Treaty depth by regionality.

Connected region	count	mean	std	min	50%	max
False	94.0	1.851	0.994	0.0	2.0	3.0
True	23.0	2.522	0.730	1.0	3.0	3.0

Table 4.8: Treaty depth by subject.

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

from Ecolex.[§] We construct a depth variable that can take values $\{0; 1; 2; 3\}$ by taking the sum of dummy variables coding monitoring provisions, enforcement provisions, and quantifiable targets. We compare treaties that were signed within a geographical region (we introduced the concept of connected regions when discussing the size of treaties) or not. The average treaty depth is significantly higher for treaties signed within geographical regions than those signed by countries with large spatial lags. This supports the hypothesis that it is easier to achieve deep environmental cooperation in a regional setting than it is in global treaties.

We find some variation in the average treaty depth in treaties of different subjects but the number of treaties in each subject differs significantly, such that comparisons across subjects become difficult to make. For subjects with a similar and sufficient number of observations, the average depth is similar. Further, we have text data for 91% of the treaties in our sample and can try to use the actual treaty text to infer more about the depth of a treaty. First, we measure the length of a treaty as the number of words in each treaty as a simple proxy for the number of provisions a treaty might contain. We find that

[§]ECOLEX is an information service on environmental law with the purpose of build capacity worldwide by providing the most comprehensive possible global source of information on environmental law.

Table 4.9: Treaty length by treaty type.

Agreement Type (level 2)	count	mean	std	min	50%	max
Agreement	332.0	6252.970	19154.054	235.0	3145.5	261389.0
Protocol	170.0	3416.565	3086.797	0.0	2660.5	16894.0
Amendment	465.0	1776.968	3776.676	41.0	696.0	37062.0

treaties vary substantially in length both within and across treaty types. On average the length of the document corresponds with the idea that agreements are more substantial than protocols, and amendments introduce only minor changes. When we split the sample by treaty type and subject we see that this is most pronounced for treaties in the human sphere subject where agreements are on average 7.6 times longer than protocols. How treaties differ in their length and how this correlates with the size of the coalition and other dimensions has to be further explored. A simple correlation exercise between the length of the treaty text and the sum of depth indicators in Bernauer et al. (2013) gives a moderate correlation of 0.323 for protocols and 0.209 for agreements. We believe that there are ways forward that allow for a more efficient use of the text data to extract functional features of treaties to add empirical evidence to the established theory models. For example by using natural language processing which is being used increasingly in economics to translate unstructured text into numerical (structured) data.

4.4 Correlations between treaty dimensions

We use this depth indicator to illustrate simple correlations in the data between the depth of a treaty, the size of the signature coalition, and the number of excess ratifications the treaty achieved. Agreements and protocols are fairly similar when it comes to the correlation between the number of signatures and the depth of the treaty. The same holds for the correlation between the number of signatures and the difference in ratifications and signatures. When it comes to treaty depth we see a negative correlation with the number of excess ratifications in agreements. To say if bigger coalitions in agreements manage to negotiate deeper treaties but deeper treaties do not attract as many members beyond the signatory countries as shallow treaties a regression model is needed. For protocols the

Table 4.10: Treaty length by subject and treaty type.

Subject	Agreement Type (level 2)	count	mean	std	min	50%	max
Climate	Agreement	6.0	5479.667	2498.073	2207.0	6126.5	8398.0
	Amendment	6.0	599.500	1075.719	48.0	172.5	2789.0
	Protocol	2.0	4561.000	5801.104	459.0	4561.0	8663.0
Energy	Agreement	18.0	3509.944	5549.467	281.0	2084.0	25160.0
	Amendment	2.0	2097.500	2287.490	480.0	2097.5	3715.0
	Protocol	5.0	2663.200	2205.922	364.0	3269.0	5529.0
Freshwater	Agreement	45.0	3509.889	2809.812	574.0	2275.0	11266.0
	Amendment	10.0	312.900	173.811	90.0	286.5	662.0
	Protocol	14.0	2202.500	2204.294	161.0	1713.5	7364.0
Habitat	Agreement	12.0	5045.667	6236.076	972.0	2779.0	19083.0
	Amendment	5.0	1305.000	1027.052	122.0	1273.0	2454.0
	Protocol	13.0	3640.538	4235.533	340.0	3011.0	16894.0
Human_sphere	Agreement	37.0	20318.324	53896.270	641.0	3178.0	261389.0
	Amendment	27.0	1384.000	1955.949	108.0	695.0	9694.0
	Protocol	25.0	2672.520	3339.536	243.0	686.0	12626.0
Other	Agreement	29.0	5087.793	12864.483	489.0	1839.0	70582.0
	Amendment	1.0	345.000	NaN	345.0	345.0	345.0
	Protocol	5.0	2596.000	2344.315	377.0	2604.0	5932.0
Pollution	Agreement	61.0	5569.377	4229.375	594.0	4068.0	15701.0
	Amendment	195.0	2303.544	4597.007	74.0	1048.0	36031.0
	Protocol	69.0	4201.652	3121.540	0.0	3521.0	15647.0
Species	Agreement	116.0	4284.466	3473.437	592.0	3215.0	16576.0
	Amendment	169.0	1219.101	2044.270	41.0	370.0	11480.0
	Protocol	30.0	2721.700	2618.797	341.0	982.5	8800.0

Table 4.11: Depth, size, and duration for agreements and protocols.

Agreement Type (level 2)		Depth	Number signatures	Difference in ratifications and signatures
Agreement (n = 75)	Depth	1.000000	0.130250	-0.187665
	Number signatures	0.130250	1.000000	0.311266
	Difference in ratifications and signatures	-0.187665	0.311266	1.000000
Protocol (n = 45)	Depth	1.000000	0.085580	0.133439
	Number signatures	0.085580	1.000000	0.320980
	Difference in ratifications and signatures	0.133439	0.320980	1.000000

Table 4.12: Depth and size by duration.

Limited duration (dummy)		Depth	Number signatures	Difference in ratifications and signatures
False (n = 116)	Depth	1.000000	0.032168	-0.135503
	Number signatures	0.032168	1.000000	0.286785
	Difference in ratifications and signatures	-0.135503	0.286785	1.000000
True (n = 4)	Depth	1.000000	0.782508	0.829515
	Number signatures	0.782508	1.000000	0.778216
	Difference in ratifications and signatures	0.829515	0.778216	1.000000

correlation between depth and the difference in ratifications and signatures is positive. Battaglini & Harstad (2016) added a third variable to the depth-participation trade-off we mentioned before. They argue that the duration of a treaty adds to this dilemma if countries can invest in green technologies, ultimately creating a hold-up problem. We group treaties by being of limited duration or not to illustrate how the data could help to quantify the relevance of this trade-off. We note that the number of treaties with limited duration is fairly small so comparisons between the two groups have to be done with caution. For treaties that were terminated, we find a sizable positive correlation between depth as measured by our variable and both the size of the signature coalition, and the number of excess ratifications. However, the number of observations for which we have a measure of depth and are of limited duration is very low. For treaties that were not terminated the correlation between the number of signatory countries and the treaty depth is close to zero and the correlation between treaty depth and the number of excess ratifications is negative.

5 Links between IEAs and other areas of international cooperation

Besides the research efforts to model the formation of environmental treaties and the resulting participation dilemma, there has been work on the intersection of environmental cooperation with other spheres of cooperation. The idea is that international environmental cooperation does not happen in a vacuum. Instead, countries are connected through trade, direct foreign investment, or defense alliances. This multidimensionality of international cooperation makes it necessary to jointly model international cooperation in, for example, trade and environment, if preferential trade agreements affect environmental outcomes or environmental treaties impact the economic competitiveness of a country. Kim and Morin

(2021) take a birds-eye view of different regimes in trade and environmental policy-making and construct a network of networks by using cross citations in international treaties. They establish a connection between regimes in environmental cooperation and trade and that this connection is growing increasingly dense, suggesting coordination between competing policy domains. This coordination is referred to as issue linkage, a bargaining strategy in which different issues are simultaneously discussed and settled jointly. Linkage can take place at different stages. Generally, the literature distinguishes between linkage in a treaty's enforcement, negotiation, and participation stages (Maggi, 2016). There are a series of datasets that allow us to study those linkages. Issue linkage can help to overcome the free rider problem of a public good game. However, if a party to a preferential trade agreement wants to restrict access to a market this can be achieved by requiring a set of environmental standards which could be contacted in an environmental treaty. Here, linkage takes place not to overcome the tragedy of the commons but might still incentivize changes in environmental policies due to their impact on market access. Besides the data on existing citation links (Kim & Morin, 2021) there is information on the existence and number of environmental provisions in preferential trade agreements (TREND, Morin et al., 2017). The TREND dataset contains 618 unique trade agreements signed between 1980 and 2018 and codes the presence of a total of 295 environmental norms (such as if the preamble of the trade agreement refers directly to the environment) across 15 groups (such as principles, or the relations with international institutions). There is a clear correlation between referring to the environment in a treatys' preamble and including further environmental provisions throughout the treaty. A treaty that explicitly refers to the environment has on average 45.6 additional environmental codes, whereas a treaty that does not have the initial reference only features 6.8 further environmental codes on average. As before, we can plot the signature of new trade agreements over time. We plot the absolute number of newly signed trade agreements and the number of trade agreements that refer to the environment directly in their preamble from 1980 onward. References to the environment were absent before 1991 but ten years later, they are already present in 20% of all newly signed trade agreements. By around 2015 this number is up to 58%, highlighting that environmental considerations have entered trade agreements at least at the symbolic level. We can look jointly at the number of new environmental agreements and trade agreements with direct reference to the environment in their preamble. The

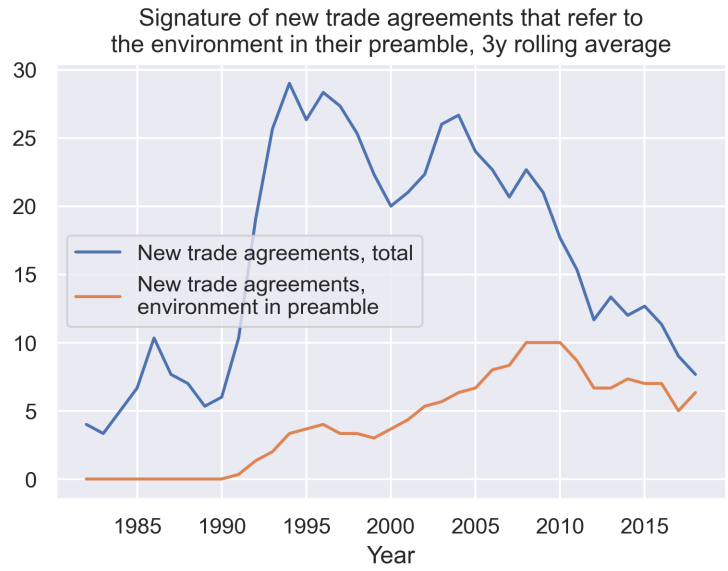
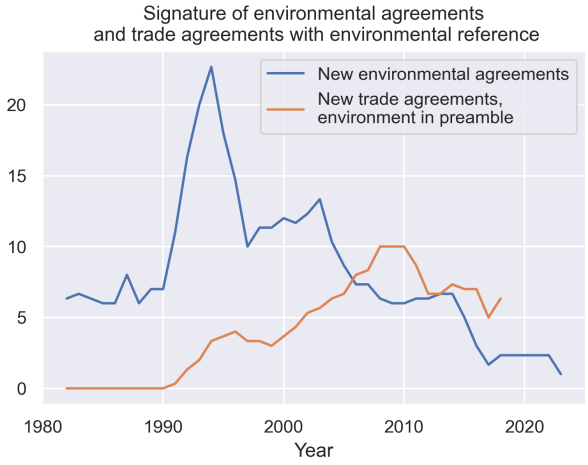


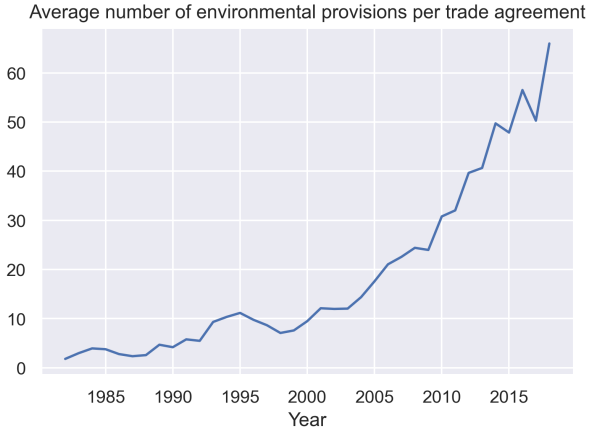
Figure 5.1: Signature of trade agreements over time

downward trend in the signature environmental agreements is contrasted by a steady increase in trade agreements with environmental reference over the same period. Further, the environmental depth (as measured by the number of environmental provisions coded by TREND in a given treaty) has increased too. The relationship between the decrease in environmental policy-making using dedicated environmental agreements and the increase in environmental provisions trade agreements is largely unexplored. Instead of discussing the other codes and their distribution over time we instead focus on how participation in environmental treaties and the likelihood of including environmental provisions correlate. To do so, we construct a dyadic panel dataset that uses the number of jointly signed environmental treaties up to year t between two countries (a, b) as the measure. This measure can be thought of as an edge in the graph of countries and their environmental policy connections. The more environmental treaties two countries jointly participate in, the higher their connectivity. To better understand how environmental cooperation and trade agreements are linked we can use some of the 295 environmental norms TREND provides. For now, we only focus on the number of trade links countries form and the number of times the trade agreement refers to the environment directly in its preamble. Table 5.1 displays the correlation between the number of joint environmental treaties up to year t, the number of newly signed trade agreements that mention the environment in their preamble, and trade agreements that directly refer to the environment as a share of newly signed trade agreements. The correlation between the number of newly signed trade

Figure 5.2: Time dynamics in environmental agreements and trade agreements that contain environmental provisions



(a) Agreement signatures over time



(b) Number of environmental provisions in new trade agreements over time

Table 5.1: Correlation between the number of shared environmental treaties, shared trade agreements, and shared trade agreements with environmental reference for dyad (a, b) in year t.

	# environmental treaties	# trade agreements	# trade agreements, environmental reference
# environmental treaties	1.000000	0.173085	0.147847
# trade agreements	0.173085	1.000000	0.740803
# trade agreements, environmental reference	0.147847	0.740803	1.000000

agreements between a pair of countries and the number of environmental links between this pair of countries is positive, suggesting that countries who have jointly participated in more environmental treaties also sign more trade agreements. Further, countries who jointly participated in more environmental treaties also include more direct references to the environment in the preamble of their new trade agreements. These are raw correlations and a regression model that allows us to control for for example dyad and year-fixed effects can be used to better understand how trade cooperation between countries appears to facilitate, or complicate, environmental cooperation through international environmental agreements.

References

Downs, G. W., Rocke, D. M., & Barsoom, P. N. (1996). Is the good news about compliance good news about cooperation? *International organization*, *50*(3), 379–406.

Mitchell, R. B. (2003). International environmental agreements: A survey of their features, formation, and effects. *Annual review of environment and resources*, *28*(1), 429–461.

Barrett, S. (2005). Chapter 28 the theory of international environmental agreements. In *Handbook of environmental economics* (pp. 1457–1516, Vol. 3). Elsevier B.V.

Bernauer, T., Kalbhenn, A., Koubi, V., & Spilker, G. (2013). Is there a "depth versus participation" dilemma in international cooperation? *The Review of International Organizations*, *8*, 477–497.

Battaglini, M., & Harstad, B. (2016). Participation and duration of environmental agreements. *The Journal of political economy*, *124*(1), 160–204.

Maggi, G. (2016). Issue linkage. In *Handbook of commercial policy* (pp. 513–564, Vol. 1). Elsevier.

Morin, J.-F., Dür, A., & Lechner, L. (2018). Mapping the trade and environment nexus: Insights from a new data set. *Global Environmental Politics*, *18*(1), 122–139.

Mitchell, R. B., Andonova, L. B., Axelrod, M., Balsiger, J., Bernauer, T., Green, J. F., Hollway, J., Kim, R. E., & Morin, J.-F. (2020). What we know (and could know) about international environmental agreements. *Global environmental politics*, *20*(1), 103–121.

Kim, R. E., & Morin, J.-F. (2021). Massive institutional structures in global governance. *Global Environmental Politics*, *21*(3), 26–48.

Bellelli, F. S., Scarpa, R., & Aftab, A. (2023). An empirical analysis of participation in international environmental agreements. *Journal of environmental economics and management*, *118*, 102783.

6 Appendix

6.1 International Convention For The Regulation Of Whaling, 1946

... Article V

1. The Commission may amend from time to time the provisions of the Schedule by adopting regulations with respect to the conservation and utilization of whale resources, fixing:

(a) protected and unprotected species;

(b) open and closed seasons;

(c) open and closed waters, including the designation of sanctuary areas;

(d) size limits for each species;

(e) time, methods, and intensity of whaling (including the maximum catch of whales to be taken in any one season);

(f) types and specifications of gear and apparatus and appliances which may be used;

(g) methods of measurement; and

(h) catch returns and other statistical and biological records.

2. These amendments of the Schedule:

(a) shall be such as are necessary to carry out the objectives and purposes of this Convention and to provide for the conservation, development, and optimum utilization of the whale resources;

(b) shall be based on scientific findings;

(c) shall not involve restrictions on the number or nationality of factory ships or land stations, nor allocate specific quotas to any factory or ship or land station or to any group of factory ships or land stations; and

(d) shall take into consideration the interests of the consumers of whale products and the whaling industry.

3. Each of such amendments shall become effective with respect to the Contracting

Governments ninety days following notification of the amendment by the Commission to each of the Contracting Governments, except that:

(a) if any Government presents to the Commission objection to any amendment prior to the expiration of this ninety-day period, the amendment shall not become effective with respect to any of the Governments for an additional ninety days;

(b) thereupon, any other Contracting Government may present objection to the amendment at any time prior to the expiration of the additional ninety-day period, or before the expiration of thirty days from the date of receipt of the last objection received during such additional ninety-day period, whichever date shall be the later; and

(c) thereafter, the amendment shall become effective with respect to all Contracting Governments which have not presented objection but shall not become effective with respect to any Government which has so objected until such date as the objection is withdrawn. The Commission shall notify each Contracting Government immediately upon receipt of each objection and withdrawal and each Contracting Government shall acknowledge receipt of all notifications of amendments, objections, and withdrawals.

4. No amendments shall become effective before 1st July, 1949.