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# The joining dilemma: A survey of the empirical literature on environmental treaty participation\*

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## Abstract

Several of the most pressing environmental problems involve transboundary issues and can only be solved through international cooperation. Given the pre-eminence of international environmental agreements as the primary tool for international cooperation, several questions are of interest to design an efficient policy response: How can more effective environmental agreements be framed? What motivates participation in environmental agreements? How can participation in environmental agreements be increased? These questions have been addressed in economic research, mostly using game-theoretical approaches, in models that predict the optimal emission abatement and participation levels. Our survey focuses on a contiguous body of work: the empirical literature on environmental treaty participation. The scope of this paper is to compile the first detailed survey of the empirical literature on participation in environmental agreements, summarise its findings and enable a better comparison with theoretical predictions.

**Keywords:** International environmental agreements, ratification, international cooperation, multilateral agreements

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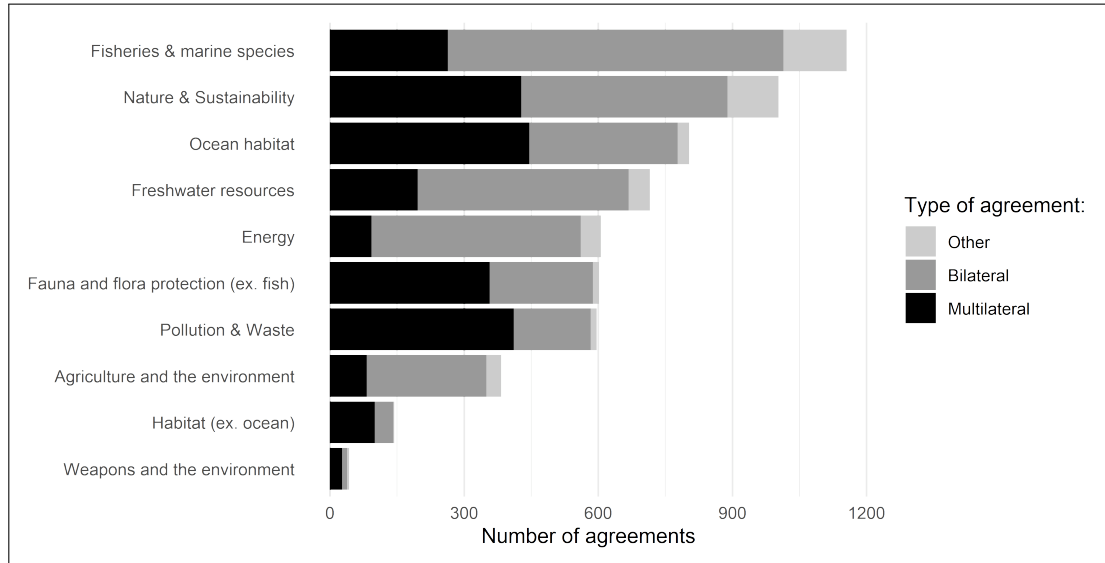
# 1 Introduction

Several of the most pressing environmental problems involve transboundary issues. Air pollution, contamination of lakes and rivers, global warming, biodiversity loss, deforestation, desertification, and overfishing are all problems that cross national borders and seldom impact a single nation. For these types of problems, traditional policy tools are insufficient or inapplicable because of the absence of a central international authority capable of enforcing decisions in all of the concerned countries. As a result, agreeing on mutual and voluntary restraints between nations is often the only viable solution to address large environmental problems. In a nutshell, transboundary environmental problems can only be solved through international cooperation.

Among all the available tools for international cooperation, international agreements are, at least in principle, the most promising. In many ways, international agreements are similar to a contract between nations — the main difference being that there is no superior power capable of enforcing the treaty on shirking parties. To date, more than 3,000 environmental agreements have been identified (Mitchell, 2020) embodying cooperation on the most disparate environmental issues (See Figure 1). Some agreements are successful, while others fail. Some attract universal participation, while others die on the negotiation table. Given the importance of international cooperation for securing environmental well-being, now more than ever, environmental agreements play a crucial role in improving environmental protection worldwide. Hence, the following questions are of great interest to economists: How can more effective agreements be framed? What motivates participation in environmental agreements? How can participation in environmental agreements be increased?

These questions have been the core subject of several economic models, mostly using game-theoretical approaches, that predict both the optimal emission abatement and participation levels. From the perspective of these models, environmental agreements are international public goods that deal with transboundary environmental externalities (Beron et al., 2003). Given the non-excludability and non-rivalry of the environmental benefits of the agreement, countries often contend with a considerable incentive to free-ride. The conclusions of classic game-theoretical models are generally pessimistic on the capacity to solve environmental problems beyond the non-cooperation level (Carraro and Siniscalco, 1993; Barrett, 1994). In these models, large participation in agreements can only be achieved with low abatement targets that fall short of the social optimum (Finus, 2008). This outlook originates from core assumptions of these models, which frame treaty participation as a one-off non-cooperative choice — just like in a prisoner’s dilemma.

Later works largely confirmed the free-riding incentive existing in treaty participation, with some improvement in the participation outlook (Finus et al., 2017). For example, participation can be improved if participants can offer side transfers (Barrett and Stavins, 2003; Barrett, 2001; Fuentes-Albero and Rubio, 2010). Under the right circumstances also the inclusion of penalties, trade restriction, minimum participation rules and permit trading schemes can considerably boost participation (Rubio and Casino, 2005; Carraro et al., 2009; Karp and Zhao, 2010; Harstad, 2015). Moreover, in repeated games — which allow countries to join the agreement in different moments — the result are generally more optimistic than in one-off games (Bloch and Gomes, 2006; Biancardi



**Figure 1:** Number of environmental agreements by subject

*Notes:* Data from Mitchell (2020). Bilateral agreements are agreements between two countries. Multilateral agreements involve three or more countries. “Other” types of agreements relate primarily to international organisations and supranational bodies. The existing empirical literature has primarily modelled multilateral agreements.

and Villani, 2015; Wagner, 2016). For example, Battaglini and Harstad (2016) show that in a dynamic game of treaty formation with non-contractible green investments, there is an incentive to form large coalition to mitigate the investment hold-up problem. And in the dynamic models of Kováč and Schmidt (2021) more countries participate to avoid renegotiation delays.

Interestingly, the empirical research on the determinants of participation in environmental agreements has been developing with little attention from the large body of game-theoretical literature. While the empirical evidence corroborates several of the game-theoretical assertions it also presents some points of contrast. Given the proximity of this empirical research with game-theoretical models on treaty participation, substantial benefits would arise from their cross-fertilisation.

The objective of this paper is to compile a survey of the empirical literature on participation in environmental agreements. This survey answers to the following questions: What are the main determinants of participation in environmental agreements and how can participation be increased? This survey has the scope of summarising the progress achieved so far in the empirical studies and present their main findings for a more systematic comparison with theoretical predictions. For the interested readers, we also supply an online addendum containing a detailed account of the data and techniques used in these studies, and highlighting the strength and limits of each empirical strategy. To the best of our knowledge, there is no comprehensive survey on this topic, hence this effort fills an evident gap in the literature.



**Figure 2:** Key stages of an international agreement

## 2 What did we learn from the empirical literature on ratification?

The life of an agreement can be divided in three key stages: the formation, participation and implementation stage (Figure 2). During the formation stage, the delegates of different countries come together to negotiate the terms of the agreement. If the negotiations are successful, they produce an agreement text that is signed by national representatives. The act of signature is usually carried out by the executive power and signals the approval with the content of the agreement. Nonetheless, at this stage, the agreement is not yet effective. Implementation requires that the treaties are ratified. Ratification has a legally binding power, and it usually is a prerogative of the legislative body of the nation — although rules may change from country to country. Ratification plays a pivotal role because it transforms the treaty into a binding contract for the ratifier, whereas signature does not imply any formal obligation for the signatories. To all intents and purposes, ratification is the moment that marks the decision to participate in the implementation of the agreement. For this reason, the empirical literature has mostly focused on ratification and the two terms, participation and ratification, are henceforward used interchangeably.

A close inspection of international environmental agreements reveals that ratification is a complex event. There are many potential reasons for a country to ratify a specific treaty: economic, political, cultural, strategic, institutional and of course environmental. Ratifications are intrinsically heterogeneous. They refer to the act of participation in treaties that are structured differently, created by diverse groups of countries under different circumstances, involving various economic agents and dealing with disparate environmental problems on a very dissimilar geographic scale. In essence, ratifications are quite diverse. Nonetheless, some common threads are recurrently linked to ratification. The empirical research has sought to dissect and understand these common threads, with interests ranging from the role of electoral rules and political systems, to the incentives provided by trade openness and economic partnership.

We will now survey the main results of the empirical ratification literature by grouping them along the principal determinants of environmental treaty ratification: *i*) the content of the agreement, *ii*) the political system of the ratifying country, *iii*) the economic incentives and disincentives to ratification, and *iv*) the international interaction between countries. Whenever possible, we compare the empirical findings with the predictions of the game-theoretical literature. Nonetheless, an exhaustive review of the game-theoretical research is beyond the scope of this paper, which focuses on the empir-

ical literature. For a detailed account of the game-theoretical literature on the formation and participation in environmental agreements, the reader can refer to [Calvo and Rubio \(2013\)](#), [Marrouch and Chaudhuri \(2015\)](#) or [Finus et al. \(2017\)](#). For a more technical review of the data and modelling approaches we invite the reader to refer to the supplementary online appendix, which also lists all the surveyed studies in three tables providing information about their sample and models.

## 2.1 Treaty design and participation trade-off

First and foremost, the reason for the success or failure of a treaty is, of course, the content of the treaty itself. Stricter agreements impose higher costs on the parties and, all else equal, should attract fewer ratifications. The empirical research on this subject is not well developed; its main limitation is the availability of data. This type of studies requires data that classifies environmental treaties on their characteristics. At present, the main sources of information on the ratification of environmental agreements are either the text of the treaties or treaty databases such as [Mitchell \(2020\)](#) and [CIESIN \(2013\)](#). Neither of these sources has a detailed classification of the characteristics of the agreements. As a result, the studies tend to be either on few agreements or on a limited number of features. In the second case there is often a problem of objectivity and consistency in the classification of agreements: some parameters can be classified in a clear-cut manner, but many notions are more nuanced.

Fundamentally, the research effort has focused on the *depth vs participation* trade-off. This phenomenon is well-rooted in the game-theoretical literature on treaty participation ([Barrett, 1998](#)), in which free-riding incentives dominate the participation choices of countries. An early contribution is made by [von Stein \(2008\)](#), who analysed how the design of treaties affects participation levels. The author defines the strictness of environmental agreements based on several characteristics. The main ones are whether or not the treaty entails obligations for the parties, the institution of decision bodies, flexibility mechanisms and the precision of environmental targets. They conclude that flexibility mechanisms are effective means to facilitate ratification and can be used to mitigate the dissuasive effect of tighter obligations. The problem of this study is that it is based solely on the [UNFCCC \(1992\)](#) and the [Kyoto Protocol \(1997\)](#), two large treaties on climate change; hence, it is hard to generalise the results to environmental agreements as a group. [Leinaweaver \(2012\)](#) expands the sample of the analysis to a total of 55 regional and global environmental agreements. According to [Leinaweaver \(2012\)](#), the cost of committing to a treaty is mainly captured by three aspects: the presence of binding obligations, the acceptance of reservations and the existence of monitoring provisions. These are very similar to the factors discussed by [Bernauer et al. \(2010\)](#). The findings of [Leinaweaver \(2012\)](#) show that agreements with precise targets and participation thresholds for the entry into force tend to attract more ratifications, supposedly by increasing the credibility of the commitment. This latter result is consistent with the game-theoretical finding that minimum participation rules can be used to enhance the size of stable coalitions in non-cooperative games ([Rubio and Casino, 2005](#); [Carraro et al., 2009](#)).

With 200 environmental agreements, [Bernauer et al. \(2013a\)](#) is the largest cross-sectional study on this topic. They argue that “depth” is a complex concept that is reflected in several design features of an environmental treaty. The existence of formal

obligations for the parties, monitoring, enforcement mechanisms, dispute settlement mechanisms, assistance mechanisms, and organisational apparatus are all factors that define the “depth” of an agreement according to the authors. Their findings indicate that tighter obligations do reduce participation to agreements, but, contrary to expectations, stricter monitoring and enforcement do not reduce the likelihood of ratification. In another large study, [Bellelli et al. \(2020\)](#) compare the ratification of regional and global agreements. One of their main findings is that regional agreements are consistently — and substantially — more likely to attract ratification. Therefore, the authors conclude that it is preferable to frame environmental cooperation through smaller regional interconnected agreements than large global treaties. Again, this result corroborates the conclusion of game theoretical works. For instance, the models of [Asheim et al. \(2006\)](#) and of [Osmani and Tol \(2010\)](#) postulate that global agreements can only sustain small coalitions, whereas a combination of regional agreements can achieve higher participation for the same issue. Much of the existing empirical literature has focused on large multilateral environmental agreements. However, most of international cooperation takes places on a smaller scale, either regionally or bilaterally (see [Figure 1](#)). Future research should investigate these types of agreements in more detail.

Finally, [Spilker and Koubi \(2016\)](#) consider different treaty designs and control for internal voting requirements for the approval of ratification. Their data is derived from [Bernauer et al. \(2010\)](#) and adopts similar definitions to [Bernauer et al. \(2013a\)](#) for measuring the strictness of environmental agreements. However, unlike [Bernauer et al. \(2013a\)](#), they use a survival model. [Spilker and Koubi \(2016\)](#) results strengthen the idea that stricter agreements deter participation. They also find that treaties that grant financial or technical assistance to developing countries have a higher chance of being ratified. This result echoes [Mohrenberg et al. \(2016\)](#), who observe that the institution or participation of a fund in the treaty reduces commitment costs and increases the likelihood of ratification. These findings reinforce theoretical predictions on the size of coalitions when countries are allowed to offer side payments ([Barrett, 2001](#); [Barrett and Stavins, 2003](#); [Fuentes-Albero and Rubio, 2010](#)).

Altogether, the findings strongly confirm the free-riding incentives induced by tighter environmental agreements. This result is highly concordant with theoretical predictions. However, empirical evidence also seems to suggest that some treaty features (e.g. monitoring and enforcement rules, minimum participation rules, technological transfers, financial assistance) have the property of increasing the abatement level of the treaty without deterring participation ([Bernauer et al., 2013a](#)). These results could be useful to frame more efficient environmental agreements. Given the patchy nature of existing results, we believe there is scope for further empirical research on the impact of treaty design on participation and abatement levels. Finally, it should also be noted that all the empirical studies implicitly assumed that the ratification of a given treaty is independent of the ratification of other treaties. In other words, any connection that could exist between different environmental agreements is ignored. However, there could be cases in which agreements are directly linked. For example, two agreements could be substitutes because they deal in contrasting ways with the same issue, hence participation in one of the agreements precludes participation in the other one. This situation could subsist between countries that fail to agree on a unified course of action or when competing solutions are offered. A set of agreements could also be linked in the opposite way, that

is to say, having complementary ratifications. We believe the assumption of independence is reasonable in most cases, however there is scope for a deeper inspection of this assumption. Future research could investigate the presence and extent of links between agreements, and how they influence participation.

## 2.2 Political system

We have talked about difference in participation *between treaties*. However, participation in environmental agreements also varies considerably *between countries*. Figure 3 shows that these differences are not random, rather, they seem to be clustered geographically, suggesting that country characteristics also play a role in treaty participation. The effect of these country characteristics are studied by regressing these variables on measures of treaty participation. Early studies tended to use as a dependent variable the number of treaties ratified by each country. But later, the dominant approach shifted towards the use of a survival analysis approach — i.e. modelling the expected time to ratification. The advantage of survival analysis is that it incorporates both information about the occurrence (did the country ratify the treaty?) and the timing (how long did it take to ratify?) of ratification. Moreover, its estimates are robust to right-censoring — the fact that certain ratifications are not observed because they take place after the observation period.

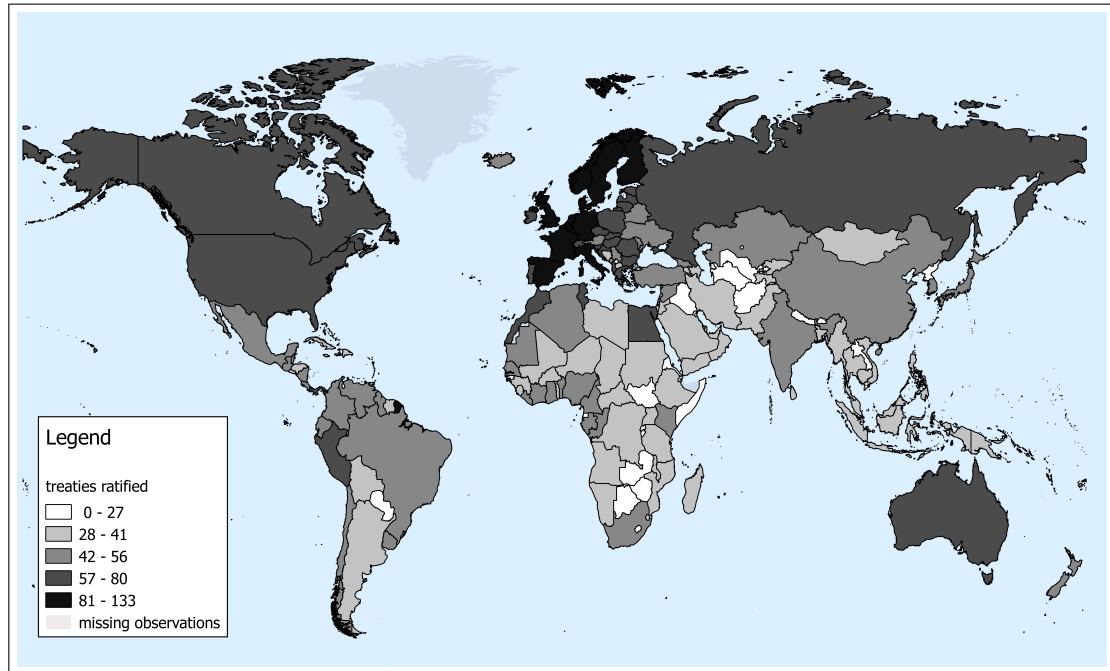
These models have been used to test several hypotheses on the effect of country characteristics on ratification probabilities. To start with, the ratification of environmental treaties is the outcome of a political decision. Therefore, a common thesis is that the political and institutional arrangements of a country have a bearing on their ratification behaviour.

### 2.2.1 The role of democracy

The early literature has been particularly keen on emphasising the role played by political factors (e.g. Congleton 1992, Neumayer 2002a). According to Neumayer (2002a) and Bernauer et al. (2010), citizens of democratic states can exert more effective political pressure on governments thanks to well functioning civil liberties, which also allow to channel the ideas and preferences of citizens more effectively and increase the likelihood of joining international environmental treaties.

These ideas have their root in the endogenous model of environmental policy selection by Congleton (1992). In their model, decisions in democracies depend on the electoral behaviour of the median voter, whereas in authoritarian regimes they are assumed to depend on the dictator's vote or the median voter of the ruling oligarchy. All other agents or pressure groups are ignored. The model set-up implies that authoritarian states have a higher equilibrium price for the abatement than democracies. As a consequence, it predicts that authoritarian states are less likely to implement environmental policies and to participate in environmental agreements.

The relationship introduced by Congleton (1992) has been extensively tested empirically. Congleton (1992) formally tests his hypothesis on two treaties on Ozone Depleting Substances (ODS), he finds that democracies are more likely to ratify when compared to autocratic nations. Again, Neumayer (2002a) explores the link between democracy and environmental commitment, measured by different indicators, one of which is rat-



**Figure 3:** Number of multilateral environmental agreements ratified by country

*Notes:* Treaty ratification data from [Mitchell \(2020\)](#). The mapped sample includes only environmental multilateral agreements (no bilateral agreement) signed in the period 1950–2017.

ification. Democracies tend to engage in environmental agreements consistently more than non-democracies. With a similar scope, [Fredriksson and Gaston \(2000\)](#) focus on the speed of ratification of the UNFCCC. They find that civil liberties and CO<sub>2</sub> emissions are strong determinants of ratification delay. There is a general consensus that democracy — in particular when measured by their citizens’ access to civil liberties and political rights — tends to encourage ratification. In all the studies that followed, with no exception, researchers have systematically controlled for the democratic characteristic of states and found it to be positively related with ratification (e.g. [von Stein, 2008](#); [Perin and Bernauer, 2010](#); [Seelarbokus, 2014](#); [Mohrenberg et al., 2016](#); [Hugh-Jones et al., 2018](#)). The most common measures for democratic government forms are the two indices by [Freedom House \(2017\)](#) and [Marshall et al. \(2016\)](#).

### 2.2.2 Electoral dynamics and veto players

The process leading to ratification often goes through several institutional bodies within the state. In most of the cases, ratifications require the approval of the parliament, but some countries consent ratification by the head of government (e.g. Israel and Bangladesh). As a result, the ratification of agreements may depend on multiple veto players — i.e. entities that have the power to block the ratification approval either as individual (e.g. head of state) or as a group of individuals (e.g. upper house of parliament). [Hugh-Jones et al. \(2018\)](#) find that the higher the number of veto players in a country, the less likely a country is to ratify the Kyoto Protocol. On a similar note,



Spilker and Koubi (2016) assessed whether parliamentary voting rules affect the ratification decisions of the country. Or, more precisely, if constitutional requirements for a supermajority, instead of a simple majority, affect ratification probability. The study is conducted on a large sample of 220 treaties and 162 countries originally assembled by Bernauer et al. (2010). The results support the idea that stricter agreements deter participation and that nations with constitutions requiring a supermajority vote by the parliament are less likely to ratify because they make the internal approval process significantly harder.

Besides constitutional rules for ratification, also electoral rules may play a role in ratification. In a sample covering 75 democracies and 250 treaties from 1973 to 2002, Böhmelt et al. (2015) find that presidential systems with majoritarian electoral rule on average provide more public goods and ratify more environmental agreements than parliamentary systems with proportional rules. Although, in this regard, a contrasting result is obtained by Cortez and Gutmann (2017) on a sample of treaties that includes several non-environmental agreements. These studies are inspired by the influential work of Persson and Tabellini (2003) and Persson et al. (2007), which highlight the link between constitutional features, such as electoral rules (majoritarian vs proportional) or political systems (parliamentary or presidential), and their impact on provision of public goods and other economic outcomes.

Ratifications timing could also be linked to election cycles. According to a Cazals and Sauquet (2015), attention to the environment is seen positively by electors, hence political leaders should display stronger environmental commitment before elections. To test the connection between electoral cycles, income levels and the timing of ratification, Cazals and Sauquet (2015) use a survival model with time measured daily so as to distinguish the pre- and post-electoral period. Their findings show that developing countries tend to ratify shortly before elections to boost electoral results. In contrast, developed countries tend to ratify soon after elections. The sample of Cazals and Sauquet (2015) sample covers the ratification of 41 global environmental agreements by 99 nations from 1976 to 1999. The time coverage is limited by the availability of consistent electoral data. Hence, the results might not accurately extend to the 2020s, given the geopolitical changes and shifts in environmental concerns in public's opinion over the last twenty years.

## 2.3 Economic factors

In the previous section, we have seen how political factors shape the ratification decision. In this section we explore the economic motivations for ratifying environmental agreements. According to the prevailing framework of analysis, the economic characteristics of a country define its interest in ratification and free-riding on the agreement. The main economic drivers for ratification are the income level, the activity of interest groups and the free-riding incentives of the country.

### 2.3.1 Income

Income is a prominent factor influencing the participation of countries in environmental agreements. Statistically, income correlates positively with treaty ratification (see Table 1). The argument invoked to explain this relationship is the well-known and much con-

troversial Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesises a bell-shaped relationship between the degradation of the environment — as measured by emissions of certain pollutants — and the level of per capita income (Cole, 2004). The theory behind the EKC postulates that at higher levels of income countries express a stronger preference for environmental improvements (Stern, 2017). Given that environmental agreements are a necessary — yet not a sufficient — condition for the resolution of transboundary environmental issues, a higher level of income should be associated with a higher likelihood of ratification (Bernauer et al., 2010). Conversely, a country with low levels of income, might give comparatively more weight to economic development than environmental protection. Therefore, it is less likely to ratify costly environmental agreement.

**Table 1:** Ratification rate by development status

Development status	Ratification rate (avg.)
<i>High-income countries</i>	57.4 %
<i>Developing countries</i>	42.9 %
Land-locked developing countries (LLDCs)	31.9 %
Least developed countries (LDCs)	35.7 %
Small island developing states (SIDS)	40.7 %
Other developing countries	50.53 %

*Notes:* Ratification rate is defined as the proportion of treaties ratifies over all treaties open for ratification to the country. Data on ratification rates comes from Bellelli et al. (2020). Classification of countries' development level follows United Nations' M49 standard country groupings.

Negotiators of environmental treaties recognise the relevance of income differences. To reduce the effect of income, developing nations often push for systems that mitigate the costs borne by less developed countries, arguing that they face other more urgent priorities as — among other things — the eradication of poverty and sustainable economic development (Hecht and Tirpak, 1995). Mechanisms such as economic and technical transfers, flexible deadlines, or less stringent objectives, are all examples of clauses that aim at mitigating the impact of income on the participation in treaties. Despite these facilitating clauses, income levels still plays a decisive role on ratification choices. Several studies confirm that richer nations tend to participate in more environmental agreements than less economically developed ones (e.g Egger et al., 2011; Seelarbokus, 2014; Davies and Naughton, 2014).

Roberts (1996) stresses that developing nations are less likely to ratify environmental agreements because of their fragile institutions and lack of infrastructures inherited from their colonial past. This thesis is further explored in Roberts et al. (2004), where the authors posit that extractive colonialism leads to a narrow base of exports that make countries more dependent on natural resources and less likely to ratify environmental agreements. Both Roberts (1996) and Roberts et al. (2004) are cross-sectional studies and cannot account for treaty characteristics nor control for unobserved country factors.

### 2.3.2 Interest groups

Putnam (1988) and Barrett (1998) conceptualise ratification as the outcome of a two-stage game. The first stage is played internationally during the negotiation phase of treaties by national representatives; the second stage takes place domestically and is led by the political institutions and interest groups. Within this framework, ratification decisions boil down to the contrast between domestic actors, which can be divided in environmental and industrial pressure groups.

Fredriksson et al. (2007), build a two-stage game to derive the equilibrium implications that are tested empirically. The model is based on the ability of firms and environmental lobbies to affect ratifications through campaign contributions, bribes and media pressure. The model predictions are tested empirically with data on the ratification of the Kyoto Protocol and find that environmental lobbying, as proxied by the number of ENGOs, is a significant determinant of ratification (a result also found in Böhmelt et al., 2015), while industrial lobbying is insignificantly linked to a lower ratification probability. This paradoxical result is studied more in detail by Bellelli et al. (2020), who generalise the findings on a sample of 258 agreements and identify the potential ratifiers for every environmental agreement in the sample. All other large-sample ratification studies implicitly assumed that all countries were potentially capable of ratifying every agreement. This misidentification of potential ratifiers leads to ratification probabilities that are biased downwards whenever regional agreements are included in the data sample. The results of Bellelli et al. (2020) confirm that environmental lobbying has a positive effect on participation in environmental agreements, while the effect of industrial lobbying is statistically insignificant. Again, this unexpected result is robust to changes in specification and proxies used. The authors advance an explanation based on the lobbying preferences of environmental and industrial interest groups whereby the latter prefer to target the implementation phase of treaties.

The results obtained by these papers broadly confirm the recent developments in theoretical literature which have attempted to embed public choice dynamics, such as lobbying practices and electoral incentives, into the classic game-theoretical framework of treaty participation (Habla and Winkler, 2013; Hagen et al., 2016; Marchiori et al., 2017).

### 2.3.3 Incentives to free ride in open economies

According to classic game-theoretical literature on treaty participation, countries face a strong free-ride incentive that effectively creates a trade-off between the level of participation in environmental agreements and the abatement commitments implied by the treaty (Wangler et al., 2013). As a result, environmental treaties are considered ineffective and do not induce abatement levels higher than what would be achieved unilaterally (Barrett 1994, Carraro and Siniscalco 1993). The general conclusion is that large coalitions can only be achieved with low abatement targets that fall short of the social optimum (Finus, 2008).

Interestingly, the prevalent theoretical conclusions seem at odds with what is generally observed with treaty ratification. It is common to have participation levels that are higher than what would be expected from theoretical results (Marrouch and Chaudhuri, 2015). Moreover, non-compliance with the agreement is rarely observed, penalties or

sanctions have seldomly been applied in environmental treaties, and free riding on commitments is generally considered less problematic than what is postulated by game-theoretical models (Wagner, 2001). All of this may suggest some degree of discrepancy between theoretical predictions and empirical observations.

However, the main problem of empirical studies dealing with participation in environmental agreement is that it is hard to appropriately control for the stringency of the agreement because the characteristics of treaties are hard to quantify and compare. Hence, it is often unclear whether these agreements involve abatement levels higher than the non-cooperative equilibrium. Some papers attempted specifically to tackle the thorny question of environmental commitments; the results are mixed. For example, Bratberg et al. (2005) found a positive effect on abatement levels compared to the non-cooperative solution, but Ringquist and Kostadinova (1985) did not. Murdoch et al. (2003) observe that the abatement cost plays an important part in explaining the adherence to the Helsinki Protocol (1985). However, the results from Beron et al. (2003) point to weak free-riding incentives for the Montreal Protocol (1987) and Sauquet (2014) finds that the free-ride incentive for the Kyoto Protocol (1997) is mitigated by other types of relationships between countries, such as trade partnership and proximity. Other papers focused on the level of participation and found that the trade-off between the strictness of the agreement and the number of members is avoidable. According to Bernauer et al. (2013b) and von Stein (2008), some design features of environmental agreements could promote participation and simultaneously induce tighter obligations for its members. Nevertheless, the limited amount of empirical evidence does not allow to validate or disprove theoretical predictions.

A specific case of incentive to free ride that received extensive empirical coverage is the pollution haven hypothesis. This states that, at the margin, weaker rules on pollution abatement in a country provide a comparative advantage to pollution havens (Copeland and Taylor, 2004; Cai et al., 2013). A well-studied example of pollution haven effect linked to environmental agreements is the phenomenon of carbon leakage. When a group of countries — such as those in Annex I of the Kyoto Protocol — commit to a reduction in carbon emissions, the uncommitted countries have an incentive to increase their emissions. Kim (2016) tests for this effect within a gravity model framework. The author uses a structural break test to assess whether the Kyoto protocol induced a change in trade flows of G20 countries. Kim (2016) finds that a structural break has probably occurred in 2003. In a similar application, Aichele and Felbermayr (2013) estimates the impact of commitment to the Kyoto Protocol (1997) on bilateral trade flows. They use matched samples with difference-in-difference estimation and find that the protocol induces a reduction of around 10% in the exports of Annex I countries, with energy-intensive industrial sectors being the most affected. The result is found by comparing average exports in the period 1999–2003 with the corresponding level in the 2004–2007 period. We suspect that the results could be inflated by a set of time-varying unobserved factors: the end of the second period corresponds with an initial slow-down in world trade and the study period also coincides with a major shift of industrial production towards developing countries. As an illustration, total exports of India grew from 60 billion USD in 2001 to 250 billion in 2007, and China exports exploded from 250 billion USD to 1250 billion USD over the same period (Data from World Bank, 2017).

In a subsequent paper, the same authors find that the Kyoto Protocol affects trade

composition. [Aichele and Felbermayr \(2015\)](#) employ a gravity model to calculate the embodied carbon in trade flows. They find that the embodied carbon in the imports of Annex I countries increased by 8% and emission intensity by 3%. The change in trade volume and trade composition suggest that environmental treaties may be able to influence trade flows. Nevertheless, results for international environmental agreements are mixed too. For instance, [De Santis \(2012\)](#) studies the link between three environmental agreements and trade with a gravity model. She finds that more stringent environmental policies tend to reduce exports. However, participation in environmental treaties has the opposite effect: it increases exports. [De Santis \(2012\)](#) observes that bilateral trade among EU-15 countries increases in a significant way after the adoption of the [Montreal Protocol \(1987\)](#), [UNFCCC \(1992\)](#) and [Kyoto Protocol \(1997\)](#). According to [Bernauer et al. \(2010\)](#), countries more focused on trade are expected to be less likely to ratify environmental agreements because they are more affected by losses in comparative advantage. On the other hand, [Neumayer \(2002a\)](#) argues that more intense trade leads to higher international integration and likelihood to participate in treaties. A similar argument is supported by [Egger et al. \(2011\)](#), who posit that participation in environmental agreements increases with more liberal trade and investment policies. Overall, trade openness does not seem to be a strong determinant of ratification. For instance, the sample of [Neumayer \(2002b\)](#) covers six treaties and 175 countries and his results show that the level of imports and exports are only relevant for the agreements that impose trade restrictions, namely the [Rotterdam Convention \(1998\)](#), [Montreal Protocol \(1987\)](#) and [CITES \(1973\)](#). For the other treaties in the sample the results are statistically insignificant (CITES, Kyoto Protocol and Cartagena Protocol, Convention on Biological Diversity). On a similar line, [Wagner \(2016\)](#) finds that trade relationships imply an acceleration of ratification time of the Montreal Protocol by 11%. However, the effect is likely to be stronger for the Montreal Protocol than for other treaties because it contains an explicit trade ban on CFCs commerce with non-ratifiers.

## 2.4 International linkage

Foreign interactions are probably the most studied factors in the empirical ratification literature. Ratification is seen as a strategic move, which does not only depend on the characteristics of the country and treaty, but also on the behaviour of foreign nations. The empirical research focused on understanding how economic and diplomatic ties between nations influence ratification choices.

The benefits of environmental agreements are typically non-rival and non-excludable — for example non-ratifiers cannot be excluded from the environmental benefits of the [Paris Agreement \(2015\)](#). Despite the incentive to free-ride, empirical evidence shows that foreign ratification, especially by big nations, increases ratification likelihood of other nations. The empirical literature agrees that this effect is partly explained by the existence of economic and political ties between countries ([Sauquet, 2014](#)), which create interdependence and mitigate the free-riding incentive postulated by non-cooperative game-theoretical models.

The effect of foreign actions on domestic ratification choices is usually tested by inserting foreign ratifications as explanatory variables (i.e. spatial lags). Foreign ratifications are then aggregated by using weighting matrices based on factors such as such as value of bilateral trade, geographic proximity, diplomatic ties, GDP, or other factors.

Empirical evidence shows that ratification likelihood increases when foreign nations decide to participate in treaties. [Bernauer et al. \(2010\)](#) and [Perrin and Bernauer \(2010\)](#) find that this is particularly true in the case of “peer nations”, that are in the same geographical area or income bracket. Even after controlling for regionality of agreements, [Bellelli et al. \(2020\)](#) find that countries are strongly affected by the ratification decisions of foreign nations in the same geographical region: they estimate that the probability of ratification increases by as much as 80% if all neighbours ratify the treaty. Both [Bernauer et al. \(2010\)](#) and [Bellelli et al. \(2020\)](#) obtain these results on samples containing more than 200 different environmental agreements. Studies on single agreements further confirm these findings and suggest that the impact of international linkage may vary according to the specific features of the treaty. For example, [Sauquet \(2014\)](#) reports that the likelihood of ratification for the [Kyoto Protocol \(1997\)](#) is affected by the behaviour of trade partners and partners in green investment projects, while neighbouring countries do not have a significant influence. Given the global impact scale of greenhouse gas emissions, this result is plausible.

[Davies and Naughton \(2014\)](#) build a model of pollution tax competition with trans-boundary pollution spillovers and test it with ratification count data. They find that the number of ratifications of other OECD countries significantly linked to domestic number of ratifications, while ratification of non-OECD countries — except for regional agreements — is insignificant. The problem with this study is that the number of treaty ratifications is a misleading measure: correlation in the aggregate number of ratifications does not imply cooperation between nations. In fact, two countries may simply be ratifying different agreement in similar numbers. Moreover, two neighbouring countries will likely be exposed to a similar set of treaties, hence correlation is driven by their eligibility to ratify a similar number of agreements rather than an increased propensity in cooperation.

[Schneider and Urpelainen \(2013\)](#) take advantage of a natural experiment to study the influence of the United States and the European Union in the ratification of environmental agreements. The study exclusively looks at the [Cartagena Protocol \(2000\)](#) on biosafety regulation, a treaty for which the United States opposed the EU because it promoted the European stance on GMOs that was seen as having a damaging effect on United States’ agricultural exports. According to [Schneider and Urpelainen \(2013\)](#), the two powers competed to influence the ratification of the treaty by third nations. They examine how the strength of the ties with the US and EU affects the decision of joining the protocol. They find that the more a country depends economically or diplomatically on one of the two powers, the more it aligns its international policy with such power. The analysis unveils that countries that are military allies or share strong economic bonds with the US have a lower probability of ratifying the Cartagena Protocol.

Besides the direct influence between pairs of countries, it is also found that countries are more likely to ratify environmental agreements when they are economically and diplomatically integrated with the rest of the world. ([Frank, 1999](#)), [Bernauer et al. \(2010\)](#) and ([Yamagata et al., 2013](#)) argue that the more a country is linked to the international community through trade and diplomatic activity, the more likely it is to join environmental agreements. In essence, ratification would be driven by a country’s degree of global integration. Integration is often proxied by the number of memberships to international organisations, international NGOs and international inter-governmental

associations. [Bernauer et al. \(2010\)](#) explain that membership to international organisations indicate openness to cooperation and should increase available information and reduce costs for the formation of multilateral agreements. Moreover, if a country linked to the international community does not ratify a treaty, it suffers a loss in reputation and expects other nations to refuse cooperation in other areas ([Finus, 2008](#); [Bernauer et al., 2010](#)). According to [Frank \(1999\)](#) global integration is the main determinant of ratification. However, this result does not take into account possible sources of endogeneity in the variables.

Another contribution to this topic comes from [Wagner \(2016\)](#). In the first part of the paper, [Wagner \(2016\)](#) builds a game-theoretical model of delay in ratification, which depends on whether there is complementarity or substitutability in country ratifications. The model is then tested empirically with data on the ratification of the [Montreal Protocol \(1987\)](#), using an accelerated failure time model with spatial lags. The result of [Wagner \(2016\)](#) indicates that ratifications of the Montreal Protocol exhibit strong complementarity. On average, the complementarity effect accelerated ratification time by 12% (208 days). The author argues that complementarity is mainly explained by three factors: *i*) Economic dependency and trade, *ii*) issue linkage and reputation costs, and *iii*) fairness. Among the three factors, economic dependency seems to have the strongest acceleration effect on ratification timings. In a similar fashion, [Yamagata et al. \(2013\)](#) and [Yamagata et al. \(2017\)](#) use a spatial lag model to explore the correlation in the ratification choices of countries. They explore different weighting matrices for the spatial lag, such as the presence of shared language, religion, or common membership in international organisations. Only two climate change agreements are studied in [Yamagata et al. \(2013\)](#), but [Yamagata et al. \(2017\)](#) expand the analysis to 8 treaties. In the latter study, they run two separate regressions, one for the period 1981-1990 and the other 1991-2008. Treaty dummies are included to control for unobserved treaty characteristics. Both [Yamagata et al. \(2013\)](#) and [Yamagata et al. \(2017\)](#) conclude that global integration and ratification by large nations play a critical role in domestic ratification decisions.

Finally, Some researchers emphasise that the act of ratification expresses the feasibility of the environmental project and is used as a signalling tool to foreign and domestic actors ([Perrin and Bernauer, 2010](#); [Hugh-Jones et al., 2018](#)). Their arguments are based on the policy diffusion literature, which stipulates that the adoption of a policy by a country conveys information on reputation costs, environmental commitment and implementation costs. A small number of papers upholds this thesis. [Schulze and Tosun \(2013\)](#) hold that some countries are willing to ratify agreements and align their environmental standards with the EU because they anticipate potential returns in the form of aid, assistance, access to the EU market and even EU membership. Hence, some countries use the ratification of environmental agreements mainly as a signalling tool. Their sample includes 25 non-EU members and 21 environmental agreements negotiated under the UN Economic Commission for Europe (UNECE). More distant UNECE members (e.g. Israel or Tajikistan) exhibit a lower propensity to ratify environmental agreements than proximate members that aspire to join the EU and are economically dependent on the EU. A similar analysis is conducted by [Milewicz and Elsig \(2014\)](#) with a survival approach on a sample of 76 multilateral agreements — although not exclusively environmental agreements. They claim that new democracies in Europe ratify

treaties to please the EU, signal political autonomy and gain international recognition. These findings are echoed by [Cortez and Gutmann \(2017\)](#) — again with a sample not only limited to environmental agreements — who find that recent democracies are more likely to ratify all types of treaties. The higher rate of ratification strongly substantiates the quest for international recognition by young democracies and the signalling role of treaty ratifications.

### 3 Conclusion and policy recommendations

To sum up, this critical literature review presents the main factors associated with the ratification of environmental agreements. Following the results of empirical studies, the determinants of ratification can be broadly grouped into three categories: *i*) domestic factors, *ii*) treaty characteristics and *iii*) international interactions. Domestic factors, such as the political system, the income level, the interests of dominant pressure groups or the export structure of a country strongly shape the set of incentives and costs associated with ratification. However, the characteristics of the treaty are arguably even more important; agreements that promote stricter environmental regulations are relatively more onerous for the parties and, as such, are joined more reluctantly. Nonetheless, empirical findings show that some type of clauses can increase participation, and there is a broad consensus that the strong interdependence between nations mitigates the free-riding incentive. Not only will ratifiers try to influence other nations to join, but economic and diplomatic partners might use the ratification of environmental agreements to reinforce partnerships and strengthen their negotiation position on other cooperation issues. Under the right circumstances, a non-ratification bears a reputational cost.

Several useful policy insights can be drawn from this body of research. First of all, there is evidence that some type of treaty provisions can foster participation without compromising effectiveness. Just as theoretically predicted, minimum participation rule, flexibility mechanisms, financial assistance or technological transfers to developing nations can help improve participation. Transfers are found to be decisive factors for participation of developing nations ([Mohrenberg et al., 2016](#); [Spilker and Koubi, 2016](#)). Moreover, contrary to expectations, monitoring mechanisms and small sanctions serve as deterrent and are not associated with reduced participation ([Bernauer et al., 2013b](#)). In this regard, treaty structured as a climate club ([Nordhaus, 2015](#)) could be a viable solution. For instance, the very successful [Montreal Protocol \(1987\)](#) managed to attract wide participation and achieve effective environment improvements by imposing sanctions for non-compliance and setting trade restrictions between members and non-members on products related to ozone-depleting substances. Another emerging suggestion is to frame global treaties as interlocked regional agreements. As the number of negotiating parties increases, finding a common ground can become increasingly hard. Therefore, participation can be hugely improved by splitting negotiation into regional agreements ([Leinaweaver, 2012](#); [Bellelli et al., 2020](#)).

Furthermore, the empirical modelling stresses that the first year of an agreement is crucial for its success. As time passes, the agreement “cools down” and its chances of attracting ratifications are reduced. Securing early ratification of big players can be a decisive factor and could trigger a domino effect in participation ([Bernauer et al., 2010](#); [Wagner, 2016](#); [Yamagata et al., 2017](#)). In this regard, empirical findings are



particularly encouraging. The strong linkage between nations implies that a handful of countries could make the difference. Finally, participation in environmental agreements can also be fostered with environmental lobbying and campaigning. Agreements with intense media coverage attract systematically higher ratification rates and environmental lobbying actions are found to have a significant effect in democracies (Fredriksson et al., 2007; Böhmelt et al., 2015).

The scope of this paper has been to summarise the progress achieved in the empirical research on treaty ratification and take stock of the main findings. We also attempted, as much as possible, to compare these findings with the predictions of the contiguous game-theoretical literature on treaty participation. By so doing, we hope to have bridged two bodies of research which have mostly evolved in parallel. There is scope for further research in this area, particularly with regards to treaty design. As of now, we possess approximate models for treaty participation and only a limited understanding of the factors that underpin successful environmental cooperation. We hope that this collection of empirical results will contribute to building more realistic models of environmental cooperation and improve our capacity to address transboundary environmental issues.

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