

RESEARCH ARTICLE

Have renewable energy leaders announced aggressive emission reduction goals? Examining variations in the stringency of country-level net-zero emission pledges

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Abstract

The 2015 Paris Agreement outlined the goal to limit temperature increases below 2°C, preferably to 1.5°C. In response, several countries have announced net-zero emission pledges (NZEP). The credibility of these pledges varies because countries have committed to different target years. Moreover, some pledges outline sectoral as opposed to economy-wide targets and vary in how they monitor progress. To assess the pledge's credibility, we create a novel NZEP stringency score. We find that climate leaders with a higher share of renewable energy in final energy consumption are more likely to have announced more stringent NZEPs. However, economic development, the size of the economy, countries' embeddedness in international environmental treaties, and the robustness of domestic civil society are not associated with NZEP stringency.

1. Introduction

The 2015 Paris Climate agreement challenged the world to limit temperature increases to below 2°C and ideally below 1.5°C compared to pre-industrial levels. In response, more than 120 countries have announced net-zero emission pledges (NZEPs). These pledges, however, do not follow a common format or reporting guidelines. Countries have established different target years to achieve net-zero greenhouse gas (GHG) emissions. Most countries have pledged to achieve net-zero emissions by 2050. However, Maldives seeks to achieve net-zero status by 2030, Germany by 2045, and India by 2070.

These varying target years could serve as a proxy for NZEP stringency, but consider the fact that some pledges encompass economy-wide GHGs emissions, while others are limited to specific sectors and/or to carbon emissions only rather than all types of GHGs. For example, Chile's NZEP focuses on carbon emissions only while Ukraine's NZEP covers all GHGs. Some pledges cover domestic emissions while others include emissions embedded in imported products. Similarly, some countries allow carbon offsets to count as emission reductions.

However, Portugal, Greece, Iceland, Slovenia, and South Sudan explicitly preclude carbon offsets [1]. Moreover, pledges also vary in the types of monitoring mechanisms to ensure that countries are on track to meet the NZEP target [2].

The variations in the structure and substance of NZEPs make it hard to differentiate NZEPs that are more stringent (therefore, more likely to deliver on the decarbonization pledge), from the ones that are “greenwashes” (or “carbon washes”), and less likely to deliver on the emission reduction targets [3]. To further both the academic and policy dialogues on decarbonization, we create NZEP stringency scores for every country [4]. To theoretically ground our empirical inquiry, we propose the *speed-accountability-scope* framework which incorporates different elements of the pledges that bear on emission reductions [5]. The challenge is to summarize the multiple pledge elements (10 in our case) in one indicator, to facilitate cross-country comparisons. This poses a challenge because elements might be correlated. Thus, if we were to simply sum up the scores of each element to arrive at the consolidated NZEP score, we will probably count the same underlying factor that affects NZEP stringency multiple times. Therefore, we employ the principal component analysis (PCA) which allows us to summarize these elements in fewer indices or principal components. Importantly, these indices are uncorrelated and hence prevent counting the same underlying factor multiple times.

If NZEP scores vary across countries, what factors might be associated with such a variation? While in this paper we do not causally identify factors that increase or decrease the likelihood of NZEPs’ stringency, we provide the first systematic analysis of factors (identified by the literature to be associated with emission reductions) that correlate with NZEP stringency.

Our key finding is that renewable energy leadership is associated with more stringent NZEPs. This has an important political lesson. Decarbonization creates a non-excludable global public good (with local spillover benefits) but concentrates transition costs on specific sectors and communities. Thus, climate policies sometimes generate backlash, especially among fossil fuel communities that bear these costs. Some countries have addressed this backlash and invested substantially in energy transition, as reflected in the share of renewable energy in the final energy consumption. This means that they have been able to develop some level of domestic political consensus on climate change. We find that these countries tend to be associated with more stringent NZEPs, all else equal. Moreover, economic development, the size of the economy, countries’ embeddedness in international environmental treaties, and the robustness of domestic civil society do not show statistically significant associations with NZEP stringency. The share of imported carbon, which reflects carbon leakages via trade, is also not associated with NZEP stringency either. Taken together, this suggests that the level of existing decarbonization, as opposed to other domestic and international factors that are expected to shape climate policy, is associated with NZEP stringency.

This paper is structured as follows. Section 2 provides a discussion on 10 elements that are common across NZEPs and bear upon their ability to deliver on the net zero emission target. Section 3 explains a non-linear PCA upon which we rely to translate 10 elements into country-level NZEP stringency scores. Section 4 reports ordinary least squares (OLS) results that investigate the associational relationship between various country-level factors and NZEP stringency score. Section 5 concludes.

2. What NZEPs can be considered stringent?

Hale et al. provide a database of country-level mitigation plans [6]. To the best of our knowledge, this database provides the most comprehensive coverage both in terms of countries and sub-components of mitigation plans. The database classifies pledges into different categories: net-zero, carbon-neutral, climate-neutral, and zero-carbon. Because these pledges are variants

of NZEPs [4], we work with the above database to construct country-level NZEP stringency scores.

Conceptually, we suggest that NZEP stringency has three dimensions, which we term the *speed-accountability-scope* framework. The first dimension pertains to how quickly the NZEPs pledge seeks to reach the net-zero status (“speed”). That is, stringent NZEPs commit countries to quicker emission reduction timelines [7]. This has important substantive implications, given the severity of the climate crisis and the need to reduce emissions quickly to limit global temperature increases.

There is vast literature examining how countries comply with inter-governmental treaties which they have ratified [8, 9]. Unlike inter-governmental treaties, NZEPs are voluntary commitments without ratification and with a lower compliance bar. This raises the issue of the confidence various stakeholders have in any country’s ability and willingness to deliver on its pledge. Arguably, as the institutional design literature suggests, monitoring and verification of the progress in meeting pledge [10] could curb shirking and create incentives for countries to deliver on it [11, 12]. Hence, the second dimension pertains to the presence of accountability mechanisms (“accountability”). A legislated pledge as opposed to a policy announcement that could be “cheap talk” [13], for instance, could compel the government to hold itself accountable for meeting the NZEP obligations. Depending on the legal system, it might even allow non-state actors to sue the government if the progress is staggering.

Periodic reporting of progress could also enhance accountability given that the pledge pertains to a future date, sometimes 30 years in the future. Thus, various stakeholders should be able to periodically assess progress towards the pledged goals and employ “insider” or “outsider” tactics to motivate governments to honor the pledge by enacting new policies. For example, annual reporting and interim targets could allow climate groups and the international community to name and shame countries if their decarbonization progress is tardy.

Third, pledges could differ in the scope of emission reductions: some might pertain to specific sectors or could be economy-wide. For reference, the European Union’s Emission Trading System covers only 41% of the European Union’s greenhouse gas emissions. Moreover, emissions could cover territorial sources or could be embedded in the products that countries import. This is a crucial issue because countries might claim to be decarbonizing by reducing their territorial emissions, while in fact, they could simply be outsourcing emission-intensive activities abroad and importing these products. This could be viewed as carbon fudging.

Moreover, some pledges might incorporate carbon offsets, which allow countries to purchase emission credits from abroad without reducing territorial emissions at home, which often pose important political and economic challenges. Viewed this way, countries using offsets have not reduced their emissions (with their political and economic costs) but simply outsourced their reduction. Further, many question whether carbon offsets, which typically suffer from poor monitoring, actually contribute to emissions reduction.

Thus, stringent NZEPs cover a wide range of possible sources that contribute to GHG emissions (“scope”) and minimize fudging. For analytic clarity, we further narrow the scope down into domestic and international ones (“domestic scope” and “international scope”). Domestic scope refers to the range of domestic sources of GHG that NZEPs cover. We suggest three elements that determine domestic scope: sectoral coverage, gas coverage, and carbon credit offsets. For instance, while some NZEPs plan to mitigate GHG emissions from all domestic industrial sectors (i.e., economy-wide), others do not. Also, while some NZEPs cover all types of GHG emissions including carbon and non-carbon gases, others cover carbon emissions only. Finally, while some NZEPs allow carbon offsets (whether procured domestically or internationally) to achieve the net-zero status, thereby allowing for some domestic GHG emissions to continue, others prohibit such an alternative means of GHG mitigation.

International scope refers to GHGs not accounted for in countries' territorial carbon footprints. We focus on three issues: imported carbon, international aviation, and international shipping. For instance, some NZEPs count carbon emissions embodied in foreign goods and therefore do not allow for carbon leakages. Such pledges are more stringent than the ones that do not include imported carbon in counting country-level emissions. Also, some NZEPs regulate carbon emissions from international aviation and shipping while others do not. The 1998 Kyoto Agreement and the 2015 Paris Agreement did not cover aviation and shipping emissions because they are governed by a different set of international agreements and conventions (namely, the Convention on International Civil Aviation and various conventions of the International Maritime Organization). However, given their increasing salience in global emissions, ignoring international aviation and shipping undercounts real emissions which lead to global temperature increases. Thus, in stringent NZEPs, countries include aviation and shipping emissions in their national targets.

3. Constructing an “NZEP stringency score”

To measure NZEP stringency, we analyze the elements of NZEPs in the following steps. We focus on 124 countries in the Hale et al. database whose mitigation plans are classified as “net-zero,” “carbon neutral,” “climate neutral,” and “zero carbon.” To check for bias, we compare this sample with countries listed in Energy & Climate Intelligence Unit's net-zero scorecard [14], and both lists completely overlap.

Next, based on the *speed-accountability-scope* framework, we identify ten elements. The *speed* dimension has one element: *target year*. The *accountability* dimension has three elements: *legal status*, *reporting mechanism*, and *interim target*. The *scope* dimension (with six elements) has two sub-dimensions: domestic and international. The *domestic scope* dimension has three elements: *economy-wide*, *gas coverage*, and *carbon credit offsets*. The *international scope* dimension has three elements as well: *imported carbons*, *international aviation*, and *international shipping*. As we explain subsequently, having a different number of elements across dimensions (or placing a given element in a specific dimension and not in another) does not bias the construction of stringency scores. These scores are based on “artificial components” which we construct by drawing on information provided in the ten elements, irrespective of how this information is classified across different dimensions.

Following Hale et al., we code the ten elements either as binary or ordinal variables to use them in PCA. In the *speed* dimension, the *year* element is coded as an ordinal variable where a value of 0 means that an NZEP has a target year after 2050 (which is the modal value in the database), 1 means the target year of 2050, and 2 means the target year before 2050. This means that all else equal, NZEPs are deemed more stringent when they pledge emission reductions earlier than 2050 but less stringent when the pledged year comes after 2050.

In the *accountability* dimension, we code the *legal status* element as an ordinal variable, which takes the value of 3 if an NZEP has been translated into domestic legislation; 2 if an NZEP is stipulated in a policy document, 1 if an NZEP is officially declared or proposed by a country government, and 0 if the NZEP is still under discussion. Among countries in our data, 16 countries have legislated their NZEPs into domestic law, 32 countries have stipulated them in their policy documents, 18 countries have officially declared the but without embedding them in domestic legislation or policy documents, and 58 countries have reported that their NZEPs are under discussion.

The *reporting mechanism* element is also an ordinal variable that takes the value 2 when an NZEP reports its progress every year, 1 when it reports less frequently (e.g., every 2 years), and 0 when it does not stipulate any reporting frequency. 36 countries including Australia, Canada,

France, and Germany have pledged that they will report their progress every year, while 87 countries have pledged to do so less frequently. Only Saint Vincent and the Grenadines did not include any reporting mechanism in their NZEPs.

The *interim target* element is binary which takes the value is 1 if an NZEP has an interim target before the pledged year, and 0 if otherwise. For example, Fiji has pledged to achieve a net-zero status by 2050 but has also identified 2030 as the interim target by which it seeks to reduce emissions by 30% compared to a business-as-usual scenario.

In the *domestic scope* dimension, we have three elements, all coded as binary variables. The *economy-wide* element takes the value of 1 if an NZEP covers all domestic industrial sectors and 0 if otherwise. For example, the United Kingdom covers carbon emissions from all territorial sources [15]. However, South Sudan's mitigation plan, as outlined in its second Nationally Determined Contribution (NDC), prioritizes emissions from 14 industrial sectors including petroleum and mining instead of taking an economy-wide approach.

The *gas coverage* element takes the value of 1 if the NZEP covers all GHG emissions and 0 if otherwise. For example, Chile's NZEP focuses on carbon emissions only while Ukraine's NZEP covers all GHG emissions. The *carbon credit* offsets element takes the value of 1 if the NZEP does not allow carbon credit offsets, and 0 if otherwise. However, the NZEPs of the remaining 119 countries in our database offer no such stipulation.

In the *international scope* dimension, we have three elements, all coded as binary variables. The *imported carbon* element takes the value of 1 if the NZEP aims for mitigating carbon emissions embodied in imported goods and 0 if otherwise. Australia, for instance, includes embodied carbon in its NZEP. The *international aviation* element takes the value of 1 if the NZEP accounts for emissions from flights coming to and leaving the country and 0 if otherwise. Finally, the *international shipping* element takes the value of 1 if the NZEP accounts for emissions from ships coming to and leaving the country and 0 if otherwise. Myanmar and Iceland include both maritime and aviation emissions in their NZEP pledges [16]. The above discussion is summarized in Table 1.

To construct NZEP stringency scores, one might be tempted to add normalized scores of different elements. But this poses problems because some elements might be correlated, leading to counting the same underlying factor that affects NZEP stringency multiple times. Therefore, we employ the PCA which allows us to summarize the 10 elements in fewer indices or principal components. PCA uses the least-square approach to identify the indices or components (think of lines or surfaces in the K-dimensional space) that summarize the data. Importantly, these indices are uncorrelated and hence prevent counting the same underlying factor multiple times. Moreover, PCA treats information provided in an element in the same way irrespective of whether the element was placed in speed, accountability, or scope dimensions. Importantly, while the generated principal components capture maximal variance across 10 elements, they cannot be mapped into any specific dimension of our theoretical framework.

Because none of the elements in our dataset is expressed on a continuous scale, we use a non-linear principal component analysis [17–19]. This approach uses optimal scaling to transform observed variables with different scales and types so that “object scores” are calculated with a single quantification. Using this approach, we are not biasing any elements or dimensions to assign more weights when calculating object scores.

Table 2 summarizes the loadings of three principal components whose eigenvalues are higher than 1, as per the Kaiser rule. Typically, most of the variance is captured in the first component. Thus, we choose the first component to reflect the NZEP stringency. It is also negatively correlated with all ten elements and hence is consistent with the theory guiding the construction of the stringency score. This means that countries with lower object scores derived from the first component are more likely to have NZEPs that score higher in all ten

Table 1. Coding elements in the NZEP stringency score.

Dimension	Element	Coding
1. Speed	Target Year	2 = target year before 2050
		1 = target year is 2050
		0 = target year after 2050
2. Accountability	Legal Status	3 = translated into domestic legislation
		2 = stipulated in policy document
		1 = officially declared or proposed
		0 = NZEP is still under discussion.
	Reporting mechanism	2 = reports progress every year,
		1 = reports less frequently
		0 = no reporting frequency
	Interim target	1 = interim target before the pledged year
		0 = no interim target
3a. Scope: Domestic	Economy-wide	1 = covers all domestic industrial sectors
		0 = otherwise
	Gas coverage	1 = covers all GHG emissions
		0 = otherwise.
	Carbon credits offset	1 = excludes carbon credit
		0 = otherwise
3b. Scope: International	Imported carbons	1 = includes imported carbon
		0 = otherwise
	International aviation	1 = includes aviation
0 = otherwise		
International shipping	1 = includes shipping	
	0 = otherwise	

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element variables. To be consistent with the notion of a higher score means more stringent NZEPs, we reversed the signs of these object scores. Thus, a higher object score indicates a higher level of NZEP stringency.

Table 2. Three components with loadings and eigenvalue.

Elements	Component 1	Component 2	Component 3
Target year	-.328	.230	.134
Legal status	-.625	.238	.304
Reporting mechanism	-.735	.353	.105
Interim target	-.185	.517	.206
Economy-wide	-.423	.021	.620
Gas coverage	-.443	.137	-.398
Carbon credits offset	-.430	.263	-.571
Imported carbons	-.191	.384	-.427
International aviation	-.734	-.567	-.124
International shipping	-.677	-.620	-.025
Eigenvalues	2.67	1.45	1.23
Variance of proportion explained (%)	26.66	14.47	12.28
Cumulative variance of proportion explained (%)	26.66	41.13	53.42
Loss value		.822	

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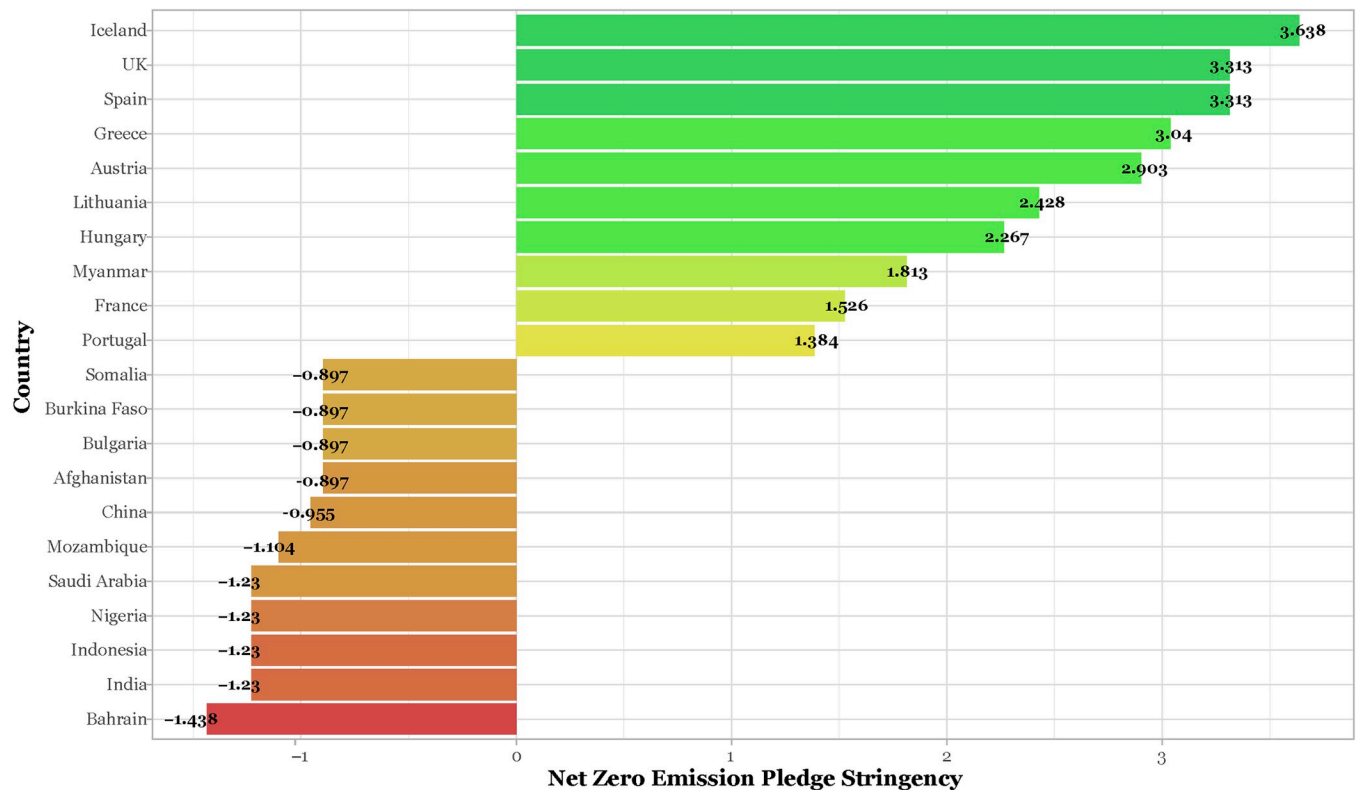


Fig 1. Top–10 and bottom–10 countries in NZEP stringency score.

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Object or stringency scores are standardized scores with a mean of zero. 44 countries have scores above zero and 80 countries have scores below zero. China, the top global emitter, has a stringency score of -0.955. The US which has contributed most to accumulated greenhouse gas emissions has a stringency score of 0.794. Iceland has the most stringent NZEP (score = 3.64), followed by Spain, the UK, Greece, and Austria. Icelandic NZEP is still in a policy document, but it pledges to achieve net-zero emissions by 2040 (as opposed to 2050 or beyond) and commits to an annual reporting of its progress. Most importantly, Iceland plans to regulate emissions from both international aviation and shipping, covering all types of GHG emissions. Based on our analysis, Iceland gets the highest NZEP stringency score in our sample. On the other hand, Bahrain has the least stringent NZEP (score = -1.44) as it aims to achieve net-zero by 2060, and provides no specific details on scope or reporting mechanism.

Fig 1 displays top-10 and bottom-10 countries in terms of their stringency scores. In S1 Text, we provide stringency scores for all 124 countries in our sample. Constructing the score in this way provides several benefits. First, it provides a single framework for comparing the NZEP stringency scores across countries. Second, should an NZEP of any country be updated, one can extract 10 elements used for PCA and create a new stringency score from it. We provide data and R code in a public repository to make sure our method for constructing the score is fully replicable.

4. What factors are associated with stringent NZEPs?

We explore the association between NZEP stringency and various country-level factors. We suggest that because NZEP pledges are also political documents, the stringency of NZEP

pledges should reflect domestic political challenges governments face in decarbonization. These challenges pertain to both the fear of global free riding and the fact that decarbonization creates winners and losers in the domestic economy. Scholars note that NZEP commitments that seek to reduce emissions create a global public good of climate protection (although they also create local co-benefits such as improved air quality), which leads to the free-rider problem [20]. This problem is particularly acute for NZEP pledges given their voluntary nature. It is not clear what sorts of sanctions countries might face should they not be able to comply with these pledges. Further, mitigation policies often lead to distributional conflicts, which also lead to political opposition [21].

There are two ways domestic politics could be associated with NZEP stringency. Many countries have overcome (to varying degrees) political obstacles and embarked on decarbonization. They have created policy momentum behind mitigation and therefore face fewer political and economic costs in outlining stringent NZEP targets. Thus, we focus on the association of levels of decarbonization as reflected in the share of renewables in final energy consumption and NZEP stringency [22, 23]. The intuition is that climate leaders that have made progress on decarbonization will also tend to pledge more stringent NZEPs. Rather than the absolute level of renewable energy consumption, we use its share in total energy consumption since decarbonization should occur by replacing fossil fuels with renewable energy [24].

However, other countries continue to struggle with decarbonization. Might they be tempted to pledge stringent NZEPs to gain some international support? Indeed, scholars debate whether countries that violate human rights are more likely to ratify human rights treaties with weak monitoring and enforcement [25]. Following this logic, because NZEP pledges are voluntary, they will reflect “cheap talk.” If so, we should expect to see climate laggards with a poor track record on renewable energy capacity to be outlining stringent NZEPs.

Our model controls for several confounding variables which scholars associate with pro-environmental behaviors, especially emission reductions. In the Environmental Kuznets Curve (EKC) literature, scholars have explored the relationship between wealth and environmental protection, including emission reductions [26, 27]. Therefore, we control for the size of the economy (logged GDP) because bigger economies could have more resources to devote to decarbonization, as reflected in NZEPs. Second, we control for wealth or the level of economic development (logged GDP per capita), both purchasing power parity (PPP) adjusted. Our results do not change even if we include squared per capita income (as per the EKC literature) to account for the non-linear relationship between wealth and NZEP stringency.

Scholars note that fossil fuel-dependent economies will face higher domestic economic and political costs as they seek to decarbonize. Hence, we control for logged GHG emissions ($\text{KtCO}_{2\text{eq}}$) as heavy emitters may face higher costs from introducing more stringent NZEPs. By the same logic, we also control for the share of imported carbons in total carbon consumed and the share of exported carbons in total carbons produced in each country [28].

Next, we introduce a track record of joining environmental treaties for each country, represented as an environmental treaty ratification score (ETRS). Holtmaat et al. [29] constructed this score based on the dataset provided by Mitchell et al. [30] by standardizing the number of international environmental agreements (IEAs) across all countries in the analysis. We follow the same method but only consider IEAs that are related to climate change. The logic is that countries that actively participate in global climate cooperation will face higher pressure from the international community to introduce more stringent NZEPs. Since the same pressure may also come from domestic civil society [31, 32], we additionally control for the robustness of the civil society in each country, as reported in the Core Civil Society Index from the V-Dem (Varieties of Democracy) database [33].

Scholars note that the European Union seeks to project itself as an environmental super-power [34]. In 2020 It announced the European Green Deal. Moreover, climate change has widespread support across EU countries. Thus, we control for European Union (EU) membership because the EU has committed to the goal of net-zero emissions by 2050.

Finally, given the debate about the complex relationship between climate adaptation and mitigation, specifically the concern that climate-resilient countries might be less enthusiastic about mitigation [35], we also control for *climate resilience* using Notre Dame Global Adaptation Initiative's ND-GAIN index [36]. Due to missing observations in some of these variables, we work with the dataset of 96 countries, which together account for 85.27% of global greenhouse gas emissions. For all these variables, we use the most recent data.

We used ordinary least squares (OLS) regression to examine how these covariates are associated with NZEP stringency. Our discussion on explanatory and control variables is summarized in the following equation:

$$score_i = \beta_0 + \beta_1 x_i + \beta_2 Z_i + \theta_j + e_i$$

where $score_i$ is an NZEP stringency score of country i , β_0 is a constant, x_i is the share of renewable energy in final energy consumption of country i , Z_i is a set of control variables, θ_j is a regional dummy depending on whether each country i is located in a region j , and e_i is an error term. We follow the regional classifications of each country based on the World Development Indicators (WDI) database.

Results are presented in Table 3. The key finding is that NZEP stringency correlates with the share of renewables in final energy consumption, which suggests that prior experience

Table 3. OLS results.

Covariates	Coefficients (standard errors)
Climate resilience (ND-GAIN)	.018 (.023)
Share of renewables in final energy consumption (%)	.013 (.005)**
Share of imported carbons in total carbon consumed (%)	.016 (.011)
Share of exported carbons in total carbon produced (%)	-.003 (.008)
GHG emissions, logged	.054 (.230)
GDP, logged	-.004 (.225)
GDP per capita, logged	.014 (.279)
Environmental treaty ratification score	-.128 (.190)
Core civil society index	.675 (.457)
EU membership	-.285 (.385)
Europe and Central Asia, region	.873 (.422)**
Latin America and Caribbean, region	-.258 (.385)
Middle East and North Africa, region	-.406 (.473)
North America, region	.573 (.686)
South Asia, region	-.628 (.460)
Sub-saharan Africa, region	-.715 (.412)*
Constant	-1.737 (3.824)
Adjusted R-squared	.439
N	96

Note: HC4 standard errors with regional clusters are reported in parentheses.

**-p < .05

*-p < .1

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with decarbonization and perhaps even the political clout of the renewable sector could support future mitigation commitments. Given that the share of renewable energy in total energy consumption is conducive to GHG mitigation in various settings [37], we suggest that countries with a higher share of renewable energy in final energy consumption are more capable of delivering the outcome of NZEPs, which may motivate them to announce more stringent NZEPs. This result supports the view that countries with more stringent NZEPs are not engaging in a mere cheap talk: Climate leaders that enjoy deeper decarbonization are also making substantial progress in their NZEP stringency.

Among other covariates, imported carbon is not a statistically significant factor. This is an important finding because countries have reduced territorial emissions simply by importing carbon-intensive products instead of producing them at home [38]. Such countries arguably should be motivated to commit to stringent NZEPs. Yet, they are not. The active discussions about a carbon border tax might imply that carbon leakages are becoming a less viable strategy for countries to meet their decarbonization targets. Similarly, we find the share of exported carbon in total domestic emissions does not have a statistically significant association with NZEP stringency. For example, one might expect that OPEC countries with high levels of exported carbon emissions might have high NZEP stringency because their territorial emissions are a fraction of their exported emissions. Yet, we find no such association.

Neither economic development nor the size of the economy is associated with NZEP stringency. Moreover, we do not find embeddedness in international environmental treaties or the robustness of civil society to be associated with NZEP stringency either. This suggests that the level of decarbonization is the most relevant factor relative to domestic and international sources of pressure for stringent NZEPs.

5. Conclusion

While rising carbon emissions and temporary increases in oil and gas prices are undermining the Glasgow momentum towards mitigation, countries, and companies alike recognize the scale of the climate crisis. The climate community needs to motivate them to accelerate decarbonization, and NZEP is a powerful tool in this regard. Arguably, policy actors should closely monitor the NZEPs of the top emitters so that their lobbying and advocacy can have the biggest impact on global decarbonization.

Recognizing that we report only associational and not causal relationships, the key finding is that renewable leaders are associated with more stringent NZEPs. This attests to the political challenge to decarbonization. Decarbonization creates a non-excludable global public good. Starting with the Kyoto Protocol, countries have agreed to international (and regional) agreements to reduce greenhouse gas emissions. Yet, the mechanisms to enforce these commitments are weak, prompting fears of free riding by countries. Moreover, based on the principle of “shared but differential responsibility” which reflects historical contributions to the accumulated stock of greenhouse gases (as opposed to current emissions), large developing countries, namely China and India, the Kyoto treaty did not mandate them to reduce emissions (they could do so voluntarily). But over the last two decades, both these countries have emerged as top carbon emitters, which has prompted a domestic backlash against decarbonization, especially among fossil fuel communities in developed Western countries. Further, mitigation policies such as carbon taxes and cap-and-trade, are imposing costs on specific sectors and communities, promoting additional backlash to climate mitigation policies.

Yet, some countries have been able to overcome this opposition and embark on decarbonization. For them, renewable energy is meeting a rising share of their energy needs. Because these countries tend to be associated with more stringent NZEPs, it raises the concern that the

gap between the climate leaders and climate laggards might widen over time. This is a cause of worry if major emitters are in the laggard category. According to our examination, China and India, which are the first and the third highest GHG emitters in the world, are included in the bottom-10 country group in terms of NZEP stringency.

Global politics has domestic drivers and domestic politics often takes place in a structural context defined by global power dynamics. Putnam described the interdependence between global and local politics as a two-level game [39]. A key insight from the two-level game framework is that country leaders might extract concessions in international agreements by pointing to the domestic political problems in getting the treaty ratified. Similarly, these leaders could push through contentious domestic policies by invoking international pressures (think of IMF conditionalities and domestic privatization). Arguably, the decision of China and India to sign on to the 2015 Paris Agreement suggests that international pressure might have motivated their leaders to accelerate domestic decarbonization efforts, despite their significant coal deposits.

How have country leaders played the two-level game in the context of NZEPs? Did they invoke international pressure to pledge stringent NZEPs? Or, domestic politics has guided NZEP stringency. Our paper lends support to domestic politics: domestic renewable energy capacity is associated with NZEP stringency. This probably suggests that the creation of a viable and growing domestic renewable sector might be crucial for moving climate laggards to the status of leaders. If domestic resources for this sort of energy transition are not available, international aid could play an important role. While the world is distracted by the Ukraine invasion, and leading western democracies are starting to support fossil fuel projects abroad, these investments could have perverse and unexpected long-term consequences for decarbonization. The reason is that more investment in fossil fuels strengthens the economic and political clout of this sector thereby creating impediments to decarbonization. Perhaps, the Ukraine invasion should prompt the redoubling of efforts for renewable energy abroad, as opposed to its slow retreat in favor of fossil fuels. It is not clear how long the current energy crisis will last and the extent to which, the fulfillment of NZEP targets will be immune to the Ukraine shock. This is an important issue for future research.

Supporting information

S1 Text. List of 124 countries in the order of NZEP stringency. Scores are the object scores derived from the first principal component with signs reverted.
(DOCX)

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