The Vertical Policy Harmonization Indices: Assessing the gap between climate pledges and policies

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Abstract Under the Paris Agreement, addressing global warming entails international mitigation pledges and national policymaking. But do countries adopt climate policies in accordance with their pledges? This paper introduces the Vertical Policy Harmonization Indices, which quantify the gap between a country's nationally determined contribution (NDC) and its national mitigation policies. These indices incorporate three dimensions of climate policymaking: emission reduction targets, the sectors covered by those targets, and the policy instruments introduced to reduce emissions. The Target Index compares the level and scope of reduction targets in the NDCs and national policies of 82 countries, covering approximately 90% of global greenhouse gas (GHG) emissions. The Policy Effort Index incorporates the policy mix of 36 countries, covering over 70% of global GHG emissions. These indices provide avenues to investigate why countries' domestic actions deviate from their international pledges and to evaluate the effectiveness of the progression mechanism as countries update their NDCs.

Keywords: Paris Agreement, Nationally Determined Contributions (NDCs), Pledge and Review, Greenhouse Gas Emission Reduction, Climate Change Mitigation Policy, Policy Mix

Since the adoption of the Paris Agreement, there have been continued calls for countries to increase the ambition of the climate change mitigation pledges in their Nationally Determined Contributions (NDCs) to close the gap between countries' NDCs and global temperature goals. In addition to this "emissions gap", there is an "implementation gap" as countries' current national policies are insufficient to reach the mitigation pledges outlined in their NDCs (Lee et al. 2023). Among the many challenges hampering the ability of the global regime to address climate change is the slow and insufficient translation of international pledges into national laws, strategies, plans, and policies for the reduction of greenhouse gas (GHG) emissions (hereafter referred to as national policies). To limit warming to 2˚C, if not 1.5˚C, countries must not only close the emissions gap but also vertically harmonize increasingly ambitious international pledges with their national policies. But to what extent are countries' current NDCs and national policies harmonized?

To answer this question, we present two Vertical Policy Harmonization Indices. These take three key dimensions of mitigation policymaking into account: *compliance emissions* which refer to the level of emissions countries aim to achieve under their GHG reduction targets (hereafter referred to as targets), *scope* which captures the sectors covered by those targets, and *policy mix* which relates to the portfolio of policy instruments introduced to reduce emissions (Figure 1). The Target Index straightforwardly compares the level and sectoral scope of the targets in the NDCs with those in national policies. Building on this, the Policy Effort Index evaluates the credibility of the targets by incorporating a qualitative assessment of countries' climate policy mix applicable to each economic sector category. The two indices thus vertically compare a country's NDC as submitted to the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) and its climate policy introduced at the national level.

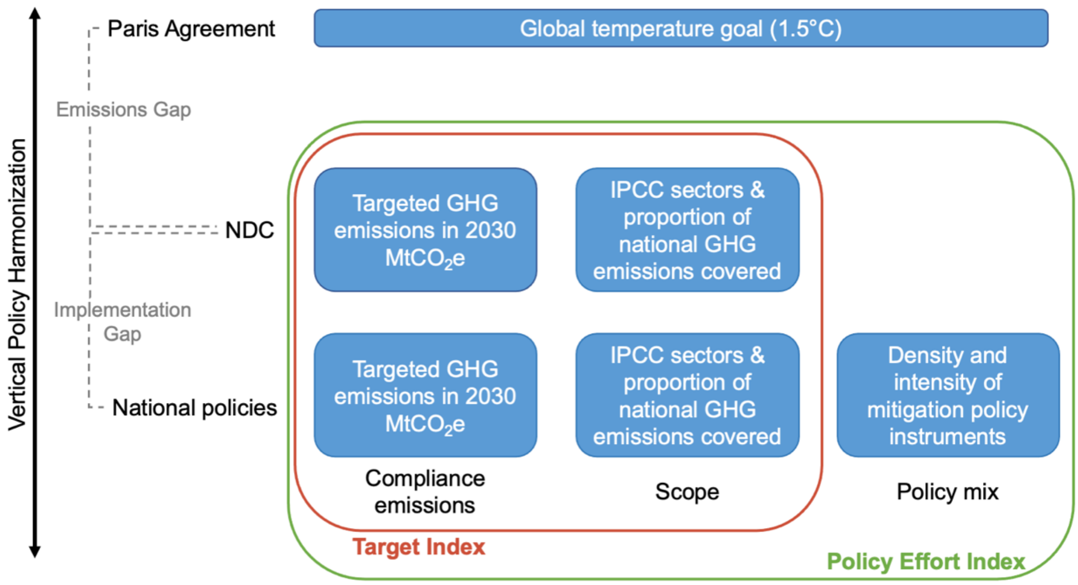
Why do we need these new indices? There are already several indices that measure mitigation performance, including the Climate Change Performance Index (CCPI; Burck et al. 2018), the C3-I (Bernauer and Böhmelt 2013), and the Climate Action Tracker (CAT). While the CAT and CCPI are widely used in the climate policy community, both are complex, rely on expert knowledge, and are relatively opaque regarding the methodological approach and assumptions taken. Additionally, they focus on comparisons of countries' performance in relation to one another (see, e.g., Iyer et al. 2018) rather than a country's performance between its own commitments and national implementation. We thereby contribute to the literature that studies the implementation gap between international commitments and national policies (Baker 2023; Brandi, Blümer, and Morin

2019; Schaub et al. 2022; Rogelj et al. 2023; Victor et al. 2022), facilitating the systematic scrutiny of this gap and strengthening our comparative knowledge of how well the international community is on track in implementing the Paris Agreement.

Other research assessing national implementation of the Paris Agreement relies on complex modelling tools and tends to focus on a small set of countries or regions (Roelfsema et al. 2020; den Elzen et al. 2019), or applies over-simplified assumptions regarding the policies adopted to implement NDCs (Staub-Kaminski et al. 2014; van Vuuren et al. 2020). In contrast, the Vertical Policy Harmonization Indices are developed using a public policy approach (Howlett and Cashore 2014) and rely on objective indicators and few assumptions. In particular, the Target Index relies only on the highly visible targets in NDCs and national mitigation policies and on publicly available emissions data. This allows us to develop a large dataset without needing rich case knowledge and makes the Target Index highly replicable. The Policy Effort Index takes a sophisticated approach by assessing countries' national climate policy mix via a transparent and replicable coding procedure using concepts widely applied by the public policy community (e.g., Schaffrin et al. 2015; Knill et al. 2012; Howlett 2014; Tosun 2013). This information is obtained from the policy documents themselves and is available in the accompanying dataset.

Hence, instead of comparing the adopted targets or policies and their projected effects on emissions, as commonly done in mitigation performance studies (Eskander and Fankhauser 2020; Holz et al. 2018; Peters et al. 2017; Robiou du Pont et al. 2017; Aldy et al. 2016), our indices perform a policy-oriented comparison with a particular emphasis on the national policy mix (Flanagan et al. 2011; Capano and Howlett 2020). This has several advantages. First, it allows us to assess what decision-makers can directly influence. Changes in emissions, in contrast, are influenced by a myriad of factors including weather patterns, geopolitical circumstances, or financial and energy crises (e.g., Iyer et al. 2017; Peters et al. 2023; Bernauer and Böhmelt 2013). Second, the Vertical Policy Harmonization Indices facilitate cross-country comparisons despite countries' diverse socio-economic and institutional characteristics. And finally, the indices can be easily replicated and updated.

Figure 1 Illustration of the Vertical Harmonization Indices



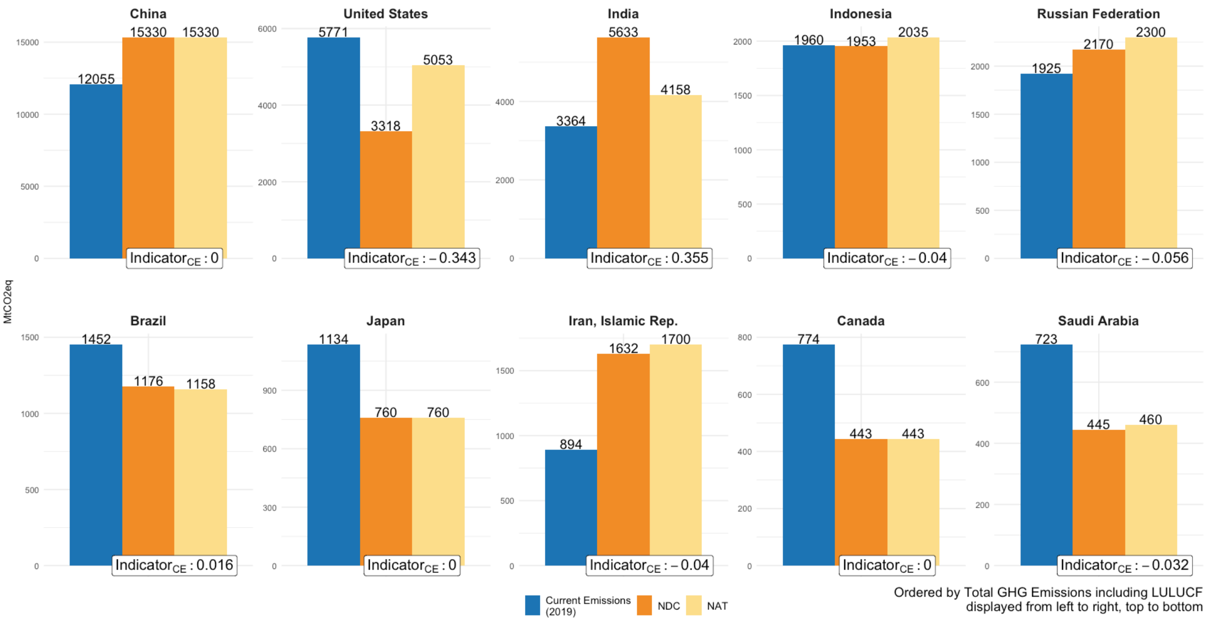
To construct the Vertical Policy Harmonization Indices, we conduct document-based coding of countries' NDCs and policy documents. Countries' latest NDC submissions and most recent national policy documents are used to extract the required information for the compliance emissions, scope, and policy mix indicators. We aggregate these indicators into two indices: the Target Index covers 82 countries that represent over 90% of global GHG emissions, and the Policy Effort Index covers 36 countries and over 70% of global emissions. The Online Methods offer further information on the sample, data collection and calculation procedures.

Results

Compliance Emissions

Figure 2 compares GHG emission levels in 2019 (World Resources Institute 2022) to the calculated compliance emissions in 2030 under the NDCs and the national policies of the top 10 GHG emitters. While for most of the top emitters the NDC and national targets are (almost) aligned with each other, the national target in the US leads to considerably higher emissions than its NDC. The reason for this discrepancy is that only federal policy with a quantified GHG reduction target (*the 2021 Executive Order on Tackling the Climate Crisis at Home and Abroad*) only covers the electricity sector. In contrast, India's NDC target results in more emissions than its national policy scenario. While India has not inscribed a target in national policy yet, a business-as-usual projection of its emissions up to 2030 is lower than the estimated emissions under the NDC target. This is in line with India's emphasis on equity and development and its unwillingness to commit internationally to an ambitious target, while domestically it has implemented ambitious renewable energy plans (Sokołowski 2019).

Figure 2 Compliance and Current Emissions (Top 10 GHG Emitters)

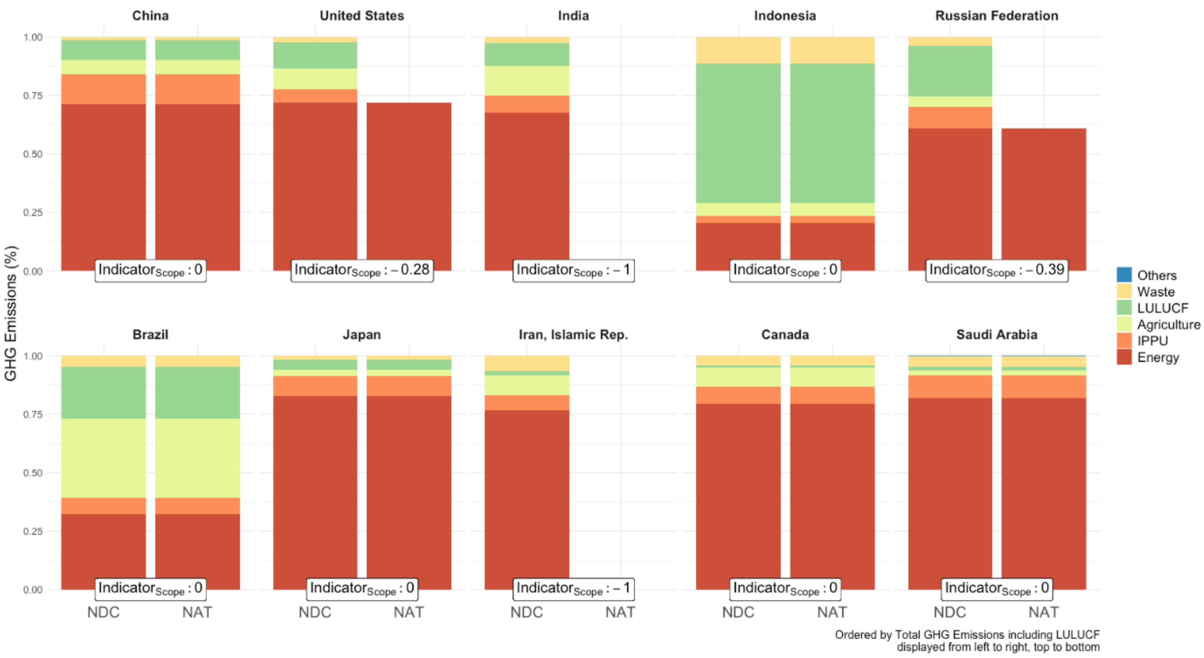


In the overall sample (see the accompanying dataset), we see that several EU member states have set higher or more encompassing targets at the national level than those under the EU's climate change regime. The EU's climate change regime is complex and characterized by collective action and burden sharing at various levels; see Online Methods for further information. Many of the countries whose national targets result in higher emissions relative to their NDC targets are in the Global South. Many of these countries have not yet reflected their NDC targets in national policy documents. Otherwise, a frequent source of disharmony is the different treatment of emissions from land use, land-use change, and forestry (LULUCF) in the NDC and the national targets.

Scope

Figure 3 shows the targets' scope for the top 10 emitters. Amongst both the top emitters and the overall sample, approximately half of the countries have a fully harmonized scope, an indication that the reduction targets outlined in their NDCs and national policies cover the same economic sectors and proportion of total GHG emissions. Discrepancies in the scope indicator result from countries' in- or exclusion of the LULUCF sector and the tendency for some countries (e.g., Russia, United States) to focus their national-level targets on the energy sector. Moreover, some countries (e.g., Bolivia, India, Iran, Qatar) have not yet inscribed any targets in national mitigation policy documents. Others have general climate plans and policies for specific (sub-)sectors, but without explicitly formulated targets.

Figure 3 Scope (Top 10 GHG Emitters)

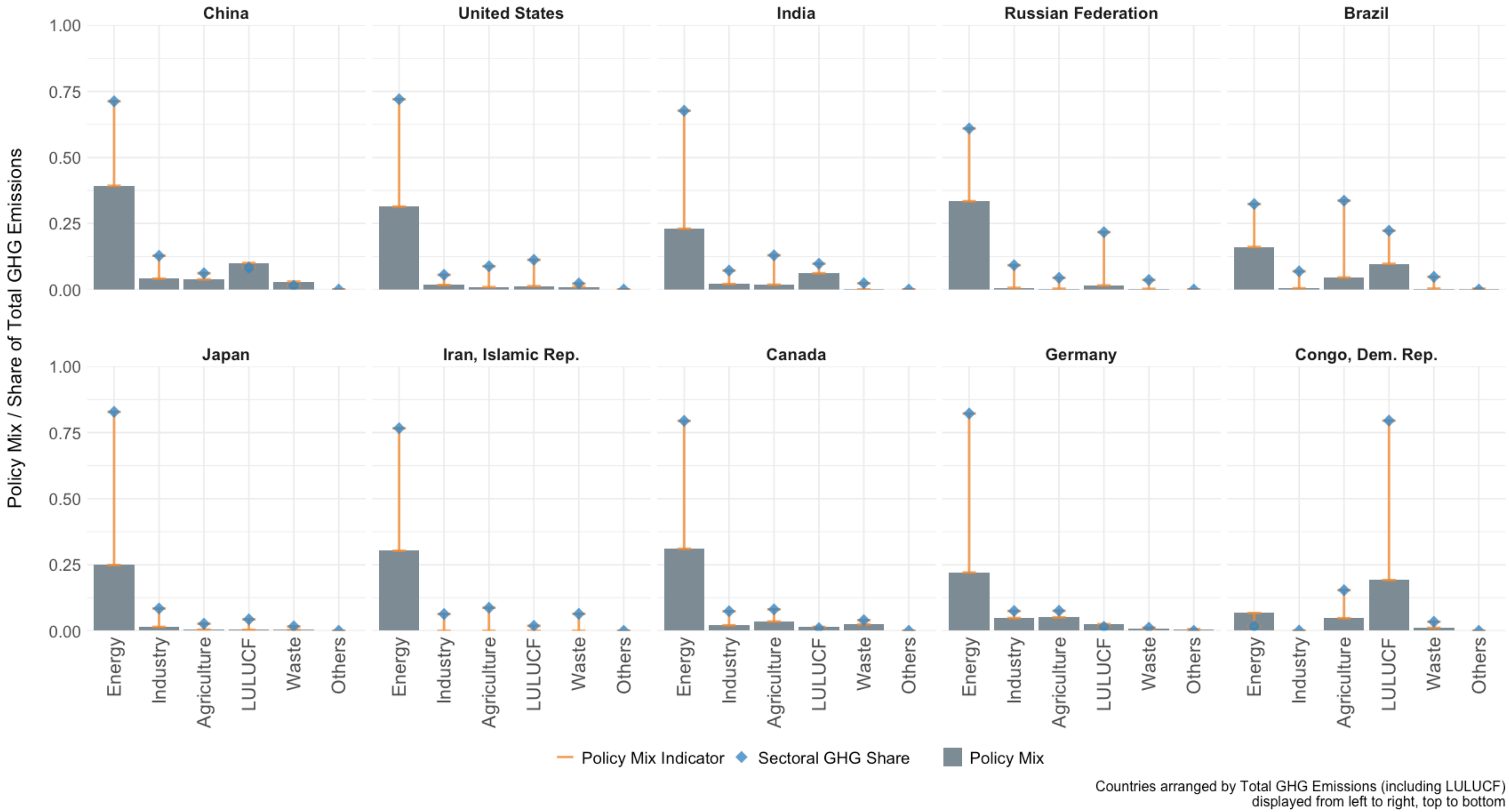


Policy mix

Aligning targets and scope is just one first step towards implementing the NDCs. Meeting defined targets requires concrete policy instruments that constitute the tools to achieve those overarching objectives (Howlett and Rayner 2007). In complex and cross-sectoral policy domains like climate change, it is a policy mix and thus a broad portfolio of instruments that is introduced to reach defined targets (Axsen et al. 2020). The relevance of such policy mixes becomes evident in different fields such as sustainability transitions (Rogge and Reichardt 2016), environmental economics (Lehmann 2010), or policy sciences (Capano and Howlett 2020). Thus, our third indicator consists of policy mixes assessed as a function of density and intensity (Schaffrin et al. 2015). Density refers to the number of policy instruments in the mix and intensity relates to the quality of those policy instruments (Schaffrin et al. 2015). We operationalize a policy instrument's intensity as a function of *instrument type* and *implementation*. The *instrument type* indicates the degree of coerciveness of a policy instrument (Fernández-I-Marín 2021; Metz and Glaus 2019). *Implementation* captures procedural aspects that indicate the likelihood of the instrument's concrete implementation (Howlett 2004; Flanagan et al. 2011). As opposed to other scholars relying on aggregate measures of the density and intensity of policy mixes (e.g., Schaffrin et al. 2015; Knill et al. 2012), we operationalize this indicator at the sector level, and contrast it with the respective sector's GHG emissions share.

Figure 4 presents the results for the top 10 emitters for which we have the policy data. The dots represent countries' sectoral share of GHG emissions, the bars display the sectoral policy mix, and the line shows the gap between each sector's policy mix and its share of GHG emissions. In most countries, the energy sector generates the largest share of GHG emissions. However, the agriculture and LULUCF sectors generate the largest share of emissions in Brazil and the Democratic Republic of Congo, respectively. With Brazil as a key exception, our analysis suggests that most countries have more dense and intense policy mixes in the sectors that have the largest share of emissions. That is, there is a relatively good alignment between the sectoral policy mixes and the sectoral share of emissions. These findings are consistent with conclusions presented in the IPCC's sixth Assessment Report, which state that "policy coverage is uneven across sectors and remains limited for emissions from agriculture and industrial materials" (Lee et al. 2023, 19). Nonetheless, many policy instruments have low levels of coerciveness or a low quality of implementation across all sectors. For this reason, the actual rating of the policy mixes is generally low.

Figure 4 Sectoral Policy Mix (Top 10 GHG Emitters with data)



The Vertical Policy Harmonization Indices

Countries' level of vertical harmonization under the Target Index is the average of their compliance emissions and scope indicator scores. Under the Policy Effort Index, the policy mix indicator is used as a sector-level weight in the calculation of the compliance emissions indicator; see the Online Methods for details on the calculation. Figures 5 and 6 show the (dis)harmony between countries' NDCs and national policies as assessed under the Target and Policy Effort indices. Positive values indicate that countries' national targets are more stringent than those outlined in their NDCs; negative values the inverse and a value of 0 means that the NDC and national policy target (including the effect of the policy mix) are the same.

Figure 5 Target Index

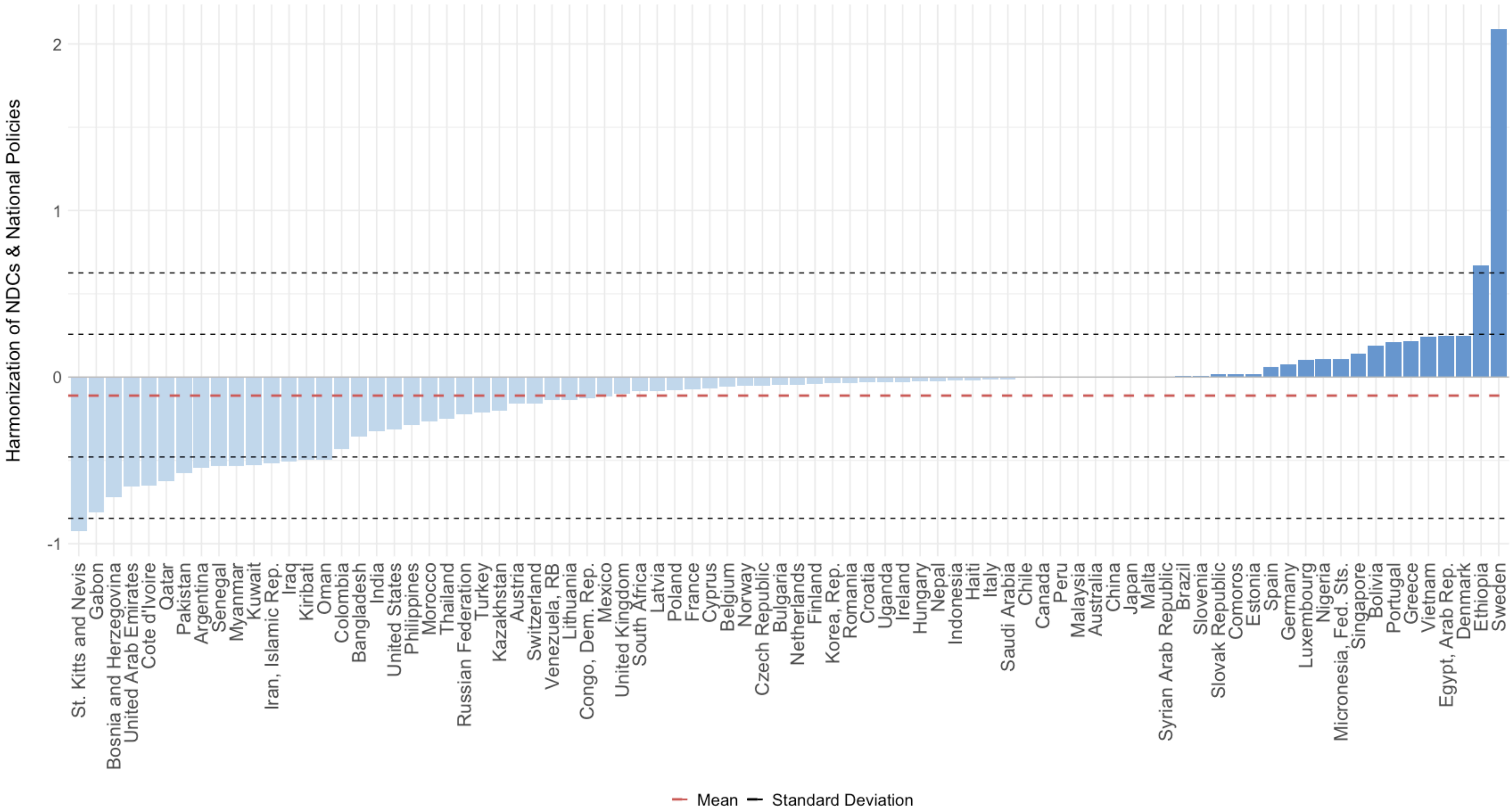


Figure 6 Policy Effort Index

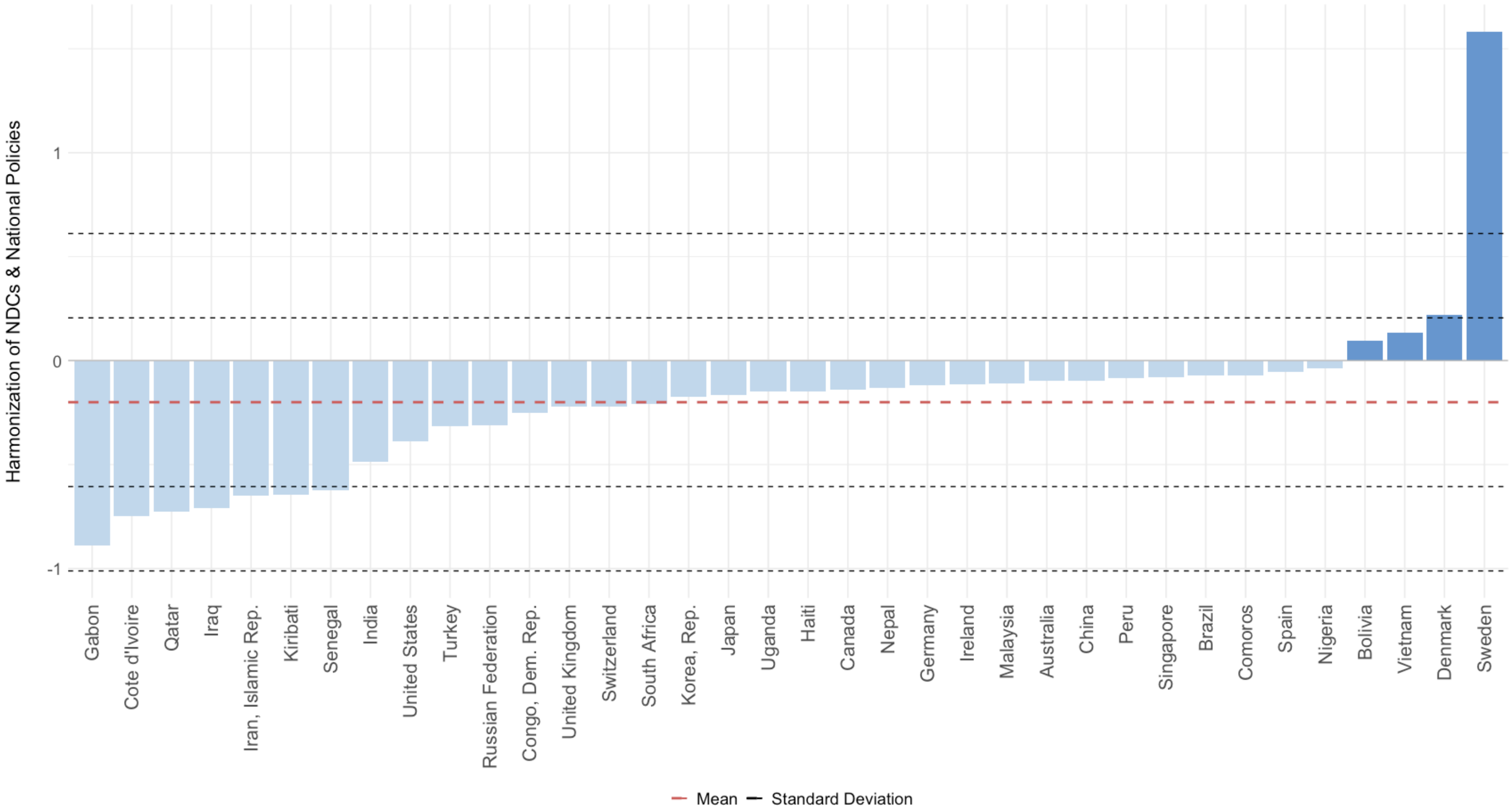


Figure 5 shows that the mean value under the Target Index is negative, indicating that countries' national targets tend to be less ambitious or narrower than the targets outlined in their NDCs. However, 20 countries have positive values which indicates that their national targets are more ambitious and/or more encompassing than the ones in their respective NDCs. It is notable that many of these countries are members of the EU; as previously mentioned many EU countries included more comprehensive targets at the national level than those under the EU climate change regime. This is the case in Sweden, as its National Energy and Climate Plan includes significant reductions in the LULUCF sector to the extent where its national level compliance emissions are far lower than the compliance emissions estimated under its international pledges. With a few exceptions, most covered countries in the Global South have a negative value in the Target Index, indicating less ambitious and/or less encompassing national level targets relative to their NDC targets. As explained above, many developing countries have not yet inscribed the NDC targets in national policy documents.

Under the Policy Effort Index (Figure 6), countries' overall harmonization scores decrease. Now, only 4 countries have a positive value and two of these countries are EU member states; this is unsurprising as the EU provides "particularly fertile ground for climate leadership/pioneership" (Wurzel et al. 2019, 4). That is Denmark and Sweden do not exhibit gaps in their policy mixes that are large enough to undermine the credibility of their national level targets. This is in line with their historic positions as climate leaders (Jänicke and Wurzel 2019; Andersen and Nielsen 2016). Germany and Spain, however, switch from having more stringent national level commitments under the Target Index to falling short of their international pledges under the Policy Effort Index. Although this runs counter to Germany's widely perceived position as climate policy leader (e.g., Wurzel et al. 2019; Jänicke and Wurzel 2019) and Spain's emergence as an active actor in climate policy (Costa 2006; 2010), both countries having a substantially weak policy mix in their energy sector, which accounts for most of their GHG emissions.

Among the top 10 GHG emitters, the US, China, and India all have a negative value in the Policy Effort Index, with the US still the furthest away from meeting its goals. As pointed out above, the US's national level target is not in line with its NDC target. Its policy mix relies strongly on economic incentives and federal investments to promote diffusion of clean technologies. While these achievements of the Biden administration are a substantial improvement to previous policy (see, e.g., Bomberg 2022; Jotzo et al. 2018), they are not yet sufficient to meet the US's NDC goals (Larsen et al. 2022). In contrast, China's NDC target, a combination of an intensity and a peak target, is much less transparent as the resulting level of emissions is contingent on other uncertain variables such as expected GDP growth. However, the exact same target has been inscribed in national policy, leading to a fully harmonized Target Index. When including the policy mix, the harmonization score under the Policy Effort becomes negative. These findings are in line with recent research that suggests China will be able to meet its NDC targets, but also identifies several policy gaps that will need to be addressed (Gallagher et al. 2019).

5. Discussion and Conclusion

In this paper, we presented an effort to systematically and transparently quantify the gap between countries' international mitigation commitments and national policies. The Target Index is based on a country's compliance emissions and the scope of the targets and the Policy Effort Index takes countries' national policy mixes into account. Following the public policy literature (Knill et al. 2012), our policy mix indicator broadly characterizes the level of coerciveness introduced by a policy instrument, as well as the likelihood that it is implemented. Both indices are highly replicable, easy to update or expand to a larger sample. The dataset, including both the indicators' values and countries' harmonization scores, as well as a rich description of the methodology accompany this article.

Our analysis provides some insights regarding the national implementation of the Paris Agreement. The Target Index shows that over a quarter of the sample, accounting for 45% of global emissions, have translated their NDC targets to national policies that are either in line with or even more ambitious than the NDC target. Yet, the Policy Effort Index shows most countries, accounting for 70% of global emissions, fall short of their targets once the policy instruments, that are implemented to achieve those targets, are taken into account. Actual implementation requires appropriate instruments that establish sufficient incentives for the economy to reduce emissions. As of yet, such instruments appear not to be sufficiently in place. However, it is important to notice that an "insufficient" policy mix does not necessarily signal an unwillingness to implement one's NDC. Different countries may still be at different stages of the policy process. In our sample, we have seen that although several countries have detailed national plans, framework laws, and institutions for addressing climate change, they have yet to adopt concrete instruments to reduce their emissions. This is particularly relevant to countries of the Global South. While some countries lack policy instruments, they have detailed plans to invest in clean energy infrastructure in the next five to ten years. Such investments are expected to significantly contribute to achieving the countries' targets. Nonetheless, in many cases the realization of such investments is at least partly dependent on external financial support, given that many NDCs of the Global South are partly conditional on receiving international climate finance (Pauw et al. 2020). As such, our indices only consider the unconditional commitments of countries' NDCs.

These indices and their underlying data open the door for further research on, for example, the reasons why countries' domestic actions may deviate from their international pledges. In addition, they offer new evidence that can be used to further enrich existing modelling efforts. This is especially relevant in assessing the effectiveness of the "ratcheting up" process of NDCs over time that is a cornerstone of the Paris Agreement's approach to achieving its long-term ambition.

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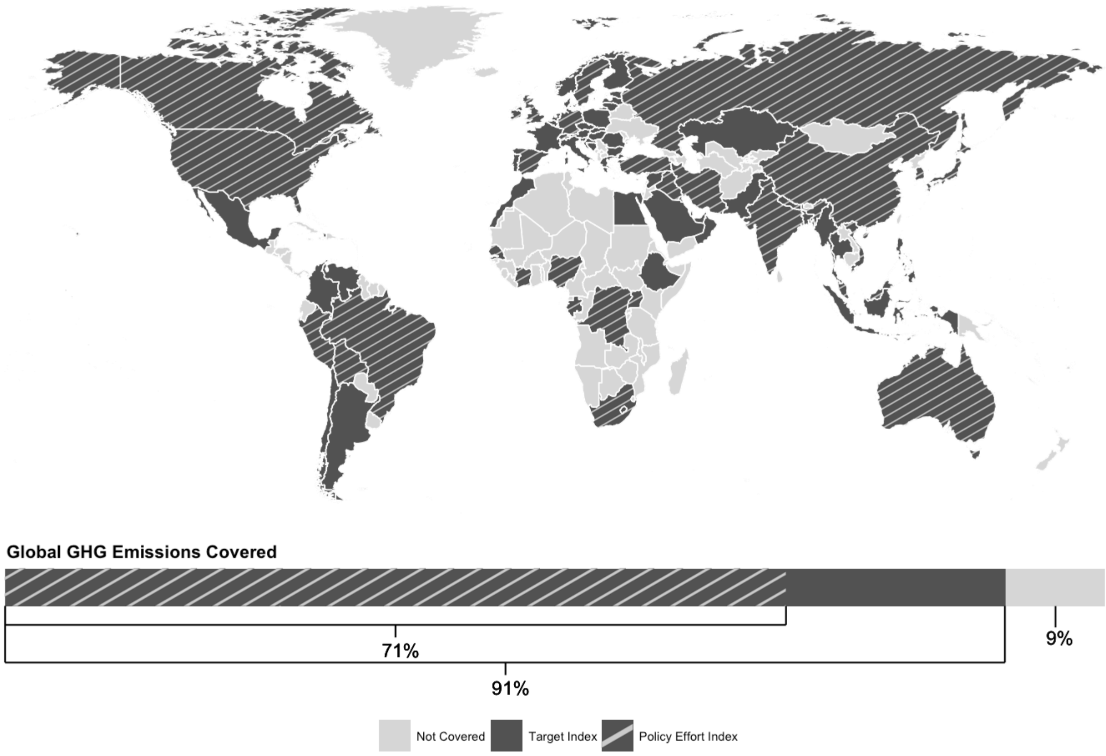
Methods

Sample of countries

Countries' contribution to global greenhouse gas (GHG) emissions was the primary criterion in case selection for both the Target and Policy Effort Indices. While the Target Index covers 91% of global GHG emissions, the Policy Effort Index covers 71% (Figure M1). A total of 82 countries were coded for the Target Index and 36 countries for the Policy Effort Index. Figure M1 shows that our sample, particularly under the Policy Effort Index, covers only a handful of countries in Africa. This does not warrant immediate concern given the largest emitters in Africa (e.g., the Democratic Republic of Congo, Nigeria, South Africa) are covered under both indices and the continent accounts for a relatively low share of global GHG emissions.

Figure M1. Countries and Global Emissions Covered



Sample of national policies

To construct the Target and Policy Effort indices, we conducted content-based coding of countries' Nationally Determined Contributions (NDCs) and national mitigation laws, policies, plans, or strategies (hereafter referred to as national policies). Both indices focus on mitigation, therefore we excluded adaptation policies from the coding process. To calculate the compliance emissions and scope indicators, we used countries' latest NDC submissions and flagship national policies. For the purpose of this study, we considered a country's flagship national policy to be its most current mitigation policy with the most comprehensive GHG reduction target. It was often, yet not always, the case that this was a national policy with an economy-wide target.

To code the policy mix necessary to construct the Policy Effort Index, we took a comprehensive approach to determine the relevancy of countries' national policies. On a case-by-case basis, we looked for the national policies mentioned in a country's NDC and consulted the Climate Change Laws of the World and ECOLEX databases. We then cross-referenced this list with other sources (e.g., a policy's inclusion in Climate Watch's Compare All Targets or its characterization as a high impact policy in the Climate Policy Database of NewClimate Institute; in see Table M1) to compile a comprehensive dataset of national policies and to access the policy documents or briefs. In a next step, we looked at the application period and the status of the national policy. If the national policy has ended in the past or no longer in place (i.e., not yet in force, or repealed) it was excluded from the coding process. Following this procedure, the comprehensive dataset of national policies used in the coding process includes policy instruments that are in force and contribute to climate change mitigation (e.g., energy security, energy efficiency, energy security, forest management).

Further, we considered the accessibility of policy documents during case selection. Specifically, whether policy documents could be found either as a full text or comprehensive summary from credible sources (e.g., sources listed in Table M1, webpages of government ministries) in either English, French, German, or Spanish. For policy documents that were only accessible in languages in which none of the co-authors or research assistants were sufficiently competent, we used translation tools such as DeepL and Google Translate.

Table M1 Sources

Indicator(s)	Name	Source
Compliance Emissions, Policy Mix	NDC Registry	UNFCCC: link
	Climate Change Laws of the World	Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law: link
	ECOLEX	Food and Agriculture Organization; International Union for Conservation of Nature; United Nations Environment Programme: link
	Climate Policy Database	NewClimate Insitute: link
	Climate Watch: Compare All Targets	World Resources Institute: link
	Climate Action Tracker	Climate Analytics; NewClimate Institute: link
	Asia Pacific Energy Portal	United Nations: link
	National Energy and Climate Plans	European Comission: link
Scope	UNFCCC GHG Inventory	UNFCCC: link
	Climate Watch: Historical GHG Emissions	World Resources Institute: link

Coding and calculating the indicators

In the following, we outline our approach for developing the Vertical Policy Harmonization Indices and the procedure for coding and calculating the compliance emissions, scope, and policy mix indicators. On the basis of the compliance emissions and scope indicators, the Target Index compares countries' targets as presented in their NDCs to the targets presented in their national policies, and the Policy Effort Index complements this assessment by evaluating the credibility of the national policy mix by incorporating the policy mix indicator.

Compliance Emissions

Compliance emissions are defined as the amount of GHGs (in megatons of carbon dioxide equivalent, $MtCO_2e$) that a country will emit in the target year if it complies with the target outlined in its NDC or national policies. To calculate compliance emissions, we proceed in three steps.

In a first step, we identify the quantified GHG reduction targets in a country's NDC and flagship national policy. For most countries, we were able to identify an unconditional GHG reduction target communicated in countries' NDCs. Some developing countries formulate conditional GHG reduction targets (for more information see Taibi et al. 2020). For all countries, we take the unconditional GHG reduction target. In some instances, NDCs or national policies contain a ranged GHG reduction target (e.g., 50 to 52%). In these cases, we take the lower (i.e., less ambitious) end as harmonization is achieved in practice when a country reaches the lower end of its stated level of commitment. Moreover, this approach ensures consistency in calculating countries' compliance emissions.

This procedure was followed to identify countries' quantified GHG reduction targets in all but three exceptional cases, which we detail here. The first exceptional case relates to whether a country's NDC or national policy does not contain a quantified GHG reduction target. In such cases, we take the projected emissions for 2030 under a business-as-usual (BAU) scenario as the NDC's or national policy's compliance emissions. In the instance that there is a quantifiable target, but it is not expressed explicitly as a reduction of GHGs (e.g., renewable energy targets, energy efficiency targets), we also take the projected BAU emissions for 2030. We do not derive compliance emission values from such targets given that estimating their foreseeable effect on GHG emissions requires additional assumptions that potentially reduce transparency. By focusing on explicit GHG reduction targets we reduce the need for external assumptions. Projections of BAU emissions are taken whenever possible from countries' NDCs or national policies, and otherwise from secondary sources such as the Climate Action Tracker. If projections differ between countries' policy documents and secondary sources, we defer to countries' own projections, if applicable.

Furthermore, there are exceptional cases in which the target year of the GHG reduction target in a country's NDC and national policy do not match. Here, we either take the projected BAU emissions or conduct a linear interpolation. In cases when the target year of the national level target is before the NDC target, we take the projected BAU emissions for 2030 as the national policy's compliance emissions. If the target year of the national level target is later than that of the NDC target, we conduct a linear interpolation to find the national level compliance emissions for the respective target year. In our sample, all but one country (Nepal) has a target year of 2035 in their NDC and only the United States has a national level target with a target year later than 2030.

The last exceptional case is the EU, as its climate change regime is complex and characterized by collective action and burden sharing at various levels. At the international level, the EU has a collective NDC with a joint GHG reduction target. The EU's effort to meet this joint target is divided at the supranational level under the EU Emissions Trading System (ETS), the Effort Sharing Regulation (ESR) and the Land Use, Land-Use Change, and Forestry (LULUCF) Regulation. The EU ETS has a joint reduction target (i.e., there are no individual reduction targets for each member state) to reduce emissions from the energy installations, industrial activities, and domestic aviation. The ESR includes individual reduction targets for member states to reduce emissions from sectors outside the ETS and the LULUCF Regulation includes trajectory targets limiting net emissions and removals from the LULUCF sector for each member state. At the national level, EU countries are required to develop National Energy and Climate Plans (NECPs) to reach their reduction targets under the ESR. Following this, we take the reduction targets at the supranational level as EU countries' individual international mitigation pledges. Specifically, we calculate international compliance emissions using the joint target of the EU ETS, member states' reduction targets under the recently amended ESR, and member states' trajectory targets under the recently amended LULUCF, see Table M2. At the national level, we follow the same procedure, unless a country has an additional national climate mitigation policy or law (i.e., additional or external to the EU climate change regime) that contains a quantified GHG reduction target. It should be noted that member states' ESR targets at the national level are taken from member's NECPs, which correspond to the GHG reduction targets outlined in the initial ESR.

Table M2 Calculating Compliance Emissions for EU Member States

	ETS	ESR	LULUCF	
International	Joint 43% reduction in GHG emissions covered by ETS by 2030 relative to 2005	Individual reduction target in GHG emissions not covered by ETS by 2030 relative to 2005	net emissions and removals in 2030 to not exceed individual target	
National	ETS	ESR	LULUCF	Additional mitigation policy / law
	Joint 43% reduction in GHG emissions covered by ETS by 2030 relative to 2005	Individual reduction target as outlined in NECP	net emissions and removals in 2030 to not exceed individual target	reduction target for 2030 as outlined in mitigation policy or law

In a second step, we translate relative GHG reduction targets into $MtCO_2eq$. following the methodology of Ross et al. (2016). This facilitates a comparison between different types of GHG reduction targets that can be found in countries' NDCs and national policies. In their methodology, Ross et al. (2016) distinguish between four different target types: base year targets, intensity targets, BAU targets, and trajectory targets. The translation of targets according to this methodology enables us to compare compliance emission levels resulting from the different target types that we find among the 82 countries analyzed. Please see Box 1 for an example on how to calculate compliance emissions.

Finally, we calculate the compliance emissions indicator ($\text{Indicator}_{\text{CE}}$) by dividing the NDC compliance emissions by the national compliance emissions and subtracting one from this quotient; see Equation (1). Positive values of $\text{Indicator}_{\text{CE}}$ indicate that the target adopted in national policy is more stringent or ambitious than the NDC target. On the other hand, negative values indicate that the NDC target is more stringent than the one in national policy. A value of 0 means that the reduction targets of a country's NDC and national policy result in the same amount of GHGs in the target year.

$$\textbf{Equation (1)}\ \text{Indicator}_{\text{CE}} = \left(\frac{\text{CE}_{\text{NDC}}}{\text{CE}_{\text{NAT}}}\right) - 1$$

Scope

The scope indicator compares the number of economic sectors and the proportion of total GHG emissions that a country's GHG reduction target covers between countries' NDCs and national policies. We follow sector categorizations of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Sánchez et al. 2006). Scope is quantified as the share of the country's total GHG emissions generated in the sectors that covered by the NDC or the national policy target. Concretely, scope is found by assigning 1's to sectors that are mentioned in the NDC or national policy and a 0's to those that are not covered. This binary sectoral coverage is then multiplied by the sector's share of the country's total GHG emissions, taken from the latest GHG inventory report available, and then summed up. A scope score of 1 implies that the NDC or national GHG reduction target covers all economic sectors and all of a country's GHG emissions. See Box 1 for an example.

This assessment is made in relation to the mitigation contribution included in countries' NDCs. If a country's NDC contains a mitigation contribution that is a quantified GHG reduction target, the national-level scope will only reflect the proportion of GHG emissions that are covered by a quantified GHG reduction target. However, if the only mitigation contribution of a country's NDC is a commitment to implementing policies and measures, i.e., not a quantified GHG reduction target, then the national-level scope can reflect the proportion of GHG emissions that are subject to policies and measures, or if applicable the proportion of GHG emissions that are covered by a GHG reduction target. Only three countries (Bolivia, Nepal, Syria) in the entire sample only commit to implementing policies and measures in their NDC.

As in the previous indicator, we take a different approach to assessing the scope of EU member states' GHG reduction targets. As opposed to differentiating between sectors following the IPCC categorizations, we code whether the international and national reduction targets cover sectors participating in the ETS or those that are regulated by the ESR and LULUCF regulations. Following the comprehensive approach to calculate the international and national compliance emissions of EU member states, most member states have a scope score of 1 unless their national level target explicitly excludes the LULUCF sector (e.g., Portugal). That is, the international and national level reduction targets under the ETS, ESR and LULUCF regulation cover all sectors of a country's economy.

The scope indicator ($\text{Indicator}_{\text{Scope}}$) is found by subtracting the scope of the NDC ($\text{Scope}_{\text{NDC}}$) from the scope of the national policy ($\text{Scope}_{\text{NAT}}$); see Equation 2. Positive values indicate that the target set out in a country's national policy covers more sectors, and therefore a larger share of its total emissions, than the NDC target. Negative values indicate the inverse and a value of 0 means that the mitigation targets in a country's NDC and national policy cover the same economic sectors and equal proportion of total emissions.

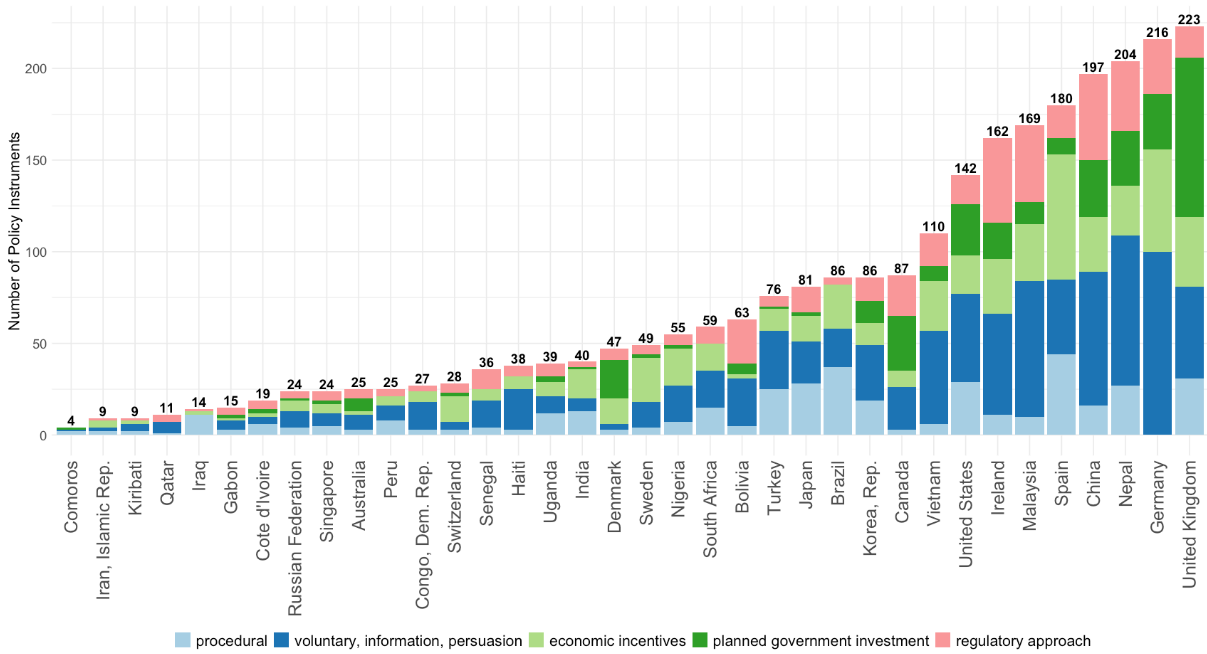
Equation (2) $\text{Indicator}_{\text{Scope}} = \text{Scope}_{\text{NAT}} - \text{Scope}_{\text{NDC}}$

Policy Mix

We measure countries' mitigation policy mix only at the national level, as the specificity of information contained in NDCs regarding policy instruments varies from highly detailed to vague or entirely absent. The operationalization of the policy mix indicator is based on the individual policy instruments implemented in the identified policy documents. We calculate policy density, which refers to the number of policy instruments identified, as well as policy intensity, which relates to "the amount of resources, effort, or activity that is invested or allocated to a specific policy instrument" (Schaffrin et al. 2015, 261).

Deriving values of density is a straightforward task, whereas calculating intensity is an intensive procedure requiring content-based coding. Density is simply the count of individual mitigation-related policy instruments identified across all policies within a country or a sector. Coders identify the economic sector of application based on the targeted activities or subsectors contained in the policy document. Figure M2 displays the total number of mitigation policy instruments and type of policy instruments identified in each covered country.

Figure M2 Total Density by Country



To evaluate intensity, we use two variables: *Instrument Type* and *Implementation*, see Table M3. While the effectiveness of policy instruments depends on the context (Huppes 2001), the level of coerciveness of a policy instrument, identified through its instrument type, already offers information about how strictly the instrument is applied. For example, we consider regulations as the most intense instrument type as they often carry sanctions for non-compliance. *Implementation* refers to the presence of different procedures that increase the likelihood of a policy instrument's successful implementation. The intensity of a given policy instrument is the average value of the instrument type and implementation; see Equation 3.

Equation (3) $\text{Intensity} = \overline{\text{Type, Implementation}}$

We then take the average intensity of all policy instruments in a given sector to arrive at a single value for a sector's policy intensity; see Equation 4.

Equation (4) $\text{Intensity}_{\text{SectorX}} = {\sum \text{Instrument Intensity}_{\text{SectorX}}}/{\text{Density}_{\text{SectorX}}}$

The policy mix indicator is calculated at the sector level and is found by multiplying the given sector's share of density by its average intensity (Equation 5).

Equation (5) $$\text{Policy Mix}_{\text{SectorX}} = \left(\frac{\text{Density}_{\text{SectorX}}}{\text{Total Density}}\right) * \left(\frac{\sum \text{Intensity}_{\text{SectorX}}}{\text{Density}_{\text{SectorX}}}\right) = \frac{\sum \text{Intensity}_{\text{SectorX}}}{\text{Total Density all Sectors}}$$

Table M3 Operationalizing Policy Instrument Intensity

Intensity variables: Instrument-level		
Instrument type (adapted from Huppes 2001; Stavins 1997)		
	0.10 =	procedural measures (refer to policy techniques designed to affect how a policy is formulated and implemented, such as establishing a climate change committee, establishing or strengthening reporting rules, or similar)
	0.25 =	voluntary measures, information, persuasion, R&D funding (refer to the voluntary agreements and the provision of resources, such as training programs, voluntary energy efficiency standards by industry, labelling, funding programs for research projects)
	0.50 =	economic incentives (relate to the use of market-based mechanisms, such as taxes and charges, carbon markets, subsidies, and tax credits)
	0.75 =	a planned government investment (relates to an investment of financial resources with a specified monetary value, for example a budgeted plan for a new hydro power plant)
	1.00 =	regulatory approaches (relate to instruments that are prescriptive or prohibitive, such as performance or technology standards or phase-outs)
Implementation		
	0.00	no statement on implementation is found
	+0.25	an implementation agency is established
	+0.25	there is sanctioning for non-compliance
	+0.25	there is a monitoring procedure
	+0.25	the instrument is strictly applied (i.e., there are no exemptions)

In order to evaluate the quality of the policy mix, we relate it to the share of GHG emissions of the respective economic sector. The idea is that the sectors generating a higher share of emissions will require more policy effort to address those emissions. Our policy mix indicator ($\text{Indicator}_{\text{Policy Mix SectorX}}$) is then calculated by taking the difference between the sector's policy mix and its share of total GHG emissions; see Equation 6. Negative values indicate that the sectoral policy mix is less intense than what it would be expected given the sector's significance. Conversely, positive values indicate that the sectoral policy mix is more intense that what would be expected given the sector's GHG contribution.

Figures M3.1-M3.3 show the sectoral policy mix for all countries (grey bars), compared to the sectoral share of GHG (blue dots). The orange bars illustrate the sectoral policy mix indicator.

Equation (6) $$\text{Indicator}_{\text{Policy Mix SectorX}} = \text{Policy Mix}_{\text{SectorX}} - \text{GHG Share}_{\text{SectorX}}$$

Figure M3.1 Sectoral Policy Mix

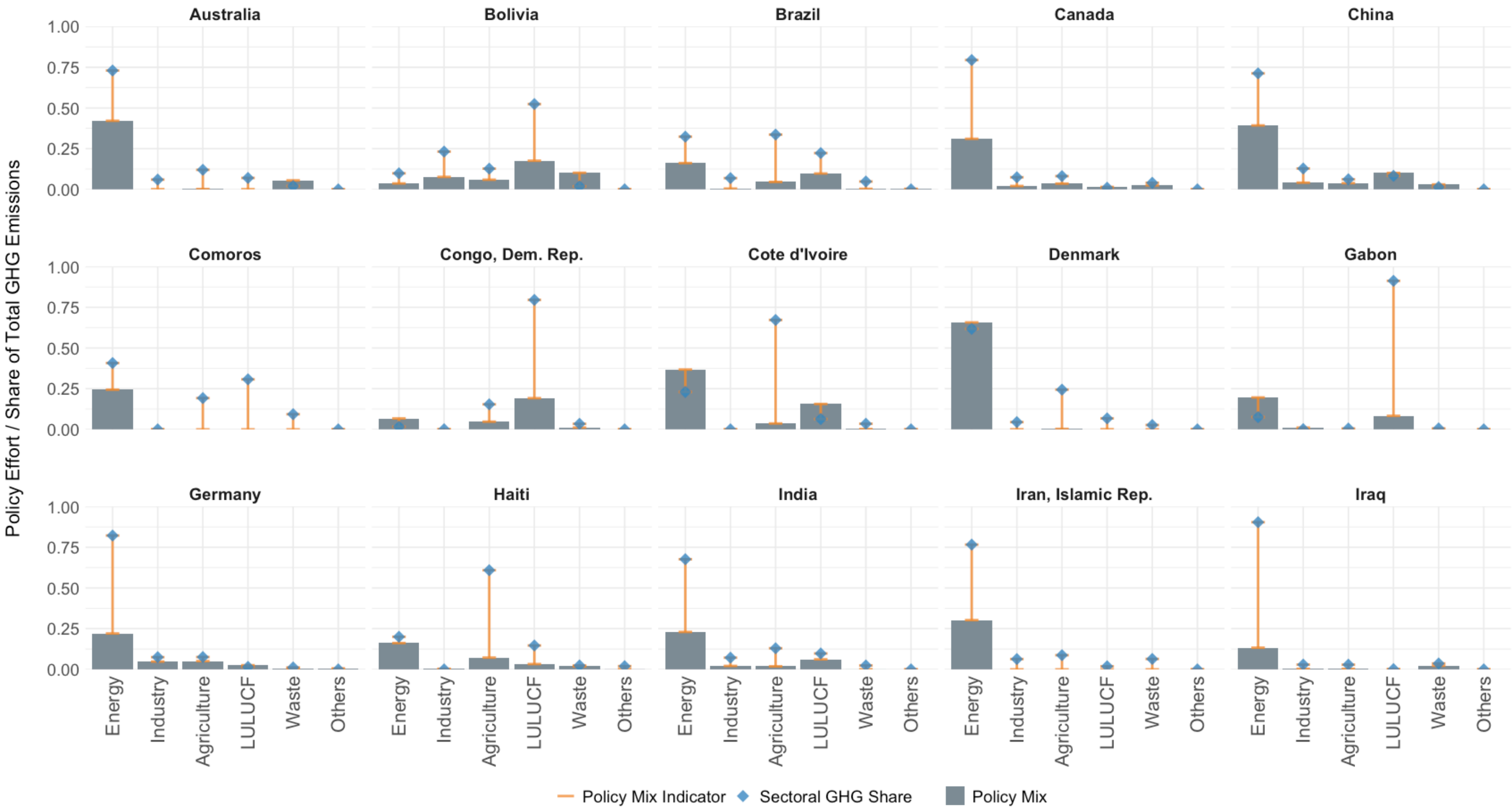


Figure M3.2 Sectoral Policy Mix

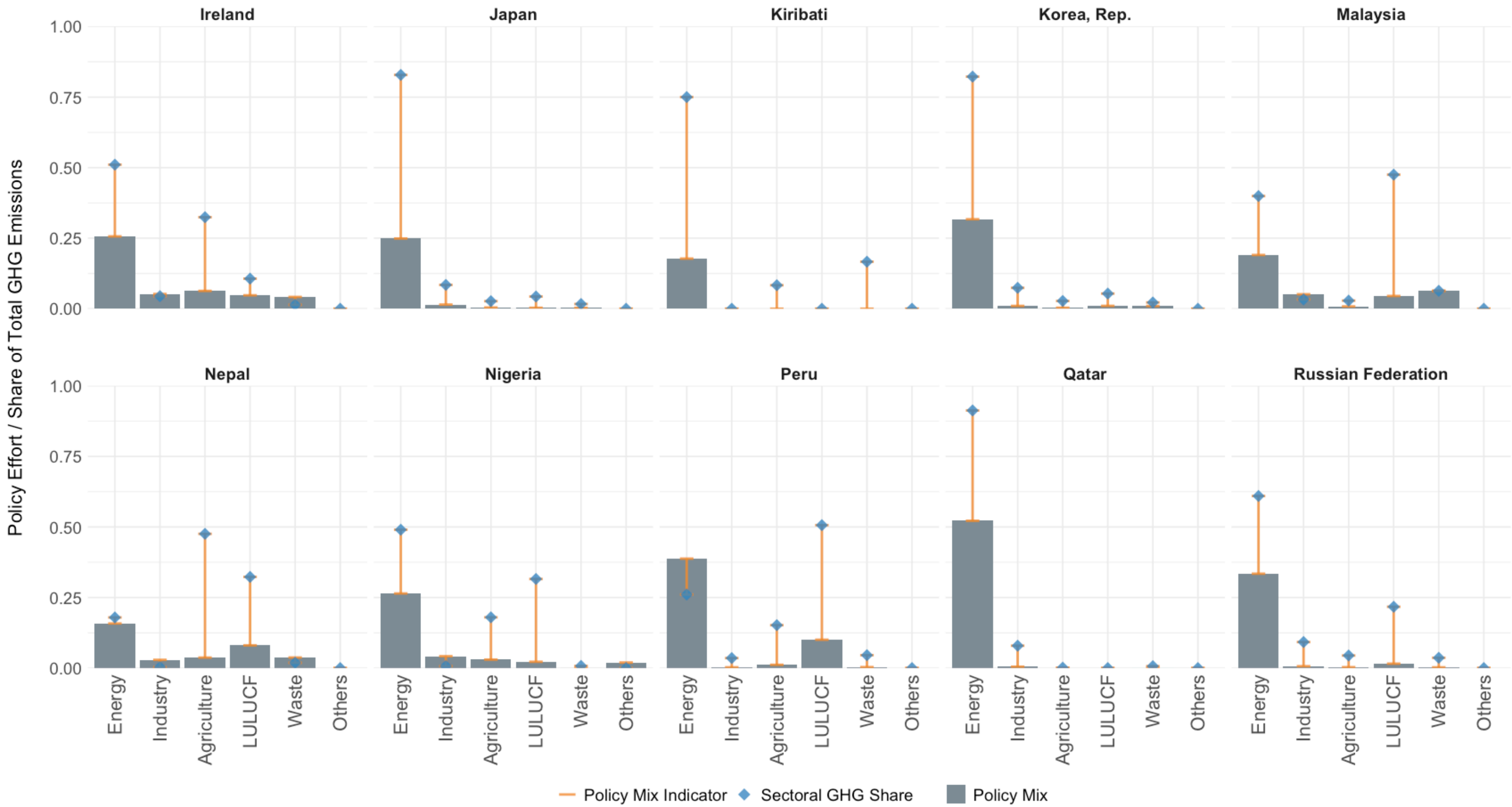
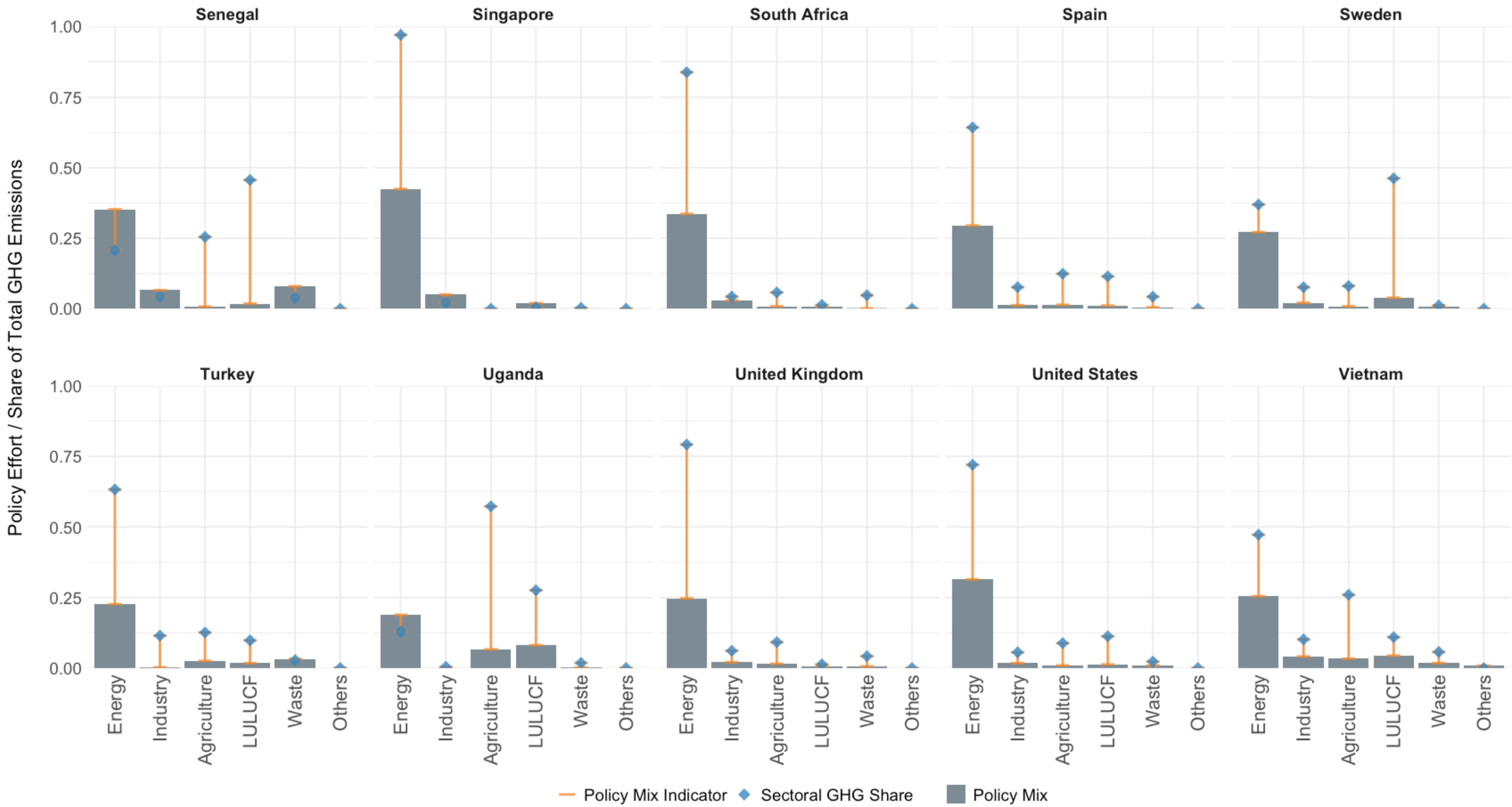


Figure M3.3 Sectoral Policy Mix



Calculating the Vertical Policy Harmonization Indices

Using the indicators described above we construct two indices. The Target Index compares the GHG reduction targets of countries' NDCs and national mitigation policies. The Policy Effort Index builds on the Target Index and incorporates the policy mix indicator to reflect countries' climate policy efforts and how they might influence a country's ability to meet its NDC commitments. Calculating the Target Index is straightforward; see Equation 7. Positive values indicate that countries' national-level reduction targets are more stringent and/or encompassing than those outlined in their NDCs. Negative values indicate the opposite. A value of 0 indicates that the NDC and the national policy targets lead to the same emissions level and sectoral distribution in 2030.

Equation (7) $$\text{Target Index} = \left(\text{Indicator}_{\text{CE}} + \text{Indicator}_{\text{Scope}}\right)\Big/2$$

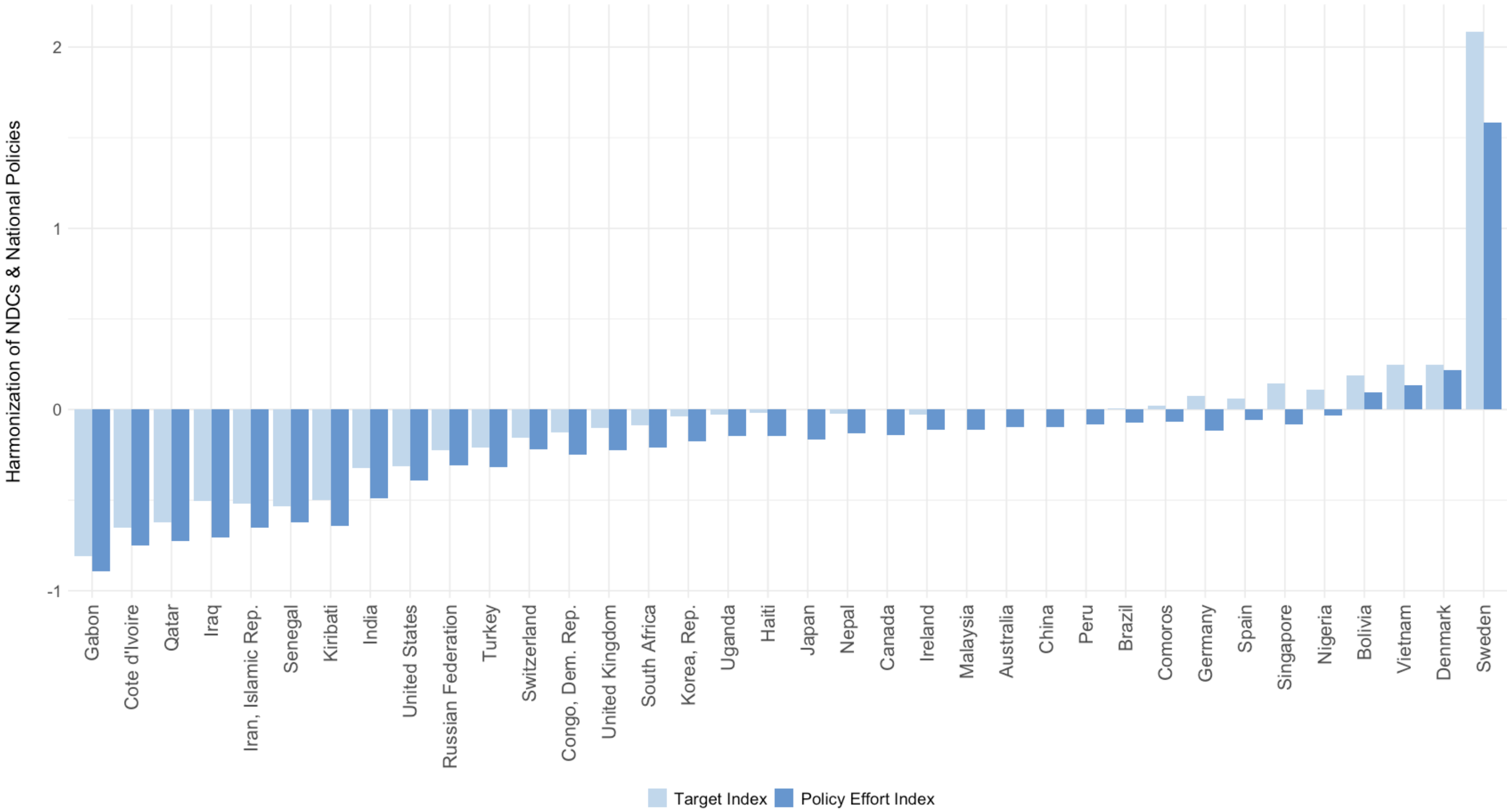
Under the Policy Effort Index, the policy mix indicator ($\text{Indicator}_{\text{Policy Mix Sector X}}$) is used as a sector-level weight in the calculation of the compliance emissions indicator; see Equation 8.

Equation (8) $$\text{Weighted Indicator}_{\text{CE}} = \left(\text{CE}_{\text{NDC}}\Big/\sum\left(\text{CE}_{\text{SectorX}} - \left(\text{Indicator}_{\text{Policy Mix SectorX}} * \text{CE}_{\text{SectorX}}\right)\right)\right) - 1$$

The calculation of the Policy Effort Index is then similar to that of the Target Index, except that we use the weighted version of the national compliance emissions indicator; see Equation 9. Figure M4 compares the harmonization values for each country under the Target and Policy Effort Indices.

Equation (9) $$\text{Policy Effort Index} = \left(\text{Weighted Indicator}_{\text{CE}} + \text{Indicator}_{\text{Scope}}\right)\Big/2$$

Figure M4 Target and Policy Effort Indices



Box 1. Calculating Compliance Emissions, Scope, Policy Mix and Harmonization Scores

Compliance Emissions

Canada's NDC	Canadian Net-Zero Emissions Accountability Act
Canada's NDC: Reduce economy-wide, GHG emissions in 2030 by at least 40-45% below the 2005 emissions	Canadian Net-Zero Emissions Accountability Act: …reduce emissions by 40-45% below 2005 levels
target type: base year	target type: base year
$CE_{NDC} = GHG_{BY} - (GHG_{BY} * \%\ Reduction)$ $738.72 - (738.72 * 0.4) = 443.232\ MtCO_2eq.$	$CE_{NAT} = GHG_{BY} - (GHG_{BY} * \%\ Reduction)$ $739 - (739 * 0.4) = 443.4\ MtCO_2eq.$

$$\textbf{Equation (1)}\ Indicator_{CE} = \left(\frac{443.232}{443.4}\right) - 1 = -0.00038$$

Scope

Reduce economy-wide.

	Coverage	% GHG Emissions
Energy	1	0.80
IPPU	1	0.07
Agriculture	1	0.08
LULUCF	1	0.01
Waste	1	0.04
Others	1	0.00

$$Scope_{NDC} = \sum(Coverage * \%\ GHG\ Emissions)$$

$(1 * 0.80) + (1 * 0.07) + (1 * 0.08) + (1 * 0.01) + (1 * 0.04) + (1 * 0) = 1$

Economy-wide, given legislation enshrines NDC target in law.

	Coverage	% GHG Emissions
Energy	1	0.80
IPPU	1	0.07
Agriculture	1	0.08
LULUCF	1	0.01
Waste	1	0.04
Others	1	0.00

$$Scope_{NDC} = \sum(Coverage * \%\ GHG\ Emissions)$$

$(1 * 0.80) + (1 * 0.07) + (1 * 0.08) + (1 * 0.01) + (1 * 0.04) + (1 * 0) = 1$

$$\textbf{Equation (2)}\ Indicator_{Scope} = 1 - 1 = 0$$

Policy Mix

	Density	Intensity	Policy Mix	Policy Mix Indicator
Energy	57	0.4189	0.3106	-0.4839
IPPU	3	0.5000	0.0207	-0.0534
Agriculture	8	0.3438	0.0353	-0.0460
LULUCF	4	0.3125	0.0147	0.0047
Waste	4	0.5000	0.0247	-0.0155
Others	0	0.0000	0.0000	0.0000
		Equation (4)	Equation (5)	Equation (6)

<table>
<tr><td>Target Index</td><td>Equation (7) $\left(-0.00038 + 0\right)/_{2} = -0.00019$</td></tr>
<tr><td>Policy Effort Index</td><td>

	% GHG Emissions	National-level Compliance Emissions	Distributed	Policy Mix Indicator	Weighted Compliance Emissions
Energy	0.7945	443.4 → distributed to sectors relative to % GHG emissions	352.2598	-0.4839	522.7090
IPPU	0.0741		32.8611	-0.0534	34.6160
Agriculture	0.0812		36.0147	-0.0460	37.6699
LULUCF	0.0100		4.4137	0.0047	4.3928
Waste	0.0403		17.8507	-0.0155	18.1281
Others	0.0000		0.0000	0.0000	0.0000
					617.5158

Equation (8) $\text{Weighted Indicator}_{\text{CE}} = \left({443.232}/_{617.5158}\right) - 1 = -0.282$

Equation (9) $\left(-0.282 + 0\right)/_{2} = -0.141$
</td></tr>
</table>