WORKING PAPER · NO. 2023-146

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NOVEMBER 2023

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Does the World Free Ride on US Pledges to Reduce Greenhouse Gas Emissions? Evidence from the Paris Climate Agreement[†]

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November 15, 2023

Abstract

The US is widely believed to play a pivotal role in the development of international agreements to reduce greenhouse gas emissions, but do other countries free ride on US pledges? This paper provides what we believe is the first empirical evidence by proposing the US Climate Reciprocity Ratio (CRR); this summary statistic is the ratio of the rest of the world's pledged reductions to the US' pledged reductions through international climate negotiations. The analysis begins by quantifying countries' Nationally Determined Contributions (NDCs) and Net Zero targets under the Paris Agreement by taking the difference between their pledges and leading "business as usual" projections of their emissions at the time of their pledges (e.g., from the International Energy Administration). Using these pledged reductions, there are two main findings: 1) pledged emissions reductions under the Paris Agreement, if successfully achieved, would reduce global net GHG emissions by 12% - 24% in 2030 and by 38% - 54% in 2050; and 2) the estimated CRR ranges from 2.5 to 10.8, with the upper end of the range applying to the middle of the century when the US' share of global emissions has declined. Although pledges are not the same as reductions, these findings suggest that US climate policy can have indirect benefits by unlocking pledged reductions in other countries that benefit the US.

[†] The authors would like to thank Neil Himwich and Sariya Stowers for their excellent research assistance.

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1. Introduction

Climate change is the quintessential collective action problem. The benefits of reducing greenhouse gas emissions (GHGs) in the United States has the same effect on the climate of the US as reducing emissions in India, and vice versa. However, the costs of reducing emissions are concentrated in the country where the reductions take place. Thus, in a vacuum, each country would prefer to benefit from others' emissions reductions and let them disproportionately bear the costs too. This static view of the climate problem can make it seem intractable in the face of the annual release of 50 billion metric tons CO2e of GHGs that come from the world's nearly 200 countries. Indeed, it is one of the reasons that climate change is referred to by some as "the problem from hell".[1]

The United Nations and other international organizations try to solve this problem through multilateral agreements where countries in principle agree to cut emissions more than they would do in isolation, but the extent to which this approach has been successful has not been quantitatively tested. Indeed, concern about whether US participation in such agreements would be met with sufficient reciprocal participation by other countries has historically limited US engagement.[2] However, the past decade has seen the advent of two new international climate change agreements with substantially broader emission reduction participation than previous agreements: the 2015 Paris Agreement under the UN Framework Convention on Climate Change (UNFCCC), and the 2016 Kigali Amendment to the Montreal Protocol. At least partially due to the broad participation in both agreements, the US is a party to both.

This paper provides an empirical test of whether international climate agreements facilitate emissions reductions, relative to a world without their adoption, by examining the Paris Agreement where countries collectively agreed to reduce their GHG emissions. It is widely believed that the United States plays a special, or even pivotal, role in the shaping and adoption of these agreements such that they would be much less ambitious or perhaps not even exist without US participation; this role is a function of the US' broad global influence due to a variety of factors (e.g., its historical role in multilateral institutions and negotiations, GDP, and military strength) and its high share of current and historical emissions. We therefore additionally quantify how many tons of GHG emissions reductions the US committed to under the Paris Agreements and the rest of the world's committed reductions that will benefit the United States. As part of the analysis, we introduce the "Climate Reciprocity Ratio" (CRR), which is the ratio of the rest of the world's committed reductions to the US' committed reduction.

The reductions in emissions due to the Paris Agreement is calculated by comparing projected emissions under countries' Nationally Determined Contributions (NDCs) to an independent Pre-Paris Agreement emissions projection baseline or counterfactual. We use the International Energy Agency's (IEA's) 2014 World Energy Outlook (WEO) report that was released on November 12, 2014 and projects emissions through 2030 at the country-level as the counterfactual for emissions. Importantly, this projection is the most authoritative and widely referenced expectation of future energy trends. At the time of each edition's publication, it reflects the current state of technology (e.g., the price of wind, solar, natural gas, etc.), a leading expectation of the future path of technology, all adopted policies, and consensus

[1] We credit the great economist Martin Weitzman for coining this phrase.

[2] For example, the United States Senate adopted a resolution in 1997 (known as the Byrd-Hagel Resolution) by a vote of 95-0 stating that the US should not participate in any international climate change agreement that did not include reciprocal emission reduction commitments. Importantly, this resolution specified that the reciprocal emission reduction commitments must include developed *and* developing countries.

macroeconomic expectations. With respect to the 2014 publication, it did not assume any reductions in GHGs due to the Paris Climate Conference. Importantly, it was coincidentally published on the same day that the US and China announced their NDCs that jumpstarted other countries' release of their NDCs throughout the remainder of 2014 and through the Paris Conference at the end of 2015. Consequently, we assume that the NDCs are based on the same assumptions about projected emissions that underlie the IEA's report. In addition to this comparison, we conduct similar exercises for the subsequent UNFCCC actions where countries updated their Paris Agreement NDCs in 2020-21 and made 2050 net zero pledges.

There are two primary results. First, the Paris Agreement has been very successful in yielding committed emissions reductions, relative to the prevailing projections of emissions trajectories before those commitments were made. Specifically, our analysis suggests that pledged emissions reductions under the Paris Agreement, if successfully achieved, would reduce global net GHG emissions by 12 – 24% in 2030 and by 38 – 54% in 2050. Using the US Government's proposed updated SCC, the 12% reduction in 2030 would by itself reduce climate damages by roughly $1.5 trillion.[3]

Second, we estimate that the US' CRR is substantial. For example, the analysis pegs it at 3.9 tons in 2030 under the initial Paris Agreement NDCs and 2.5 to 3.0 tons in 2030 under the updated Paris Agreement NDCs. Further, the US' CRR grows later in the century such that we estimate it at 7.0 to 10.8 tons in 2050. The increase reflects that the US' share of global emissions declines throughout the century and the rest of the world made meaningful longer run pledges under the Paris Agreement.

We emphasize that these calculations are based on projected, rather than actual, emissions reductions and that analyzed commitments are voluntary. With respect to the former, we think that examining realized emissions is a less convincing approach to estimate the impacts of multilateral negotiations because it will necessarily confound the pledges with unexpected changes in technology, macroeconomic growth, etc., underscoring the challenges of developing a reliable counterfactual. With respect to the commitments being voluntary, we note that this is common among international agreements of all kinds.

The remainder of this paper is organized as follows. Section 2 provides background on the Paris Agreement. Section 3 provides an overview of the data and Section 4 the methods used to quantify the CRR for the United States under that agreement. Section 5 describes the results of the analysis and Section 6 interprets the results and concludes the paper.

2. The UN Framework Convention on Climate Change and the Paris Agreement

To address climate change's collective action problem, the international community gathered at the "Earth Summit" in Rio de Janeiro in 1992 and signed the UN Framework Convention on Climate Change (UNFCCC 1992). The treaty set as its objective the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" but did not include specific mechanisms for the coordination of national action to achieve that goal.

[3] Calculated using the central 2030 SCC estimate (2% discount rate, 2020 USD) from https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf

The first attempt to create such mechanisms under the UNFCCC was the 1997 Kyoto Protocol. The Kyoto Protocol included negotiated absolute emissions reductions obligations (with penalties for non-compliance), but these obligations only applied to countries considered developed at the time the UNFCCC was signed (known as "Annex I" countries). The U.S. Senate (which would ultimately need to ratify the Protocol) signaled its opposition in the Byrd-Hagel Amendment and the Clinton Administration signed the Kyoto Protocol but never submitted it to the Senate for ratification. When George W. Bush was inaugurated President he rejected U.S. participation in the Kyoto Protocol, echoing the criticism of the Byrd-Hagel Amendment (The White House 2001).

In 2007 in Bali, Indonesia, the international community set out to negotiate a new agreement with broader participation. These negotiations ultimately concluded in 2015 with the Paris Agreement (UNFCCC 2015). Two years before the Paris conference in Warsaw, countries agreed to develop "intended nationally determined contributions" or INDCs and communicate those "well in advance" of the Paris conference (UNFCCC 2014). The idea was that if all countries put forward their intended emission reduction pledges in advance of the Paris conference, other countries would have time to assess whether there was sufficient reciprocal action to justify their own intended emission reduction pledge.

On November 12, 2014, President Obama of the United States and President Xi Jinping of China took the international community by surprise by jointly announcing their INDCs, the result of nine months of bilateral negotiations (Lander 2014). In their joint announcement, the Presidents of the world's two largest emitters said, "The United States and China hope that by announcing these targets now, they can inject momentum into the global climate negotiations and inspire other countries to join in coming forward with ambitious actions as soon as possible" (The White House, 2014). By the time the Paris conference began on November 30, 2015, 151 countries had announced INDCs, suggesting that the joint announcement has been successful (UNFCCC 2023a).

The Paris Agreement sets a collective goal of limiting global temperature increases "well below" 2 degrees C relative to pre-industrial period, and "pursuing efforts" to limit temperature increases to 1.5 degrees C. To meet this goal, Parties agree to develop "nationally determined contributions" or NDCs that outline their GHG emission reduction commitments and plans and submit these NDCs to the UNFCCC Secretariat (INDCs announced before the Paris Agreement are resubmitted as NDCs under the Paris Agreement). All Parties are expected to contribute, with each Party's NDC containing the "highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances". Developed countries "should continue taking the lead by undertaking economy-wide absolute emission reduction targets", while developing countries "should continue enhancing their mitigation efforts and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances." The first U.S. NDC under the Paris Agreement (mirroring the INDC communicated in the U.S.-China Joint Announcement) is a commitment to reduce net GHG emissions 26-28% below 2005 levels by 2025.

The Paris Agreement is a "pledge and review" system, where countries make emission reduction or limitation pledges (NDCs). The combined effect of those national commitments is reviewed collectively through the UNFCCC process, and countries are expected to update their NDCs to continue to move the world towards the temperature targets contained in the Agreement.

In 2020 countries began their first round of updates to their NDCs. Among major emitters, the EU and China were some of the first to announce updated NDCs. The U.S. did so as well shortly after President Biden was inaugurated, with a commitment to reduce net GHG emissions 50-52% below 2005 levels by 2030 (The White House 2021). Japan and Canada joined the U.S. in announcing their NDC updates the same day.

As of mid-2023, 195 of the 198 Parties of the UNFCCC had signed the Paris Agreement (UNFCCC 2023). One hundred and ninety-four Parties had submitted NDCs under the Paris Agreement, and Taiwan, while not a UNFCCC Party, had also developed an NDC. Of these, 165 Parties, plus Taiwan, had also submitted updated NDCs as of mid-2023.

While most of these NDCs focus on emission reduction commitments between 2015 (when the Paris Agreement was reached) and 2030, the Paris Agreement also calls on all Parties to "strive to formulate and communicate long-term low greenhouse gas emission development strategies". As part of these strategies, a growing number of countries have set targets to reduce net GHG emissions to zero by mid-century (known as "net zero targets"). According to the Climate Action Tracker, as of March 2022, 60 countries had established net zero targets either in law or in a policy document (Climate Action Tracker 2023).

Overall, this qualitative history of the Paris Agreement, including countries' original NDCs and their updates, reveal the United States' central role in setting the ambition of commitments and the timing of their announcements. The remainder of the paper develops quantitative estimates of the Agreement's impact on projected total emissions and the US' CRR. Our primary focus is on estimating the impact of the initial NDCs under the Paris Agreement. We additionally examine the impact of the updated NDCs that began in 2020 and on the net zero commitments, both of which were consequences of the original 2015 Paris Agreement but are both more difficult to evaluate credibly as we explain below.

3. Data

The estimation of the Paris' Agreement's impact on projected emissions and the US' resulting CRR require the construction of a counterfactual for the global path of emissions in the absence of the Agreement. Since there is only one planet Earth, randomized control trials or quasi-experiments are unavailable, it is therefore necessary to develop a counterfactual that is based on all available information (e.g., about economic growth, policy, technologies, etc.) just before the Paris Agreement. If the counterfactual is identified, then a comparison with the NDCs provides a valid estimate of the Agreement's impacts.

We use the "Stated Policies Scenario" (STEPS) from the International Energy Agency (IEA)'s 2014 World Energy Outlook (WEO) as the counterfactual. The STEPS projections in the IEA WEO are the most widely used projections for energy-related CO2 emissions given expected economic growth, current policy, the current state of energy technologies, and their projected future changes at the time of publication. With respect to the 2014 publication, it did not assume any reductions in GHGs due to the Paris Agreement. Indeed, the 2014 WEO was released the same day that the US and China jointly announced their intended emission reduction pledges under the still-under-negotiation Paris Agreement. The basis of the analysis is therefore the assumption the WEO provides a valid counterfactual or baseline of Pre-Paris

projected global energy-related CO_2 emissions. We use IEA's 2019 WEOs in a similar way to develop a counterfactual for countries' updated NDC pledges in 2020 and their net zero pledges.

To quantify the impact of commitments under the Paris Agreement on emissions, relative to this baseline, we reviewed the NDCs of all developed countries and the largest developing country emitters. "Developed" and "Developing" countries are not defined in the Paris Agreement so we turned to three widely-used definitions. The most expansive measure of a "developed" country are those with a score equal to or greater than 0.8 on the UN Development Programme's Human Development Indicator (HDI). In the 2022 edition of the HDI, there were 66 countries (including the United States) in this category, accounting for 38.8% of global net GHG emissions in 2014 according to Rhodium Group data (see Panel A of Table 1).[4] We included all of these countries in our analysis. We also included the 33 developing countries (those with an HDI of less than 0.8) with the largest emissions in 2014, bringing the total coverage to 99 countries that account for 95% of global GHG emissions.

Table 1's Panels B and C conduct the same exercise using alternative definitions of developed and developing countries. Specifically, Panel B uses membership in the Organization for Economic Cooperation and Development (OECD) and C uses the Annex I designations from the original UNFCCC in 1992. The number of countries considered "developed" drops to 42 and 41 respective with these definitions. These alternative divisions of countries do not change developed countries' share of emissions by much. The remainder of the paper will focus on results from the HDI designation, while providing the results from the other two categorizations in appendix tables.

For net zero targets, we rely on the list of commitments compiled by the Climate Action Tracker. As of mid-2023, there were 53 countries with net zero commitments in law or policy documents with specific target years. These countries accounted for 79% of global net GHG emissions in 2014 according to Rhodium Group data.

4. Methods

This section details how the emissions reductions commitments were calculated for each country for the three different phases of Paris Agreement commitments. The approach for each phase is detailed in a separate subsection.

4.1 Initial Paris Pledges or NDCs

[4] For historical GHG emissions estimates, we use data from Rhodium Group (Rivera et. al. 2022), an independent research organization (where Houser and Larsen are employed).

To construct our Pre-Paris emissions baseline for all countries, we apply projected 2012-2030 growth rates for energy CO_2 from the 2014 IEA WEO to 2012 historical data from Rhodium Group.[5] The WEO includes projections at the region level, and at the country level for major economies. We apply the relevant country/region level emission growth rates from the 2014 WEO to country-level historical GHG emissions data from Rhodium Group.

Projections from the 2014 WEO only covered energy-related CO_2 emissions, which accounted for 65% of global net GHG emissions in 2014 (Rivera et al 2023). Given the absence of global methodologically consistent projections for other GHGs, we apply projected energy-related CO_2 emission growth rates from the 2014 WEO to process CO_2 emissions and other gases. For emissions from land-use, land-use change and forestry (LULUCF) we take the 2001-2012 annual average from Rhodium Group and hold that constant going forward.

To quantify the impact of 2030 emission reduction commitments included in NDCs submitted under the Paris Agreement, we start by comparing the pledges in the initial NDCs for each country to that country's Pre-Paris baseline. Most all developed countries defined their commitments as absolute reductions below a base year (most commonly 1990 or 2005) which makes quantification straight-forward. We treat the difference between the country's Pre-Paris baseline for the year 2030 and their net GHG emissions that year if they achieve their absolute reduction target as the quantity of emissions reductions pledged by that country under the Paris Agreement.

Most developing countries frame their commitment as a reduction below a business-as-usual (BAU) trajectory. For those countries that define their BAU level in their NDC, we calculate a target emissions amount in 2030 based on that BAU and the pledged reduction below it, but we calculate their emissions reduction commitment as the difference as between our Pre-Paris baseline and the country's target emissions level in 2030. We do *not* calculate their emissions reduction commitment as the difference between their stated BAU and the target because they can choose their BAU strategically. Indeed, the BAU included in the NDCs is considerably higher than our Pre-Paris baseline for several countries, which has the effect of making their NDC seem more ambitious than would be suggested by the independently developed WEO.

China and India's NDCs include a carbon-intensity target, a non-fossil energy/electricity target, and a LULUCF target (the only two countries to use this format). For the carbon-intensity and zero-carbon energy/electricity targets, we treat the energy sector projections for each country from the 2014 WEO STEPS scenario as our Pre-Paris baseline and measure the impact of the targets in each country's NDC relative to that. For LULUCF we measure the impact of the targets relative to the average emissions reductions from LULUCF in each country between 2001 and 2012 from the Rhodium Group data. China also includes a commitment to peak emissions before 2030 in its NDC.

Several countries were dropped from the analysis, because it was not possible to convert their pledges into quantitative reductions in GHGs. For example, Algeria and Saudi Arabia did not provide a specific BAU but had a NDC commitment against a BAU. Additionally, 13 countries did not include sector-wide or economy-wide targets but rather a list of individual policies and measures they intend to pursue; we

[5] We use historical data from Rhodium Group instead of the IEA for consistency across GHGs. The IEA only includes energy-related CO2 emissions, which while accounting for the majority of global GHG emissions, omits other important gases like methane and nitrous oxide.

were unable to credibly quantify the impact of these NDCs so these countries were excluded from the analysis.[6] Finally, we did not include four countries that made NDC commitments conditional on financial support from developed countries.

Panel A of Table 2 reports on the number of countries with quantifiable and binding NDC commitments under the original Paris NDCs. Ultimately, it was possible to quantify the emissions reductions impact of meeting the targets included in NDCs for 77 of the 99 countries in our starting sample (recall column (1b) of Table 1's Panel A); these countries accounted for 83.4% of the 2014 net global GHG emissions. Of those 77, we estimate that the targets of 57 were binding – meaning they would result in emissions reductions relative to the Pre-Paris baseline in 2030. These 57 account for 72.5% of 2014 global net GHG emissions. In cases where countries specify their target as a range, we quantify the impact of both the high and low end of that range and report and average of the two.

4.2 Updated Paris Pledges or NDCs

For a secondary analysis, we quantified the impact of the updated NDCs announced in 2020 and 2021 on projected 2030 emissions. As with the initial NDCs, it is necessary to specify a counterfactual or baseline emissions expectations and we consider two different baselines. The first is motivated by knowledge of the process by which the updated pledges were developed.[7]Specifically, it became clear that the initial pledges were insufficient to put the planet on a path to limiting temperature increases to the Paris Agreement goal of "well below 2 degrees C" or its aspirational goal of 1.5 degrees, and that more ambitious pledges were necessary to achieve these goals. In these negotiations, countries generally took each other's initial pledges as given and then aimed to take on what they determined to be their share of the further reduction necessary to increase the odds of achieving the Paris Agreement temperature goals.[8] The second approach is to use the same approach used for the initial pledges except using the 2019 WEO projections (the most recent version at the time of the NDC updates) which assumes that these updated NDCs were treated by countries as an entirely new negotiation. Panel B of Table 2 reports on the number of countries with quantifiable and binding updated NDC commitments. We report whether the commitments are binding relative to each of the two counterfactuals: 2019 WEO estimates and their initial NDCs. It is noteworthy that the estimates of the number of countries with binding updated emissions pledges (and their total share of emissions) are similar with the two counterfactuals. Furthermore, this count of countries with binding updated pledges and their share of emissions is nearly identical to the entries in Panel A that reports on the initial pledges.

4.3 Net Zero Targets

[6] These countries are Bahrain, Bolivia, Egypt, Iraq, Kuwait, Myanmar, Panama, Qatar, Sudan, Turkmenistan, UAE, Uruguay, and Venezuela.

[7] https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

[8] Two countries included in our analysis, Angola and Brunei Darussalam, did not submit initial NDCs but submitted NDCs as part of the 2020/2021 update round. Also, as stated previously, for a number of countries that did submit initial NDCs, the impact was either non-quantifiable or found to be nonbinding. For these countries, we use a WEO 2019 baseline as the counterfactual for quantifying the impact of NDCs submitted during the 2020/2021 round.

We conduct an additional secondary analysis, which considers the impact of the net zero targets of the 53 countries that made these commitments and are included in the analysis sample. This analysis is conducted from 2030 through 2050 and in this respect is a complement or extension of the previous exercises both of which end in 2030.

This analysis requires the development of estimates of pledged emissions in 2050, as well as counterfactual or baseline emissions in 2050. The 2050 pledged emissions are calculated as the resulting level of emissions from assuming a linear reduction between the country's projected 2030 emissions under their updated NDC and the country's net zero target year. Since the net zero target years range from 2050 to 2070, the 2050 pledged emissions level are equal to zero for countries with a 2050 target and are positive for those with later net zero target years. In cases where countries specify a range of target years, we quantify the 2050 pledged emissions levels using both ends of that range.

As with the updated pledge analysis, we estimate the CRR with two separate counterfactuals. The first assumes that countries hold emissions constant at whatever their 2030 updated pledged emissions level is until 2050. That is, they do not allow emissions to increase after 2030 but neither do they decrease them further. The second counterfactual returns to relying on the IEA's WEO forecasts. Specifically, we apply the energy-related CO_2 emissions growth rate from the STEPS scenario in the IEA's 2019 WEO, as this includes policies countries are adopting to meet their current 2030 NDCs. These projections extend to 2050 and these midcentury values form the second counterfactual.[9]

Panel C of Table 2 reports on the number of countries with quantifiable and binding net zero commitments. Again, we report whether the commitments are binding relative to each of the two counterfactuals against which we compare Net Zero targets.

It is noteworthy that the estimates of the number of countries with binding emissions pledges (and their total share of emissions) are similar with the two counterfactuals.

5. Results

This section reports on three separate exercises to develop estimates of the United States' CRR. The first two do so based on pledged emissions reductions in 2030 and the last one does this based on pledged 2050 emissions.

5.1 Initial Paris Agreement NDCs

The starting point for this analysis is a calculation of the United States' initial NDC for emissions reductions in 2030. This is calculated as the difference between pledged US net GHG emissions in 2030 under its initial NDC (a 26-28% reduction below 2005 levels) and the counterfactual, based on the IEA's 2014 WEO. This difference is reported in Panel A of Table 3 that indicates that the US pledged an average 1,350 million metric tons of carbon-dioxide equivalent ($MtCO_2e$) of GHG emissions reductions in 2030.

[9] The 2019 WEO only included projections through 2040, so we apply 2030-2040 average annual emission growth rates to the 2040-2050 period.

With the United States's estimated emissions reduction in hand, it is possible to calculate the US climate reciprocity ratio. The second row of Table 3's Panel A reports that other developed countries pledged 1,571 $MtCO_2e$ of emissions reductions, while row 3 indicates that developing countries pledged 3,685 $MtCO_2e$. So, in total, the rest of the world pledged 3.9 $MtCO_2e$ of emissions reductions for every ton the U.S. pledged to reduce. We label 3.9 ratio the US's CRR, based on the initial round of Paris Agreement 2030 NDCs.

Figures 1A and 1B graphically displays the magnitude of the pledged reductions. On the y-axis, Figure 1A reports each country's pledged 2030 reduction in absolute terms relative to its baseline or counterfactual 2030 emissions. Figure 1B reports each country's pledged 2030 reduction as a percent of its baseline or counterfactual 2030 emissions. The x-axis for both figure 1A and 1B are the country's projected baseline or counterfactual 2030 emissions. The top 5 emitters are identified in the figure. Appendix Table A5 reports all the underlying data, which we believe is the first time that pledged country-level emissions reductions estimates have been reported in common units.

It is also possible to estimate the total pledged emissions reductions and their benefits under the Paris Agreement's initial round. Summing the emissions reductions across all countries, Panel B suggests that the world pledged 6,606 $MtCO_2e$. of emissions reduction in 2030 under the initial Paris Agreement NDCs, a 12% reduction from baseline. One approach to determining the benefits of these reductions is to use the social cost of carbon (SCC), which is an estimate of the monetized value of the damages associated with the release of an additional metric ton of CO_2. Using the US Government's current estimate of the Social Cost of Carbon (SCC), annual emissions reductions in 2030 alone would reduce climate damages by $410 billion.[10] Using the US Government's proposed updated SCC, that rises to $1.5 trillion.[11]

5.2 Updated Paris Agreement NDCs

If the impact of updated 2030 NDCs under the Paris Agreement is measured relative to initial NDCs, the US pledged to reduce net GHG emissions in 2030 by an additional 1,589 $MtCO_2e$ (Table 3). Other developed countries (using the HDI definition) pledged 2,058 $MtCO_2e$, while developing countries pledged 2,660 $MtCO_2e$. This yields a US CRR of 3.0.

If, instead, the updated Paris NDCs are treated as an entirely new negotiation exercise, and measured against a baseline from before those announcements were made (our WEO 2019 based baseline), the US pledged 2,258 in 2030 GHG emissions reductions (Table 3). Other developed countries (using the HDI definition) pledged 3,189 $MtCO_2e$, while developing countries pledged 2,561 $MtCO_2e$. The CRR for the US using this approach is 2.5.

Measured against a pre-Paris baseline, the updated NDCs increase the reduction in global emissions in 2030 from 12% to 24%.

[10] Calculated using the central 2030 SCC estimate (3% discount rate, 2020 USD) from https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[11] Calculated using the central 2030 SCC estimate (2% discount rate, 2020 USD) from https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf

5.3 Paris Agreement Net Zero Targets

Looking out beyond 2030, the US CRR grows. The US has committed to achieve net zero emissions by 2050. That would result in a 3,244 $MtCO_2e$ reduction in emissions in 2050 relative to a post-NDC baseline where emissions are held constant at 2030 levels (Table 3). The net zero targets of other developed countries (using the HDI definition) would deliver an additional 7,225 $MtCO_2e$ if successfully achieved. The net zero targets of developing countries would deliver 15,532 $MtCO_2e$. The CRR of the US net zero target is 7. If measured against a post-NDC baseline where emissions grow at the rate projected in the 2019 IEA WEO, the US CRR would be 10.8. These reduction global pledged reductions, if achieved, would account for a 38% - 54% reduction relative to baseline emissions in 2050.

6. Discussion and Conclusions

This paper has two primary findings, both of which contradict the view that the climate collective action problem is so severe that US actions to cut emissions fail to generate reductions from other countries. First, the Paris Agreement led to commitments to substantially reduce emissions, relative to the prevailing projections of emissions trajectories just before these agreements. If the promises are met, they will reduce global emissions by 12% - 24% in 2030. Additionally, the net zero emissions reduction commitments under the Paris Agreement, if successfully met, would reduce emissions in 2050 by 38% - 54%. Second, US commitments to reduce emissions appear to unlock significant commitments to reduce emissions by other countries. We estimate that the US' CRR ranges from 2.5 to 10.8, with the upper end of the range applying to the middle of the century when the US' share of global emissions has declined.

It is important to highlight two caveats to these findings that bear underscoring. First, there is a single planet Earth, so these results do not come from a randomized control trial or a compelling quasi-experiment. Instead, they come from constructing a counterfactual out of the IEA's projections from before the relevant NDCs, so tautologically these estimates cannot be considered causal. Second, the analysis is based on commitments or promises to reduce emissions but not on realized emissions. It is possible that countries will ultimately fail to meet their promises for 2030 and beyond, and this would naturally alter the paper's conclusions.

Finally, the results have important implications for US climate policy. First, it provides evidence that the more comprehensive recent approach to international climate change agreements successfully addresses past concerns among US policymakers that US commitments would not be met by reciprocal action from other countries. Second, it provides evidence that domestic policy adopted in the US to help meet the country's NDC yields benefits to US citizens beyond the resulting decline in GHG emission within the territorial US through the reciprocal emissions reductions in other countries identified in this analysis. This supports the consideration of global benefits when weighing the benefits and costs of such policy.

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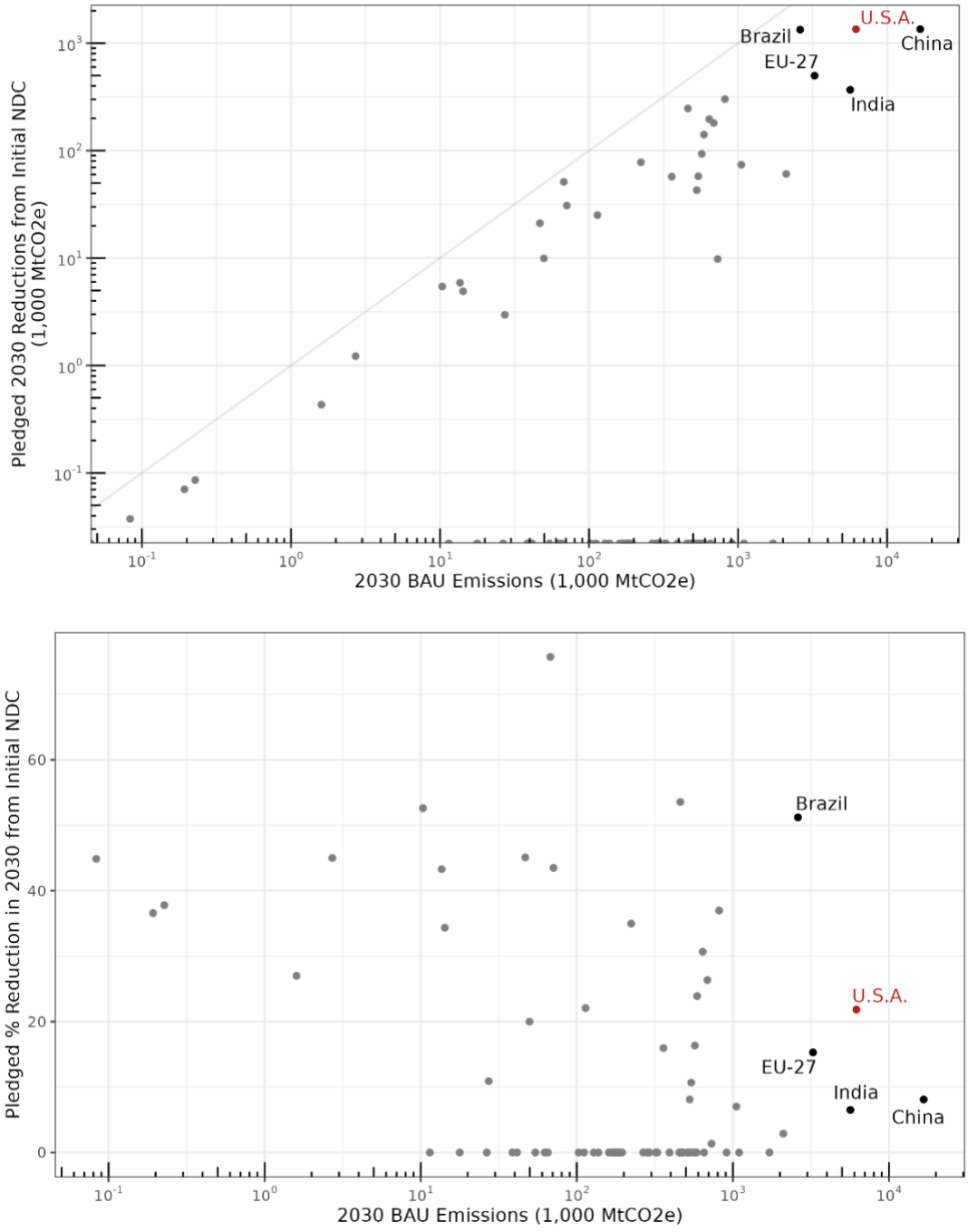
Figures

Figure 1: Pledged GHG Abatements in 2030 from Initial NDCs



Note:

The first panel (Figure 1A) shows the raw pledged amount of reductions against the BAU emissions from the 2014 WEO projections resulting from the initial NDCs. The second panel (Figure 1B) translates those emissions reductions into percent reductions from their BAU emissions. The 5 largest emitters are labelled.

Tables

Table 1: Developed and Developing Countries' Share of CO2 Emissions and Inclusion in Analysis, Alternate Definitions

	Number of UNFCCC Parties		Share of Global Emissions (2014)	
	Total (1a)	Included in Analysis (1b)	Total (2a)	Included in Analysis (2b)
A. HDI Definition of Developed and Developing				
United States	1	1	13.0%	13.0%
Other Developed Countries	65	65	24.2%	25.8%
Developing Countries	132	33	61.1%	56.3%
Total	198	99	98.3%	95.0%
B. OECD Based Definition of Developed and Developing				
United States	1	1	13.0%	13.0%
Other OECD+EU27**	43	42	18.5%	18.5%
Non-OECD	155	56	68.4%	63.6%
Total	199	99	99.9%	95.0%
C. UNFCC Original Annex I Definition of Developed and Developing				
United States	1	1	13.0%	13.0%
Other Annex I	41	41	18.9%	18.9%
Non Annex I***	156	57	68.0%	63.2%
Total	198	99	99.9%	95.0%

Note:
* Excludes international bunkers
* Not all EU members are OECD members. Since EU member states submit NDCs collectively, non-OECD EU members are included here
** Includes Taiwan, which while not an official party to the UNFCCC, has submitted an NDC

Table 2: Quantifiable and Binding Emissions Reductions Commitments, NDCs and Net Zero Targets

	Commitment Impact Quantified		Commitment found to be binding using WEO		Commitment found to be binding using initial NDC		Net Zero found to be binding	
	Number of Parties (1a)	Share of Global Emissions (2014) (1b)	Number of Parties (2a)	Share of Covered Emissions (2014) (2b)	Number of Parties (3a)	Share of Covered Emissions (2014) (3b)	Number of Parties (4a)	Share of Covered Emissions (2014) (4b)
A. Initial NDC								
United States	1	13.0%	1	13.0%				
Other Developed Countries	56	23.0%	47	18.2%				
Developing Countries	20	47.5%	9	41.3%				
Total	77	83.4%	57	72.5%				
B. Updated NDC								
United States	1	13.0%	1	13.0%	1	13.0%		
Other Developed Countries	61	22.9%	51	20.6%	45	19.1%		
Developing Countries	27	53.5%	17	47.3%	15	39.6%		
Total	89	89.4%	69	80.8%	61	71.6%		
C. Net Zero								
United States	1	13.0%	1	13.0%			1	13.0%
Other Developed Countries	18	23.8%	18	23.8%			18	23.8%
Developing Countries	9	42.4%	9	42.4%			9	42.4%
Total	28	79.1%	28	79.1%			28	79.1%

Note:
This table quantifies the extent of global emissions covered by different commitments and whether those commitments are binding relative to different baselines. Global emissions calculations exclude international bunkers. WEO baselines are for 2030 when judging whether NDCs are binding, and for 2050 when judging whether Net Zero commitments are binding. For Initial NDCs the 2014 WEO is used, for Updated NDCs the 2019 WEO is used. For the test of whether the commitment is binding in the final two columns we assume that 2050 emissions equal the emissions for 2030 under the updated NDCs. We use HDI at least 0.8 as our definition of developed/developing countries.

Table 3: GHG Abatement in 2030 and 2050 from NDCs and Net Zero Targets

	From WEO		From Initial NDC		From 2050 emissions at 2030 updated NDC levels	
	MtCO2e (1a)	Percent of total (1b)	MtCO2e (2a)	Percent of total (2b)	MtCO2e (3a)	Percent of total (3b)
A. Initial NDCs						
United States	1,350	20.4%				
Other Developed Countries	1,571	23.8%				
Developing Countries	3,685	55.8%				
Total	6,606	100.0%				
CRR	**3.9**					
B. Updated NDC						
United States	2,258	28.2%	1,589	25.2%		
Other Developed Countries	3,189	39.8%	2,058	32.6%		
Developing Countries	2,561	32.0%	2,660	42.2%		
Total	8,007	100.0%	6,307	100.0%		
CRR	**2.5**		**3.0**			
C. Net Zero						
United States	2,972	8.5%			3,244	12.5%
Other Developed Countries	8,237	23.4%			7,225	27.8%
Developing Countries	23,943	68.1%			15,532	59.7%
Total	35,152	100.0%			26,001	100.0%
CRR	**10.8**				**7.0**	

Note:
This table quantifies the level of GHG abatement in NDCs and Net Zero commitments relative to different baselines. For WEO projections, for initial NDCs we use the 2014 WEO projections for 2030, for updated NDCs we use the 2019 WEO projections for 2030, and for net zero commitments we use the 2019 WEO projections for 2050. For the 2030 initial NDC commitments we compare updated NDCs to the initial commitments by those same parties. For 2050 emissions at constant updated NDC levels we assume that emissions in 2050 for all parties are at the levels in their updated NDC commitments for 2030. We use HDI at least 0.8 as our definition of developed/developing countries.

Appendix

Table A1: Quantifiable and Binding Emissions Reductions Commitments, NDCs and Net Zero Targets (OECD Definitions)

	Commitment Impact Quantified		Commitment found to be binding using WEO		Commitment found to be binding using initial NDC		Net Zero found to be binding	
	Number of Parties (1a)	Share of Global Emissions (2014) (1b)	Number of Parties (2a)	Share of Covered Emissions (2014) (2b)	Number of Parties (3a)	Share of Covered Emissions (2014) (3b)	Number of Parties (4a)	Share of Covered Emissions (2014) (4b)
A. Initial NDC								
United States	1	13.0%	1	13.0%				
Other OECD+EU27	42	18.5%	38	15.5%				
Non-OECD	34	52.0%	18	44.0%				
Total	77	83.4%	57	72.5%				
B. Updated NDC								
United States	1	13.0%	1	13.0%	1	13.0%		
Other OECD+EU27	42	18.3%	40	17.3%	39	17.5%		
Non-OECD	46	58.1%	28	50.6%	21	41.1%		
Total	89	89.4%	69	80.8%	61	71.6%		
C. Net Zero								
United States	1	13.0%	1	13.0%			1	13.0%
Other OECD+EU27	13	16.7%	13	16.7%			13	16.7%
Non-OECD	14	49.4%	14	49.4%			14	49.4%
Total	28	79.1%	28	79.1%			28	79.1%

Note:
This table quantifies the extent of global emissions covered by different commitments and whether those commitments are binding relative to different baselines. Global emissions calculations exclude international bunkers. WEO baselines are for 2030 when judging whether NDCs are binding, and for 2050 when judging whether Net Zero commitments are binding. For Initial NDCs the 2014 WEO is used, for Updated NDCs the 2019 WEO is used. For the test of whether the commitment is binding in the final two columns we assume that 2050 emissions equal the emissions for 2030 under the updated NDCs. Not all EU members are OECD members. Since EU member states submit NDCs collectively, non-OECD EU members are included here.

Table A2: Quantifiable and Binding Emissions Reductions Commitments, NDCs and Net Zero Targets (UNFCCC Definitions)

	Commitment Impact Quantified		Commitment found to be binding using WEO		Commitment found to be binding using initial NDC		Net Zero found to be binding	
	Number of Parties (1a)	Share of Global Emissions (2014) (1b)	Number of Parties (2a)	Share of Covered Emissions (2014) (2b)	Number of Parties (3a)	Share of Covered Emissions (2014) (3b)	Number of Parties (4a)	Share of Covered Emissions (2014) (4b)
A. Initial NDC								
United States	1	13.0%	1	13.0%				
Other Annex I	41	18.9%	37	14.2%				
Non Annex I	35	51.6%	19	45.4%				
Total	77	83.4%	57	72.5%				
B. Updated NDC								
United States	1	13.0%	1	13.0%	1	13.0%		
Other Annex I	40	15.5%	38	14.5%	35	14.9%		
Non Annex I	48	60.9%	30	53.4%	25	43.7%		
Total	89	89.4%	69	80.8%	61	71.6%		
C. Net Zero								
United States	1	13.0%	1	13.0%			1	13.0%
Other Annex I	10	17.8%	10	17.8%			10	17.8%
Non Annex I	17	48.3%	17	48.3%			17	48.3%
Total	28	79.1%	28	79.1%			28	79.1%

Note:
This table quantifies the extent of global emissions covered by different commitments and whether those commitments are binding relative to different baselines. Global emissions calculations exclude international bunkers. WEO baselines are for 2030 when judging whether NDCs are binding, and for 2050 when judging whether Net Zero commitments are binding. For Initial NDCs the 2014 WEO is used, for Updated NDCs the 2019 WEO is used. For the test of whether the commitment is binding in the final two columns we assume that 2050 emissions equal the emissions for 2030 under the updated NDCs. Non Annex I includes Taiwan, which while not an official party to the UNFCCC, has submitted an NDC.

Table A3: GHG Abatement in 2030 and 2050 from NDCs and Net Zero Targets (OECD Definitions)

	From WEO		From Initial NDC		From 2050 emissions at 2030 updated NDC levels	
	MtCO2e (1a)	Percent of total (1b)	MtCO2e (2a)	Percent of total (2b)	MtCO2e (3a)	Percent of total (3b)
A. Initial NDCs						
United States	1,350	20.4%				
Other OECD+EU27	1,237	18.7%				
Non-OECD	4,019	60.8%				
Total	6,606	100.0%				
CRR	**3.9**					
B. Updated NDC						
United States	2,258	28.2%	1,589	25.2%		
Other OECD+EU27	2,560	32.0%	1,800	28.5%		
Non-OECD	3,190	39.8%	2,919	46.3%		
Total	8,007	100.0%	6,307	100.0%		
CRR	**2.5**		**3.0**			
C. Net Zero						
United States	2,972	8.5%			3,244	12.5%
Other OECD+EU27	4,725	13.4%			4,770	18.3%
Non-OECD	27,455	78.1%			17,988	69.2%
Total	35,152	100.0%			26,001	100.0%
CRR	**10.8**				**7.0**	

Note:
This table quantifies the level of GHG abatement in NDCs and Net Zero commitments relative to different baselines. For WEO projections, for initial NDCs we use the 2014 WEO projections for 2030, for updated NDCs we use the 2019 WEO projections for 2030, and for net zero commitments we use the 2019 WEO projections for 2050. For the 2030 initial NDC commitments we compare updated NDCs to the initial commitments by those same parties. For 2050 emissions at constant updated NDC levels we assume that emissions in 2050 for all parties are at the levels in their updated NDC commitments for 2030. Not all EU members are OECD members. Since EU member states submit NDCs collectively, non-OECD EU members are included here.

Table A4: GHG Abatement in 2030 and 2050 from NDCs and Net Zero Targets (UNFCCC Definitions)

	From WEO		From Initial NDC		From 2050 emissions at 2030 updated NDC levels	
	MtCO2e (1a)	Percent of total (1b)	MtCO2e (2a)	Percent of total (2b)	MtCO2e (3a)	Percent of total (3b)
A. Initial NDCs						
United States	1,350	20.4%				
Other Annex I	1,099	16.6%				
Non Annex I	4,157	62.9%				
Total	6,606	100.0%				
CRR	**3.9**					
B. Updated NDC						
United States	2,258	28.2%	1,589	25.2%		
Other Annex I	2,010	25.1%	1,504	23.8%		
Non Annex I	3,740	46.7%	3,214	51.0%		
Total	8,007	100.0%	6,307	100.0%		
CRR	**2.5**		**3.0**			
C. Net Zero						
United States	2,972	8.5%			3,244	12.5%
Other Annex I	5,164	14.7%			5,330	20.5%
Non Annex I	27,016	76.9%			17,427	67.0%
Total	35,152	100.0%			26,001	100.0%
CRR	**10.8**				**7.0**	

Note:
This table quantifies the level of GHG abatement in NDCs and Net Zero commitments relative to different baselines. For WEO projections, for initial NDCs we use the 2014 WEO projections for 2030, for updated NDCs we use the 2019 WEO projections for 2030, and for net zero commitments we use the 2019 WEO projections for 2050. For the 2030 initial NDC commitments we compare updated NDCs to the initial commitments by those same parties. For 2050 emissions at constant updated NDC levels we assume that emissions in 2050 for all parties are at the levels in their updated NDC commitments for 2030. Not all EU members are OECD members. Since EU member states submit NDCs collectively, non-OECD EU members are included here. Non Annex I includes Taiwan, which while not an official party to the UNFCCC, has submitted an NDC.

Table A5: Pledged 2030 Emissions Reductions from Initial NDCs

Country	Business as Usual Emissions (MtCO2e)	NDC Commitment*	Percent Reduction
Algeria	392.97	392.97	0.00
Andorra	0.00	0.00	0.00
Angola	182.71	182.71	0.00
Argentina	540.78	483.00	10.69
Australia	590.27	449.22	23.90
Bahamas	2.71	1.49	45.00
Bahrain	62.32	62.32	0.00
Bangladesh	320.47	320.47	0.00
Belarus	65.21	65.21	0.00
Bolivia (Plurinational State of)	128.36	128.36	0.00
Brazil	2611.72	1274.41	51.20
Brunei Darussalam	17.78	17.78	0.00
Cambodia	67.72	16.44	75.73
Cameroon	185.86	185.86	0.00
Canada	816.27	514.46	36.97
Chile	70.90	40.06	43.49
China	16690.56	15338.93	8.10
Colombia	266.30	266.30	0.00
Congo, Democratic Republic of the	511.78	511.78	0.00
Costa Rica	14.27	9.37	34.35
EU-27	3262.13	2763.15	15.30
Egypt	546.22	546.22	0.00
Ethiopia	222.99	145.00	34.97
Georgia	11.44	11.44	0.00
Iceland	13.62	7.72	43.29
India	5658.56	5290.46	6.51
Indonesia	2106.25	2045.51	2.88
Iran (Islamic Republic of)	1095.79	1095.79	0.00
Iraq	290.33	290.33	0.00
Israel	137.47	137.47	0.00
Japan	1052.08	978.21	7.02
Kazakhstan	359.03	301.75	15.95
Korea, Republic of	570.69	477.38	16.35
Kuwait	173.43	173.43	0.00
Liechtenstein	0.23	0.14	37.79
Malaysia	522.45	522.45	0.00
Mauritius	10.34	4.90	52.61
Mexico	730.02	720.21	1.34
Monaco	0.08	0.05	44.87
Montenegro	1.60	1.17	27.00
Myanmar	289.28	289.28	0.00
New Zealand	49.77	39.82	19.98
Nigeria	482.39	482.39	0.00
Norway	27.25	24.28	10.89
Oman	113.84	88.71	22.07
Pakistan	572.68	572.68	0.00
Panama	26.51	26.51	0.00
Paraguay	111.30	111.30	0.00
Peru	181.01	181.01	0.00
Philippines	282.66	282.66	0.00
Qatar	160.35	160.35	0.00
Russian Federation	1715.35	1715.35	0.00
San Marino	0.19	0.12	36.58
Saudi Arabia	910.87	910.87	0.00
Serbia	54.25	54.25	0.00
Singapore	102.67	102.67	0.00
South Africa	686.34	505.50	26.35
Sudan	168.12	168.12	0.00
Switzerland	46.78	25.69	45.09
Taiwan, Province of China	460.82	214.00	53.56
Tanzania, United Republic of	178.28	178.28	0.00
Thailand	640.46	444.00	30.67
Trinidad and Tobago	41.46	41.46	0.00
Turkey	585.10	585.10	0.00
Turkmenistan	186.78	186.78	0.00
Ukraine	470.83	470.83	0.00
United Arab Emirates	327.69	327.69	0.00
United Kingdom of Great Britain and Northern Ireland	528.91	486.03	8.11
United States of America	6182.86	4832.89	21.83
Uruguay	38.66	38.66	0.00
Uzbekistan	195.10	195.10	0.00
Venezuela (Bolivarian Republic of)	652.81	652.81	0.00
Viet Nam	453.54	453.54	0.00

* Mean of High and Low Commitments