Policy Brief

Achieving Paris Climate Agreement Pledges: Alternative Designs for Linking Emissions Trading Systems

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The 2015 Paris Climate Agreement: Opening the Door to International Collaboration

The Twenty-First Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), held in Paris in December 2015, resulted in 195 countries making voluntary greenhouse gas (GHG) reduction pledges, called Nationally Determined Contributions (NDCs). In a departure from their previous positions, many low- and middle-income (LMI) countries made substantial pledges to mitigate and sequester GHGs. However, the limited financial, technological, and institutional capacity of these countries raises challenges for the attainment of their COP21 pledges.

Several approaches have been proposed to overcome these barriers to climate policy in LMI countries. The first is direct financial or technology transfers, including use of the Green

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Climate Fund,[1] which is aimed at providing much of the financing needed by LMI countries to meet the Paris pledges (UNFCCC 2015). However, payments into this fund are currently insufficient to reach the agreed-upon annual goal of $100 billion. A second approach, included under Article 6 in the COP21 Paris Agreement, seeks to help countries meet their pledges by linking mitigation efforts internationally (Stavins and Stowe 2017). In particular, this might involve the linking of national and regional cap-and-trade (C&T) systems that have been or are being implemented in several countries and regions. In this context, "linking" refers to the formal recognition of emission allowances issued under a C&T system in one jurisdiction (a regional, national, or subnational government) by another jurisdiction for the purposes of complying with the first jurisdiction's requirements, and vice versa (Bodansky et al. 2016). Such linking will lead to the harmonization of initially asymmetric allowance prices across trading entities, which will lower the overall costs of achieving the same emissions reduction goals and can facilitate international financial transfers to LMI countries. Moreover, such linked carbon markets could form a common climate commitment that fosters broad international cooperation (Cramton, Ockenfels, and Tirole 2017).

Emissions trading is a policy instrument that has great promise for mitigating and sequestering GHGs. Successful applications include the European Union Emissions Trading System (EU ETS), the Regional Greenhouse Gas Initiative in the United States, the California Cap-and-Trade System, and the trading systems in Quebec (already linked with California in the context of the Western Climate Initiative) and Ontario (to be linked with California and Quebec beginning in 2018). Valuable experience has also been gained from the flexibility mechanisms under the Kyoto Protocol—that is, through the project-based Clean Development and Joint Implementation mechanisms and the government-level emissions trading provision that enables international transfer of so-called assigned amount units (AAUs). C&T systems have the advantage of establishing a limit on the total amount of emissions while allowing purchases and sales between participants to attain this emissions cap at the lowest overall cost. Moreover, minimizing costs will enhance political support for achieving the ambitious global emissions reduction goals.

In theory, a system of international emissions allowance trading could be designed to achieve much of the COP21 GHG reduction pledges and subsequently the more ambitious goal of confining global average temperature increases from preindustrial levels to less than 2 °C or 1.5 °C by the end of the century. Although economic theory predicts that a global, economy-wide emissions trading system covering all GHGs would provide the greatest cost savings, implementation may not be straightforward (Green, Sterner, and Wagner 2014).

This suggests that it may be more realistic to build up a global emissions trading system through a series of incremental programs that demonstrate the merits of such a system by first bringing on board the most willing countries. The G20 countries[2] could demonstrate leadership in this regard by implementing regional or national C&T systems and linking them among themselves; then, in a second stage, expanding the coverage nationally; and finally bringing in more countries over time. Thus the gains from emissions trading would be

[1]This fund was established at COP15 and reinforced at COP21.

[2]Table 1 lists G20 countries that made unconditional pledges in Paris (with the EU counting as a single entity). The remaining nonlisted countries are South Africa and Turkey. For brevity, throughout the article, references to the G20 countries indicate those listed in table 1.

progressively increased in the process of international policy coordination. This policy brief examines the creation of an international emissions trading system that links national and regional C&T systems (Flachsland, Marschinski, and Edenhofer 2009; Ranson and Stavins 2016; Rose et al. 2017a).[3] More specifically, we consider a stepwise approach that focuses on two intermediate arrangements (stages) on a path to ultimately implementing a global system of GHG emissions trading:

- Stage 1— a G20 trading system that includes only subregions for some major countries (Canada, China, United States),[4] while considering national coverage for the other G20 countries, in 2020.
- Stage 2— a more complete arrangement composed of all regions of all G20 countries, in 2025.[5]
- Stage 3— a full global system of all countries that offered unconditional pledges at COP 21, in 2030.

These stages would coincide with the five-year pledge-and-review cycles of the UNFCCC and allow for quantitative comparisons of progress across countries (Aldy et al. 2017).

Many countries have regulations in place for GHG mitigation options that are less responsive to a price signal (e.g., renewable portfolio standards [RPSs] for electricity generation, land use planning, vehicle standards, energy efficiency labels). Although linking mitigation efforts across countries could, in principle, include heterogeneous policies (Metcalf and Weisbach 2012; Bodansky et al. 2016), harmonizing nonprice measures are likely to face institutional challenges. Thus our analysis focuses only on linking C&T systems. We also distinguish between emissions reductions from C&T and those due to other policy instruments. The remainder of our discussion is as follows. In the next section we provide an overview of the methodology. This is followed by an analysis of the simulation results for each of the three stages. We then discuss the equity implications of each stage of the trading system. We conclude with a summary and policy recommendations.

A Quantitative Exploration of Future International Cooperation: Overview of Analytical Approach

For our analysis we use information on unconditional Paris pledges, emissions projections, and mitigation costs, combined with well-established economic modeling, to generate

[3]Not all countries are amenable to an allowance trading system. However, the effect of implementing a harmonized carbon tax (a strong alternative to allowance trading) across countries would have a very similar outcome to linking pure auction-based trading systems in terms of allocating mitigation efforts (Cramton, Ockenfels, and Tirole 2017). In the tax case, however, individual countries would collect the tax and could transfer some of the revenues (in a manner similar to transferring allowance auction revenues) to LMI countries.

[4]We base these subregions on areas that have already implemented C&T systems, such as the Regional Greenhouse Gas Initiative (RGGI) and Western Climate Initiative (WCI) in the United States, which could more easily work towards international system linkages, as, for example, California and Quebec have already done.

[5]Note that we include the entire EU (and all of its member countries) as a single entity, which maintains its own emissions trading system (i.e., the EU ETS) and which would link in its entirety with other systems.

simulations of the costs and savings from implementing the three stages of the proposed C&T system, as well as the costs of non-C&T GHG reductions.

The management of an international C&T system requires a careful institutional design. In particular, linked carbon markets result in interdependencies between participating countries' policies, with unilateral institutional changes (e.g., adjustment of caps or related policies such as RPSs) affecting all other participants in the trading system (Burtraw et al. 2013).[6] Moreover, when designing an international system that combines C&T programs across borders, it is important to consider a number of features. The ones we examine include: (1) regional coverage, (2) sectoral coverage, (3) GHG coverage, (4) grandfathering or auctioning allowances, (5) allocation of auction revenues, (6) supplementary transfers, and (7) stringency and evolution of the cap.

The numerical analysis that forms the basis of this policy brief combines the *unconditional* NDCs of ninety countries—aggregated into fifteen regions— with data from the Climate Equity Reference Project (CERP 2016) and the World Resources Institute (WRI 2016). We derive *macroeconomic* marginal mitigation cost curves from the global General Equilibrium Model for Economy – Energy – Environment (GEM-E3), an integrated energy, environment, and economic model (Vandyck et al. 2016). The cost curves are then inserted into a mitigation cost-minimizing model developed for emissions trading analysis (Rose et al. 1998) and recently refined for the Paris Agreement (Rose et al. 2017b). Then, based on a meta-analysis of the database underlying the Intergovernmental Panel on Climate Change's Fifth Assessment Report (AR5), we derive an estimate of the shift of the marginal mitigation costs that result from technological progress over time.[7]

The simulations we present here consider C&T systems based on carbon dioxide (CO_2) emissions in the power and industry sectors alone, as this is the common denominator across existing trading schemes. Emission reductions in other sectors, such as households and transportation, are assumed to be achieved through non-C&T policies (mainly regulations). We derive separate cost curves for non-C&T sectors and for CO_2 in C&T sectors.[8]

The simulations explore a gradual stepwise expansion of the regional coverage of allowance markets for CO_2 emissions in the power and industry sectors, starting with national and subnational (for Canada, China, and the United States) coverage in 2020 (stage 1), then linking all G20 countries' allowance markets in 2025 (stage 2), and finally considering global coverage in 2030 (stage 3).[9]

[6] Note that we do not address some potential complications of linking C&T systems. For details, see, e.g., Doda and Taschini (2017).

[7] We do this by adjusting the slope parameters of the C&T sector cost curves downward from 2020 to 2025 and then further downward to 2030 (see appendix C in the online supplementary materials).

[8] We use the GEM-E3 model to derive the marginal abatement cost curves in both C&T and non-C&T sectors. How the mitigation effort is shared between C&T and non-C&T sectors is based on the results of the Prospective Outlook on Long-term Energy Systems (POLES) model (Kitous et al. 2016).

[9] Although carbon leakage—i.e., the increase of emissions in some jurisdictions in response to other jurisdictions' unilateral emission reduction efforts—is a relevant concern in the strategic analysis of international climate policy (Nordhaus 2015), the analysis here assumes that countries that are not included in the intermediate stages of our global emission trading system (i.e., stages 1 and 2) will still meet their Paris pledges.

Stage 1: Linking G20 National and Subnational C&T Systems in 2020

The results for stage 1 indicate that linking national and subnational C&T systems of G20 countries offers significant benefits. More specifically, we find that emissions trading that covers the power and industry sectors can reduce the total associated mitigation costs of G20 participating countries (or subcountry regions) from $73 billion (in 2015 dollars) to $30 billion, or a savings of more than 59 percent (see table 1). Generally, regions with high marginal costs of mitigation in the power and industry sectors are allowance buyers and regions with low marginal costs are allowance sellers. For example, the United States, EU, and other high-income regions are buyers, while countries like China, India, and Russia are sellers. However, the results also indicate that each country gains from participating in the emissions trading, whether it is an allowance purchaser or seller (see "Cost savings" column in table 1). In addition, some countries (such as Argentina) with no mitigation obligations (over and above their mitigation associated with compliance to in-country regulations) can still benefit from joining a trading system by selling emission allowances. Finally, given the strong push many high-income countries have already been making towards emissions reductions in the power and industry sectors, many of them would meet 100 percent of their interpolated intermediate 2020 pledges submitted to COP21 without additional reductions in the non-C&T sector. Thus these costs associated with the non-C&T sector mitigations are relatively low or even zero.

Stage 2: Linking C&T Systems of G20 Countries in 2025

The results for stage 2 (see appendix table 1) indicate that linking the C&T systems of G20 members in 2025 can bring them sizeable benefits. This stage simulates GHG emissions trading in 2025 among the G20 members that made unconditional pledges at COP21, assuming full national coverage within countries. Again, the shape of the marginal cost curve is a major determinant of a country's buyer or seller status. However, unlike under stage 1, many LMI regions become allowance buyers, including more advanced countries (e.g., Brazil) and countries with relatively much lower per capita income (e.g., Indonesia). One reason for this result is that these countries have made high pledges, both in absolute terms and in relative terms compared to their mitigation commitments prior to COP21 (Rose et al. 2017b). This result is also driven by the vast potential for inexpensive GHG mitigation in China and India. The results indicate that while China and India, as major allowance sellers, more than offset their mitigation costs (i.e., resulting in a negative net cost), LMI countries such as Mexico and Indonesia will incur more than $10 billion in annual net costs. Note, however, that this value would be more than $17 billion without emissions trading. In addition, all regions are better off with trading, but the lower-income regions' net cost savings is smaller in both absolute and relative terms.

Stage 2 has advantages over stage 1: (1) the total emissions reduction in the C&T sectors is 196 percent higher and (2) although mitigation costs nearly double, the percentage cost savings from trading increase from 59 percent to 75 percent. The major reasons for these differences between the two stages are the increased GHG reduction goals over time and the

Table 1 Simulation of emissions allowance trading in stage 1: G20 national and subnational systems in 2020 (in million 2015$ unless otherwise indicated)

Trading party	Before trading	After trading						Non-C&T mitigation cost
	C&T mitigation cost	Allowances traded ($mtCO_2$)	Emissions reduction ($mtCO_2$)	C&T mitigation cost	Trading cost[a,b]	Net cost	Cost savings	
Argentina	0	−9	9	526	−642	−116	116	514
Australia	434	3	0	0	182	182	251	1,172
Brazil	10,795	88	0	0	5,994	5,994	4,801	778
Canada	279	3	0	0	213	213	66	0
China	102	−99	101	5,817	−6,732	−916	1,018	0
EU	31,770	299	0	0	20,373	20,373	11,397	0
India	0	−349	349	18,274	−23,784	−5,510	5,510	0
Indonesia	0	0	0	0	0	0	0	2,898
Japan	2,292	−7	48	2,788	−510	2,279	13	0
South Korea	20,242	94	0	0	6,407	6,407	13,835	0
Mexico	51	−18	19	1,082	−1,245	−162	213	635
Russia	0	−25	25	1,656	−1,728	−73	73	0
Saudi Arabia	297	2	0	0	117	117	180	326
USA	6,467	20	0	0	1,354	1,354	5,113	353
Total	72,729	508	552	30,142	0	30,142	42,586	6,676

Notes: Analysis assumes free allocation of allowances and includes only power and industry sectors covered by C&T. Analysis also assumes the trading system includes only the national/partial G20 countries/regions with unconditional pledges and hence excludes South Africa and Turkey.

[a]Allowance price: $68.24/$tCO_2e$; average mitigation cost with trading: $54.63/$tCO_2e$. [b]Negative entries signify revenues from allowance sales.

Source: The authors.

89 percent additional emissions reduction potential of expanding China's regional coverage to the entire country.

Stage 3: A Global Carbon Market in 2030

The results for stage 3—which simulates GHG emissions trading in the power and industry sectors in 2030 for all ninety countries (fifteen aggregated regions) that made unconditional pledges at COP21— indicate that there is great potential for broader emissions trading to substantially reduce mitigation costs. More specifically, in this stage, emissions trading could reduce total mitigation costs from $900 billion to $252 billion, a savings of 72.1 percent, while still achieving the pledged emissions reductions (see table 2). This cost saving is consistent with other estimates of the benefits of allowance trading under the Kyoto Protocol and Paris COP21 Agreement, which range from approximately 60 percent (Böhringer 2000), to 75 percent (Fujimori et al. 2016), to 88 percent (Nordhaus and Boyer 1999). More than 3.4 billion tons of CO_2 equivalent (tCO_2e) in emissions allowances would be traded at a price of $83.78 per tCO_2e and an average cost per tCO_2e reduction of $63.75 in 2030. This allowance price is higher than the price under stages 1 and 2, primarily because a much higher emissions

Table 2 Simulation for stage 3: emissions trading among ninety countries in 2030 (in million 2015$ unless otherwise indicated)

Trading party	Before trading	After trading						Non-C&T mitigation cost
	C&T mitigation cost	Allowances traded ($mtCO_2$)	Emissions reduction ($mtCO_2$)	C&T mitigation cost	Trading cost[a,b]	Net cost	Cost savings	
Australia	2,072	12	0	0	1,032	1,032	1,040	80,608
Brazil	19,912	139	11	916	11,666	12,582	7,330	196,158
Canada	16,437	137	0	0	11,519	11,519	4,918	104,352
China	12,007	−2,401	2,643	170,355	−201,159	−30,804	42,811	589
EU 28	116,856	725	74	5,839	60,728	66,568	50,288	190,138
India	0	−849	849	49,877	−71,136	−21,259	21,259	0
Japan	5,890	0	92	5,901	−11	5,890	0	51,041
Mexico and South America	32,625	185	145	9,072	15,495	24,567	8,057	6,249
North Africa and Middle East	11,596	64	0	0	5,383	5,383	6,213	19,444
Rest of Europe	1,893	12	0	0	983	983	910	9,673
Rest of the world	97,288	716	0	0	59,948	59,948	37,340	126,295
Russia	0	−132	132	9,617	−11,089	−1,472	1,472	0
Singapore and South Korea	80,227	250	0	0	20,942	20,942	59,286	10,404
Ukraine, Belarus, and Moldova	0	0	0	0	0	0	0	0
United States	503,992	1,142	0	0	95,699	95,699	408,294	228,362
Total	900,795	3,383	3,946	251,578	0	251,578	649,217	1,023,313

Notes: Simulation aggregates the ninety countries into fifteen regions. Analysis assumes free allocation of allowances and includes only power and industry sectors covered by C&T.

[a]Allowance price: $83.78/t$CO_2$e; average mitigation cost with trading: $63.75/t$CO_2$e. [b]Negative entries signify revenues from allowance sales.

Source: The authors.

reduction goal needs to be achieved in 2030 in order to meet 100 percent of the unconditional pledges.

As with the other simulations, the results for stage 3 indicate that although all regions are better off with emissions trading, the net cost savings for the lowest-income regions are smaller in both absolute and relative terms. In effect, although emissions trading results in sizable cost savings for high-income regions, the cost savings are minimal for LMI regions, suggesting an inequity in the distribution of benefits (Kverndokk and Rose 2008).[10] Note that by 2030 (see table 2), much greater reductions are undertaken in the non-C&T sectors, which increase the associated costs considerably. This provides further support for the $100 billion annual fund to help low-income countries meet their pledges, which was endorsed by the Paris Agreement.

[10]This conclusion is based on the analysis of the distribution of mitigation burden in terms of traditional equity principles such as ability to pay and egalitarian equity (see Rose et al. 2017b).

Using International Transfer of Auction Revenue to Address Equity Issues

With these equity concerns in mind, we next consider a system design that would generate at least $100 billion in auction revenue that could be transferred to LMI countries (see appendix table 2). Under this design, the five highest-income regions purchase 13 percent of their allowances at auction (or internally auction at least this share of allowances and transfer the resulting funds internationally) and the remaining regions receive all of their allowances freely. Consistent with economic theory, this system results in the same allowance price (both in the trading market and auction) as in the pure trading system and results in the same cost savings for all LMI regions as under stage 3. However, the five highest-income regions become worse off than in the 100 percent grandfathering case because of their need to pay for the additional 13 percent of allowance value. The lowest-income regions (“Rest of the world” in appendix table 2) would still incur $60 billion in total net costs in the C&T sectors and $126.3 billion in non-C&T costs, as shown for stage 3 in table 2. Thus, although equal to the climate financing fund target, the $101.8 billion of auction revenue would only partially offset the cost burden on the poorest countries.

Contributions of China and the United States

Next, we examined the contributions of China and the United States, the world’s two largest economies and GHG emitters, to the global trading system by simulating their nonparticipation in the system.[11] The results indicate that China’s absence would have the larger impact on cost within the system, with the allowance price nearly doubling and the total emissions reduction within the trading coalition declining from 15.3 percent to 14.6 percent. If the United States does not participate, the allowance price falls because of a large drop in demand, and the percentage of GHG emissions reduction within the trading coalition would fall significantly, to 11.9 percent. Another implication of the United States nonparticipation is that the total mitigation cost for the rest of the world (i.e., mostly LMI countries in Africa, Southeast Asia, and Central and South America that made unconditional pledges at COP21) would decline by $8.6 billion. This is because the United States is a major allowance buyer, and the allowance price decreases when it does not participate.[12] Additionally, Japan would become an allowance buyer. Overall, the nonparticipation of either China or the United States would reduce the total cost savings and the emissions reduction that could be achieved through the trading coalition.

Conclusion and Policy Recommendations

The coordination of international climate policy, such as linking systems of tradable GHG emissions allowances, can greatly lower the cost to all participants of slowing climate change. Using a stepwise approach, we have examined three incremental policy stages to implement the 2015 Paris Climate Agreement’s GHG reduction pledges. More specifically, we have

[11]See table S4 in the online supplementary materials for detailed results.

[12]Note that the total C&T cost when the United States does not participate is lower than in the base case. This is because the total GHG emissions reduction within the trading coalition is lower than in the base case.

estimated the costs and benefits of alternative configurations of participating countries and examined the importance of allowance trading design features, such as the transfer of auction revenues to low-income countries. Across the three stages, we find that adopting a C&T system makes all G20 countries better off and that the non-G20 countries included in the analysis are also better off in the case of global (ninety-country) emissions trading (see table 2). Moreover, the results indicate that under a partial auction, the $100 billion climate financing fund target could be easily fulfilled without severely impacting the savings to countries participating in the proposed global emissions trading system.

To summarize (see table 3), stage 1 indicates that simply by linking the existing G20 national and subnational C&T systems, more than 23 percent of world emissions would be covered, reducing these emissions in the C&T sectors by 1.02 percent,[13] while saving more than $42.5 billion (59 percent) in mitigation costs. Stage 2, which expands the system to fully include all G20 countries, increases the coverage of world emissions to almost 46 percent and their reduction to 2.75 percent in C&T sectors, while increasing the mitigation cost savings to more than $268 billion (75 percent). Finally, stage 3, which expands the system to cover all countries that submitted unconditional NDCs, covers almost 50 percent of world emissions, results in a 6 percent emissions reduction in C&T sectors, and further increases global mitigation cost savings to nearly $650 billion (72 percent).

The results of our analysis support several policy recommendations:

1. **G20 countries should display leadership in establishing and linking C&T systems to realize significant economic benefits in the implementation of the Paris Climate Agreement.** Progress by G20 countries in linking C&T systems has the potential to illuminate the path forward towards a truly global system of emissions trading that would further reduce total costs for all countries achieving their pledged emission reductions.
2. **Use emissions trading systems to mobilize financial support of $100 billion annually for low-income countries to support them in meeting their COP21 pledges.** Our findings indicate that auctioning 13 percent of the allowances in the five highest-income regions would generate sufficient auction revenue to mobilize the $100 billion annual transfer endorsed by the Paris Agreement.
3. **If full linking of C&T systems is not feasible, international harmonization of domestic carbon prices should be pursued.** Linking C&T systems involves a number of practical challenges, including the need for—and the increased complexity of—governing a joint system. This might lead to conflicts if the climate policy preferences of linking regions (such as preferred levels of carbon prices) are very diverse. A more modest alternative would be to internationally harmonize domestic carbon prices (e.g., via coordinated GHG taxes or price floors in C&T systems). This would reap most or all of the efficiency gains of fully linked allowance trading. Such international policy coordination may need to be complemented by international cash transfers in order to

[13]This is primarily because countries are expected to achieve only a small amount of their pledged emissions reduction in 2020: 17 percent for countries that include land use, land use change, and forestry (LULUCF) in their NDC and 30 percent for countries that exclude LULUCF. Moreover, only about one-third of the pledged emissions reduction is achieved by the C&T sector.

Table 3 Summary of mitigation costs and expected savings under incremental emissions trading stages

Country	Partial G20 stage (2020)		Full G20 stage (2025)		Global stage[d] (2030)	
	Allowance purchases/ sales	Cost savings (%)[b]	Allowance purchases/ sales	Cost savings (%)	Allowance purchases/ sales	Cost savings (%)
Argentina [MSA][a]	−9	—[c]	14	15.13	[185]	[24.70]
Australia	3	57.83	3	59.29	12	50.19
Brazil	88	44.47	47	30.17	139	36.81
Canada	3	23.66	52	35.14	137	29.92
China	−99	998.04	−990	156.10	−2,401	356.55
EU	299	35.87	503	46.83	725	43.03
India	−349	—	−431	—	−849	—
Indonesia [ROW]	0	—	143	43.95	[12]	[38.38]
Japan	−7	0.57	−52	—	0	—
South Korea [SSK]	94	68.35	146	72.31	[250]	[73.90]
Mexico [MSA]	−18	417.65	−9	5.93	[185]	[24.70]
Russia	−25	—	−19	—	−132	—
Saudi Arabia [NAM]	2	60.61	0	—	[64]	[53.58]
USA	20	79.06	593	82.73	1,142	81.01
G20 total [Global total]	508	58.55	1,502	74.77	[3,383]	[72.07]
Allowance price	$68.24/tCO_2e		$65.99/tCO_2e		$83.78/tCO_2e	
Global emissions covered by C&T system (%)	23.44		45.55		49.90	
Global emissions reduced by C&T system (%)[e]	1.02		2.75		6.01	
Total emissions reduced (%)[e] G20 [global]	3.13		8.76		[13.98]	

[a]Brackets denote which of the respective fifteen regions a G20 country belongs to and that region's values in the global stage. MSA = Mexico and South America; ROW = rest of the world; SSK = Singapore and South Korea; NAM = North Africa and Middle East. [b]As a percentage of C&T sector mitigation costs. [c]Undefined due to zero-cost before trading. [d]Including only those countries that offered unconditional NDCs at COP21. [e]Compared with a business-as-usual baseline without the Paris Agreement pledges.

compensate for increased policy stringency in countries that have lower carbon prices initially.

4. **The design and implementation of an integrated international allowance trading system should be considered within a broader policy context that includes accompanying measures.** In particular, a monitoring, reporting, and verification framework is needed to guarantee the additionality of emissions reductions under the trading system. Governance arrangements are also necessary to coordinate reforms in individual linked systems that can affect the functioning of the integrated market. Finally, capacity building to improve institutional frameworks in LMI countries, as well as technology transfers, may be required to help these countries fulfill their COP21 pledges.

Appendix. Additional Simulation Results of Emissions Allowance Trading Stages

Appendix Table 1 Simulation of emissions allowance trading in stage 2: national coverage of G20 countries in 2025 (in million 2015$ unless otherwise indicated)

Trading party	Before trading	After trading						Non-C&T mitigation cost
	C&T mitigation cost	Allowances traded ($mtCO_2$)	Emissions reduction ($mtCO_2$)	C&T mitigation cost	Trading cost[a,b]	Net cost	Cost savings	
Argentina	1,771	14	11	586	917	1,503	268	484
Australia	560	3	0	0	228	228	332	29,995
Brazil	4,425	47	0	0	3,089	3,089	1,335	57,678
Canada	5,308	52	0	0	3,442	3,442	1,865	50,034
China	5,353	−990	1,099	62,341	−65,345	−3,004	8,356	243
EU	62,422	503	0	0	33,187	33,187	29,235	20,488
India	0	−431	431	22,204	−28,463	−6,259	6,259	0
Indonesia	16,805	143	0	0	9,420	9,420	7,385	0
Japan	0	−52	52	2,952	−3,442	−489	489	0
South Korea	34,898	146	0	0	9,665	9,665	25,233	0
Mexico	691	−9	22	1,226	−576	651	41	6,159
Russia	0	−19	19	1,233	−1,266	−33	33	0
Saudi Arabia	0	0	0	0	0	0	0	5,328
USA	226,609	593	0	0	39,143	39,143	187,466	47,010
Total	358,840	1,502	1,635	90,543	0	90,543	268,297	217,419

Notes: Analysis assumes free allocation of allowances and includes only power and industry sectors covered by C&T.
[a]Allowance price: \$68.24/tCO_2e; average mitigation cost with trading: \$54.63/tCO_2e. [b]Negative entries signify revenues from allowance sales.
Source: The authors.

Appendix Table 2 Simulation of emissions allowance trading in 2030, with auctioning to address equity issues (in million 2015$ unless otherwise indicated)

Trading party	NDC emissions ($mtCO_2$)	Free-allocation allowances ($mtCO_2$)	Emission reduction undertaken after trading ($mtCO_2$)	C&T mitigation cost	Allowances needed from trading or auction[a]	Trading plus auction costs	C&T total cost
	1	2[b] (= 1 × 87%)	3	4	5	6	7 (= 4 + 6)
Australia	408	355	0	0	65	5,476	5,476
Brazil	1,197	1,197	11	916	139	11,666	12,582
Canada	525	457	0	0	206	17,237	17,237
China	19,252	19,252	2,643	170,355	−2,401	−201,159	−30,804
EU28	3,141	2,733	74	5,839	1,133	94,940	100,780
India	5,695	5,695	849	49,877	−849	−71,136	−21,259
Japan	732	637	92	5,901	95	7,962	13,863
Mexico and South America	2,592	2,592	145	9,072	185	15,495	24,567
North Africa and Middle East	2,491	2,491	0	0	64	5,383	5,383
Rest of Europe	109	109	0	0	12	983	983
Rest of the world	6,570	6,570	0	0	716	59,948	59,948
Russia	1,865	1,865	132	9,617	−132	−11,089	−1,472
Singapore and South Korea	569	569	0	0	250	20,942	20,942
Ukraine, Belarus, and Moldova	532	532	0	0	0	0	0
United States	4,543	3,952	0	0	1,733	145,181	145,181
Total	50,221	49,006	3,946	251,578	4,598[c]	101,828[d]	353,406

[a]Negative entries signify excess allowances regions can sell in the trading market. [b]Auction of 13 percent of allowances pertains only to the United States, EU28, Japan, Canada, and Australia; 100 percent free allocation of allowances for all other regions. [c]The column total is the sum of all the positive numbers in this column, which represents the total amount of allowances needed from trading and/or auction. [d]Since allowances purchased equal allowances sold, this value represents total auction revenues.

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Abstract

The coordination of international climate policy, such as linking systems of tradable greenhouse gas (GHG) emissions allowances, can greatly lower the cost to all participants of slowing climate change. We consider alternative policy designs of international agreements that would help implement the 2015 Paris Climate Agreement's GHG reduction pledges. In particular, we examine a stepwise approach to implementing a global system of GHG emissions trading, which includes estimating the benefits of alternative configurations of participating countries. We also illustrate the importance of allowance trading design features, such as the transfer of auction revenues to low-income countries. Numerical simulations indicate that an emissions trading system covering the power and industry sectors in all countries that made unconditional pledges could reduce the associated mitigation costs by more than 72 percent. Moreover, transferring the revenues from the sale of emission allowances could greatly enhance the capability of lower-income countries to meet their Paris Agreement pledges. (*JEL*: Q54, Q56, Q58, H23, F53)