Bilateral Cooperation between China and the United States: Facilitating Progress on Climate-Change Policy

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Sections of this paper pertaining to policy in China were drafted by affiliates of the National Center for Climate Change Strategy and International Cooperation; Sections pertaining to United States policy were drafted by Harvard affiliates.[1]

1. BACKGROUND AND INTRODUCTION

China and the United States, the two largest greenhouse gas (GHG) emitters in the world, together accounted for 35%[2] of global GHG emissions in 2012. While there are major socioeconomic and political differences between the two countries, it is widely acknowledged that action by China and the United States is necessary for the world to effectively address global climate change.

Cooperation between China and the United States with regard to climate change was one important factor in the success of the Twenty-First Conference of the Parties (COP-21) of the United Nations Framework Convention on Climate Change (UNFCCC). At COP-21, in Paris in December 2015, a major new international agreement to address climate change was concluded. For most purposes, the agreement will begin to be implemented in 2020.[3]

Domestic social, economic, and political changes have helped shape the manner in which China and the United States are dealing with climate change—using domestic policy (that is, a "bottom up" approach), in addition to working through the UNFCCC. As the Chinese

1 This paper is based in part on a workshop organized jointly by China's National Center for Climate Change Strategy and International Cooperation (NCSC) and the Harvard Project on Climate Agreements, and hosted by NCSC in Beijing June 25-26, 2015. Information on the workshop, as well as links to most presentations, may be found at: http://belfercenter.ksg.harvard.edu/publication/25678. The authors are grateful for support for the workshop and this paper from the Hui Fund for Generating Powerful Ideas in the Ash Center for Democratic Governance and Innovation, Harvard Kennedy School.

2 World Resources Institute Climate Analysis Indicators Tool; http://cait.wri.org. Data incorporates land-use changes and forestry. China: 10.684 $GtCO_2e$; USA: 5.823 $GtCO_2e$; World: 47.599 $GtCO_2e$. Excluding land-use changes and forestry, the corresponding data are: China: 10.976 $GtCO_2e$; USA: 6,235 $GtCO_2e$; World: 44,816 $GtCO_2e$; China and the United States then account for 38% of emissions in 2012.

3 The text of the Paris Agreement is here: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf. For analysis, see: Robert N. Stavins, "Paris Agreement—a good foundation for meaningful progress," blog post, *An Economic View of the Environment*, December 12, 2015, www.robertstavinsblog.org/2015/12/12/paris-agreement-a-good-foundation-for-meaningful-progress; Center for Climate and Energy Solutions, "Outcomes of the U.N. Climate Change Conference in Paris," December 2015, www.c2es.org/international/negotiations/cop21-paris/summary.

society and economy have entered a new epoch, the significance of low-carbon development and energy-structure transformation have begun to draw attention. Under such circumstances, climate policy is regarded as a key strategy to encourage manufacturing industries to upgrade their technologies and improve energy efficiency.

Since 2013, China has been addressing climate problems raised in the Twelfth Five-Year Plan: implementing the action plan for controlling greenhouse gas emissions, adjusting the industrial structure, saving energy, increasing energy efficiency, optimizing energy infrastructure, increasing carbon sinks, adapting to climate change, and increasing institutional capacity. As a result of these actions—and of industrial modernization and structural changes in the economy—carbon dioxide emissions per unit of gross domestic product (GDP) in 2013 were 4.3 percent lower than in 2012, and 28.6 percent lower than in 2005.

Also, energy consumption per unit of GDP was reduced by 3.7 percent in 2013 (as compared with 2012). In the first three years of the Twelfth Five-Year Plan period (2011-2013), energy consumption per unit of GDP was reduced by 9 percent; the equivalent of approximately 350 million tons coal equivalent was saved—that is, a reduction of more than 840 $MtCO_2$ (million tons of carbon dioxide). These measures also bring collateral benefits in reducing air pollution in urban areas, which has become a significant threat to public health.

In the United States, the Obama Administration has taken several executive actions under existing statutory authority (primarily the Clean Air Act) that either have the immediate purpose of reducing GHG emissions or incidentally have that effect. In addition, the state of California, which by some measures would have the world's eighth largest economy if it were a country,[4] has implemented an ambitious, nearly economy-wide GHG emissions trading system (ETS) and other policies to reduce emissions. Finally, the development and deployment of hydraulic fracturing technologies has very significantly increased the supply—and lowered the price—of natural gas in the United States, with the result that gas is replacing coal as the primary fuel for a significant portion of electricity generation. Since natural gas produces roughly half as much CO_2 per unit of combustion heat compared to coal, this has led to a significant reduction in U.S. power-sector GHG emissions.[5]

On November 12, 2014, immediately following the Asia-Pacific Economic Cooperation (APEC) meeting in Beijing, Presidents Xi Jinping and Barack Obama jointly announced their intentions to reduce each country's CO_2 emissions. In the announcement, the two governments also pledged to expand ongoing collaboration to develop and demonstrate clean-energy and

4 www.lao.ca.gov/LAOEconTax/Article/Detail/1.

5 Though there is significant leakage in the natural-gas distribution system. See research conducted by the Environmental Defense Fund at the following web page: www.edf.org/energy/methaneleakage.

carbon-capture-and-storage technologies; advance previous collaboration to reduce emissions of hydrofluorocarbons, a group of gases with very high warming potential; share best practices on low-carbon cities; and promote trade in "green goods."[6]

The announcement states that China's CO_2 emissions would peak by "around 2030" (earlier, if possible) and China would "make best efforts" to increase the contribution from non-fossil sources to 20% of total energy consumption by the same year. The United States would cut economy-wide GHG emissions by 26% to 28% below the 2005 level by 2025 and would make "best efforts" to hit the high end of this range. The commitments in this China–U.S. bilateral announcement were included in nearly the same form in the Intended Nationally Determined Contributions (INDCs) the two countries submitted to the UNFCCC in 2015, in preparation for COP-21 in Paris.[7] (INDCs are the voluntary ["nationally-determined"] commitments that countries submitted for inclusion in the Paris Agreement.)[8]

China and the United States made a second joint announcement on September 25, 2015.[9] In this statement, the two countries agreed to work together to ensure an ambitious international agreement in Paris in December 2015, enhance bilateral and multilateral cooperation on climate change, and advance domestic climate action in each country. China, among other things, announced plans to implement a national emissions trading system in 2017, provide significant financial support for climate action in developing countries, and lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level by 2030. The United States, among other things, announced intentions to finalize its implementation approach for the Clean Power Plan in 2016 and finalize regulations for improved fuel efficiency in heavy-duty trucks.[10]

Given that China and the United States are the world's two largest GHG emitters; the momentum that already exists with respect to bilateral cooperation on climate change and clean energy technologies;[11] and the completion of the Paris Agreement at COP-21—it is

6 English version at: www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change.

7 China's INDC: http://www4.unfccc.int/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf; United States' INDC: http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf.

8 For all INDCs submitted to the UNFCCC, see: http://www4.unfccc.int/submissions/indc; for summary data on the INDCS, see WRI CAIT: http://cait.wri.org/indc. As of January 22, 2016, INDCs representing 187 countries, out of a total of 195 UNFCCC member countries, had been submitted. (Contributions are referred to as "NDCs" in the Agreement, but this paper will continue to use the term "INDC.") The Agreement encourages or requires (depending on the precise action) countries to revise their INDCs post-Paris—or, for those few remaining countries, to submit them.

9 English version at: www.whitehouse.gov/the-press-office/2015/09/25/us-china-joint-presidential-statement-climate-change.

10 See also Höhne, et al. (2014).

11 See bibliography included at the end of this paper for further reading on China-U.S. cooperation on energy and climate change.

important to explore opportunities for and challenges to furthering this cooperation. Among other reasons, much work remains to be done to elaborate the Paris Agreement over the next five years—to specify rules, procedures, and guidelines for the various elements of the accord. China-U.S. collaboration will continue to be very important during this preparatory phase. More generally—beyond the UNFCCC process—it is important to explore how China–U.S. cooperation can facilitate multilateral cooperation in global efforts to address climate change.

In this discussion paper, we address three areas for potential cooperation—or expansion of current cooperation: 1) the design and implementation of emissions trading (cap-and-trade) systems; 2) standards and procedures for accounting for emissions and for measuring progress in achieving INDCs. Such standards and procedures could help advance the effectiveness and equity of the Paris Agreement as it is elaborated—by making possible more accurate comparison of effort. They could also promote the use of domestic market mechanisms and the crediting of these toward INDCs, as well as linkage among ETSs and among heterogeneous policy systems (Bodansky, et al. 2014; Metcalf and Weisbach 2012); 3) The intersection of trade and climate policy—how China-U.S. trade might be affected by domestic policies and international agreements (bilateral and multilateral) to reduce greenhouse-gas emissions, and how China and the United States can collaborate to magnify possible trade benefits and reduce possible trade risks of the movement toward low-carbon societies.

2. MARKET MECHANISMS FOR REDUCING GREENHOUSE-GAS EMISSIONS

2.1 Background

Policies that put an explicit price on carbon—ETSs and carbon taxes—can be cost-effective approaches to achieving carbon-reduction goals. Where abatement costs are heterogeneous across regions and industries (as is inevitably the case), pricing policies are cost-effective in the short run because they direct abatement, through the market, to the least costly abatement options (tending to equalize marginal abatement costs across sources). Carbon pricing is also the least costly approach over the long term, because it results in higher prices for fossil fuels and thereby provides incentives for the innovation and deployment of low-carbon technologies.

ETSs and carbon taxes each have advantages and disadvantages.[12] An ETS provides certainty about future emissions levels, but prices are determined by the market and may be difficult to predict. A carbon tax provides certainty about the price to be paid for emissions, while leaving uncertain how much emissions reduction will occur. Both systems can be designed to address equity concerns, in the case of a cap-and-trade system through the allocation of permits and, in both approaches, through the distribution of revenues.

12 Compare Stavins (2007) and Metcalf (2007).

Emissions trading has a track record of successful adoption and implementation over several decades in the United States and elsewhere. Cap-and-trade systems were used in the United States to phase out the use of leaded gasoline between 1982 and 1987, to reduce sulfur dioxide emissions under the Clean Air Act Amendments of 1990, and to reduce GHG emissions within a group of northeastern states (through the Regional Greenhouse Gas Initiative—RGGI[13]), and in California.[14] Worldwide, the largest GHG cap-and-trade system implemented to date is the European Union's Emissions Trading System.[15]

China has also implemented market-based environmental policies in the past two decades. The Chinese central government has initiated several government-led payment systems to incentivize private landowners to protect water sources and reduce soil erosion. In 2002, the State Environmental Protection Administration approved pilot sulfur dioxide emission trading programs in five provinces (Shandong, Shanxi, Jiangsu, Henan, Tianjin), two cities (Shanghai, Liuzhou), and a key state-owned company (China Huaneng Group). Since 2007, the Chinese government has further developed eleven pilot pollution rights trading programs (Jiangsu, Zhejiang, Tianjin, Hubei, Hunan, Inner Mongolia, Shanxi, Chongqing, Shaanxi, Hebei, Jiangxi) and plans to complete related system design in 2017. The program covers chemical oxygen demand, sulfur dioxide, nitrogen oxides, ammoniacal nitrogen, and other major pollutants described in Twelfth Five-Year Plan. As carbon emission control becomes increasingly important in ecological improvement and international negotiations, China has set up pilot programs on carbon emission trading, as discussed in detail below.

Both China and the United States have indicated—to varying degrees—a preference for using emissions trading to achieve GHG reductions, and both have some experience with this approach at the regional level. The remainder of this section discusses the current status of emissions trading in China and the United States, with the aim of drawing lessons from each country's efforts to date and identifying opportunities for future bilateral cooperation in this area.

2.2 Cap-and-trade in the U.S.

Despite successful experiences with cap-and-trade systems, the United States faces significant political challenges to adopting national carbon-pricing policies. Such policies can be politically controversial, in part because they render the costs of carbon abatement transparent. In contrast, conventional regulatory instruments, such as emission control standards or low-carbon technology requirements, hide abatement costs.

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13 Program overview at: www.rggi.org/design/overview.

14 www.arb.ca.gov/cc/capandtrade/capandtrade.htm.

15 http://ec.europa.eu/clima/policies/ets/index_en.htm.

In the United States more recently, considerable opposition has arisen to addressing climate change through any means—but especially through cap and trade.[16] This opposition is based in part on aversion to increasing energy costs through climate regulation, but also reflects deeper political polarization in the United States. Given this polarization, a meaningful national-level, economy-wide cap-and-trade system is unlikely to be established in the United States in the foreseeable future.

As noted above, however, the cap-and-trade components of RGGI and, especially, California's Assembly Bill 32 (AB 32) constitute significant sub-national climate change initiatives in the United States. RGGI is a CO_2 cap-and-trade system for the power sector in nine northeastern states. Nearly all allowances are auctioned, with revenues used by the respective states largely for clean-energy initiatives. Since RGGI began operation in 2009, its cap has, for the most part, been non-binding (i.e., too high) due to low natural gas prices as a result of the shale gas revolution, the economic recession in 2008-09, and other policies in the various states that have reduced emissions under RGGI's cap. The RGGI states lowered the cap by 45% from 2013 to 2014 and approved additional annual cap reductions of 2.5% from 2015 to 2020, which has made RGGI moderately binding (Murray and Maniloff, 2015).

AB 32 is a broad and ambitious initiative to cut California's GHG emissions to 1990 levels by 2020 through a set of policies that includes an upstream ETS that covers approximately 85 percent of California's greenhouse gas emissions. Initially, covered sources received a free allocation of allowances, but auctions will increasingly be used, and eventually almost all allowances will be auctioned. Trade-sensitive, energy-intensive industries are protected in California's cap-and-trade system through an output-based updating allowance allocation mechanism. The use of offsets is allowed for up to 49% of required emissions reductions.

The use of emissions trading in the United States could potentially be significantly expanded by President Obama's Clean Power Plan (CPP), announced in final form in August 2015.[17] The goal of the CPP is to reduce CO_2 emissions from existing power plants by 32% in 2030, compared with 2005 levels. The CPP is complex and subject to legal review, but among other things it would provide incentives and tools for emissions trading within and among U.S. states, and, indeed, a number of states are considering trading as a means to meet the obligations of power plants within their borders under the CPP.

16 Opponents labeled the Waxman-Markey bill of 2007, which would have established a national ETS in the United States, "cap-and tax," where "tax" had negative connotations.

17 See a fact sheet on the final version of the CPP prepared by the U.S. Environmental Protection Agency at: http://www2.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan.

2.3 Cap-and-trade in China

China has also utilized cap-and-trade systems to reduce GHG emissions. In 2011, China's Twelfth Five-Year Plan[18] (Chapter 21) stated that China should "actively cope with global climate change…and gradually establish carbon emissions trading." In the same year, the National Development and Reform Commission (NDRC) approved seven pilot carbon emissions trading programs in five cities (Beijing, Shanghai, Tianjin, Chongqing, Shenzhen) and two provinces (Guangdong and Hubei). According to "The Decision on Major Issues Concerning Comprehensively Deepening Reforms," published in 2013,[19] China will implement a national carbon emissions trading scheme.

The seven pilots cover a population of 252 million, energy consumption of 830 million tons of coal equivalent, and GDP of 14 trillion Yuan RMB, accounting for 19%, 24% and 27% of the country's total respectively (data for 2012).[20] In principle, the NDRC supervises the design and implementation of all the ETS pilots. In practice, the NDRC delegates authority to provincial and municipal Development and Reform Commissions to make their own rules. Therefore the pilot programs have different implementation plans, legislations, and government regulations. The key features of the ETSs, including cap-setting, coverage of industries, allocation of allowances, rules for measuring, verifying, and reporting emissions (MRV), and type of allowances vary across the pilot programs. Table 1 provides a summary of key features of the seven ETS pilot programs.

The ETS pilot programs are accompanied by voluntary GHG emission offsetting programs. As a non-Annex B country in the Kyoto Protocol, China issued measures for operation and management of Clean Development Mechanism (CDM) projects in 2005. In 2012, the NDRC published Interim Measures on Voluntary GHG emission reduction trading, and the CDM was largely replaced by a domestic offsetting program that yielded Chinese Certified Emission Reductions (CCERs). Trading of CCERs is usually restricted to 5-10% of the total emissions in the pilot programs, and some programs have further restrictions on the use of CCER credits, such as excluding CCERs from hydropower projects.

18 English translation at: http://cbi.typepad.com/china_direct/2011/05/chinas-twelfth-five-new-plan-the-full-english-version.html.

19 http://news.xinhuanet.com/2013-11/15/c_118164235.htm.

20 Zheng Shuang, "China's carbon market—progress and outlook," presentation for workshop, "Bilateral Cooperation between China and the United States: Facilitating Progress on Climate-Change Policy," June 25-26, 2015, slide 4, http://belfercenter.ksg.harvard.edu/publication/25678.

Table 1. Summary of the seven ETS pilots[21]

	Cap	Coverage	Allocation	Tradable products
Beijing	About 55 Mt CO_2	Power, heating, cement, petrochemical, other industries, and services	*Free:* grandfathering benchmarking	BEA*, CCER, energy savings, carbon sink
Tianjin	About 160 Mt CO_2	Iron & steel, chemical, power and heating, petrochemical, oil & gas drilling	*Free:* grandfathering benchmarking	TJEA, CCER
Shanghai	About 150 Mt CO_2	Iron & steel, petrochemical, chemical, power and heating, non-ferrous, building materials, aviation, airport, ports, railways, hotels, commercial and retails, and finance	*Free:* grandfathering benchmarking *Auction:* 7220 tons (June 30, 2014)	SHEA, CCER
Guangdong	About 388 Mt CO_2	Power, cement, iron & steel, petrochemical	*Free:* grandfathering benchmarking *Auction:* 3%, 11.12 million tons (2013); 5% in power sector, 3% in other sectors (2014); 8 million tons (2014)	GDEA, CCER
Shenzhen	About 30 Mt CO_2	26 sub-sectors (manufacturing industries), public and commercial buildings	*Free:* manufacturing sector: competitive gaming building sector: benchmarking *Auction:* 75,000 tons (Jun 6, 2014)	SZA, CCER
Hubei	324 Mt CO_2	Power, iron & steel, cement, chemical, petrochemical, cars and equipment manufacturing, non-ferrous	*Free:* grandfathering benchmarking *Auction:* 30% allowance for auction; auctioned 2 million tons on Mar 31, 2014	HBEA, CCER
Chongqing	130 Mt CO_2	Power, metallurgy, chemical industry and other industries	*Free:* combination of cap-trade and competitive gaming	CQEA-1, CCER

* EA: "emission allowance"; the letters before EA are the abbreviations of the provinces' or cities' names.

21 Adapted from presentation by Zheng Shuang.

With further development of emissions trading, the market scale has increased continuously and the performance of pilot markets has become more active. There were over 22 million allowances (denominated in tons of CO_2) trading in seven pilot carbon markets by May 31, 2015, which had a market value of approximately 772 million Yuan. The price of the allowances varied from 10 Yuan/tCO_2 to 90 Yuan/tCO_2. Meanwhile, the auction scale of the seven pilots' allowances is approximately 16 million tCO_2, which amounts to roughly 788 million Yuan. The average price of auctioned allowances has been approximately 48 Yuan/t CO_2.

The gradually improving mechanism for emissions trading can bring compliance with carbon market rules and performance, leading to achieving the goal of emissions reduction. From 2014 and 2015 results, most covered enterprises have fulfilled their responsibilities in the emissions trading systems. Most pilot programs reached a compliance rate of 96%, with some as high as 100% in the past two years. As a result, government and enterprises have a deeper understanding of carbon emissions trading systems, which can provide experience for national carbon market design. Furthermore, the ETSs promote the performance of reducing emission in pilot areas. For example, the CO_2 emission of covered enterprises in the Beijing ETS in 2014 is 6% lower than 2013, and the CO_2 emission of covered enterprises in the Shenzhen ETS in 2013 is 11% lower than 2010.

The seven ETS pilots have achieved multiple policy goals since their establishment. They have covered major emission sectors and enterprises in the pilot regions, and have played important roles in reaching local carbon intensity targets and controlling GHG emissions. The various characteristics of legislation, technical standards, and market operation that have been tested in different pilot programs have helped accumulate empirical experience for future ETS programs. The operation of the programs helps build technical foundations and institutional capacities, and also shaped the first carbon markets and revealed market carbon prices in China. The capacity of enterprises for emission reduction and public awareness of climate change issues have been enhanced through these programs. Finally, emissions trading has provided the foundation for reducing the difficulty of corporate financing for energy conservation and emission reduction.

There are, however, also noticeable shortcomings with the pilot ETS programs. The disparities among the pilots in terms of registry and trading standards, MRV rules, and other aspects have yielded significant challenges for linkage between and among systems and implementation of the future national program. The pilots have also featured weak legal enforcement, lack of basic data and scientific methods, and lack of supervision on market operations. More importantly, the effectiveness of the programs was to a certain extent paralyzed by policy uncertainty and lack of transparency. For example, the restriction on using CCERs from hydropower projects was announced suddenly and was unanticipated, which caused volatility in the market. The transition from pilot programs to a national program is also unclear, which discourages enterprises from actively trading in carbon markets.

Despite all the problems, the seven pilot programs have accumulated rich experience for a national ETS. The China-U.S. joint announcements on climate change mitigation in November 2014 and September 2015 lend considerable momentum to China's efforts to design and launch a national ETS. The national system will cover key industry sectors such as iron and steel, power generation, chemicals, building materials, paper-making, and nonferrous metals. Once established, the national ETS is likely to become the cornerstone of China's climate policy architecture. Its design, implementation, and outcomes will to a considerable degree determine whether China can achieve its INDC.

In the next subsection we explore opportunities for cooperation between the two countries with regard to emissions trading.

2.4 China–U.S. Cooperation on emissions trading systems

One approach to bilateral collaboration is to mutually review the lessons learned from emissions trading in both countries and in other parts of the world, as a guide to further developing domestic ETSs. Among the important lessons that might usefully be studied:

- Interaction of various policies (in the same or overlapping jurisdictions) that reduce GHG emissions—either directly or indirectly—may be problematic for ETS performance. One example is California's Low Carbon Fuel Standard in the presence of the California ETS. If such "complementary" policies affect emitters with obligations under the ETS, they provide no additional environmental benefit (allowances will simply be re-allocated by the market), they depress allowance prices (by reducing demand), drive up aggregate abatement costs (by introducing abatement-cost heterogeneity), and can constrain technological innovation in the longer term, as a result of depressed prices (Goulder and Stavins, 2011).

- Policy regarding offsets must be considered carefully. Offsets can reduce compliance costs, but limiting their geographic origin so that emissions reduction occurs only within the ETS jurisdiction makes little sense with regard to climate change, which is a global commons problem. On the other hand, co-benefits—especially from reduced use of coal for generating electricity—are indeed geographically specific. There are other issues to be considered with offsets, as well, beyond the scope of this paper—including inherent verification problems in offset systems.

- In general, the narrower the geographic and sectoral coverage of an ETS, the more "leakage" there will be, where leakage refers to the migration of emitters outside the jurisdiction to seek lower production costs. (With regard to electricity markets, such migration may be "virtual," as in-jurisdiction utilities purchase potentially lower-cost power from outside the jurisdiction.)[22]. "Upstream" systems with broad geographic coverage will experience relatively less leakage.

- An advantage that emissions trading systems have over carbon tax systems is that the initial allocation of allowances may be used to secure political support for the system and otherwise enhance equity (because allowances have cash value). This can be accomplished without adversely affecting the environmental performance of the system, because the manner in which allowances are initially allocated will not typically affect the incentives facing firms with mitigation obligations (Hahn and Stavins, 2011); these incentives depend on marginal abatement costs, which are not affected by the initial allocation of allowances. Finally, leakage and competitiveness concerns may be addressed in an emissions trading system by distributing free allowances in proportion to firms' output or production (a so-called updating, output-based allocation system, used in the California ETS, as noted above).

Exchanging insights into these and other lessons is a major way that China and the United States can continue to cooperate with regard to the development of emissions trading.

As a next step in identifying opportunities for cooperation, it is useful to examine how the political and economic context in China and the United States differs. A first significant difference lies in the policy-making processes in the two countries. In the United States, the political parties have polarized perspectives on climate change, and carbon markets have emerged principally in the more liberal states, in the absence of a national framework. National climate policy can be affected by the results of presidential and congressional elections.

In contrast, in China, consensus on policy making is reached at different levels of government. Once consensus is built, political will can be translated into policies that are then implemented by ministries and various levels of governments. Since the development of a national carbon emissions trading market was included in the Twelfth Five Year Plan, which is China's highest-level national plan and one that the Chinese government takes seriously, stakeholders can have reasonable confidence that the central government will launch its national ETS in the coming years.

22 It has been estimated that emissions leakage from RGGI would be up to 50% of total emissions if the program was fully binding (Sue Wing and Kolodziej, 2008).

Second, China and the United States offer different socioeconomic contexts for the implementation of climate policy. Compared to the United States, which has achieved a relatively homogeneous state of economic development, different regions of China are at very different stages of economic development. While the coastal provinces increasingly face a problem of excess production capacity, the inland provinces are still in the process of industrialization and rapid urbanization. Thus, a national cap-and-trade scheme for China will largely be shaped by central–local interactions in the allocation of emission allowances to different provinces, taking into consideration the uneven social and economic development status of these provinces. How to avoid leakage and balance economic growth and emissions reductions in the less developed provinces presents a major challenge in the design of national ETS for China.

Third, the U.S. economy is a mature market economy with comprehensive rules, regulations, and mechanisms for resolving conflicts. In contrast, China has a market economy with many features remaining from the central planning era. A number of these features could create challenges for a national ETS, which relies on well-functioning market mechanisms. As an example, researchers have pointed to potential problems associated with China's highly regulated electricity market. Regulated electricity prices could mean the cost of carbon emissions in electricity production will not be passed through to electricity consumers in a timely manner. However, in 2015 the government announced a plan to deepen electricity-system reform that would introduce competition and allow market-based electricity-price setting in non-public sectors. How to make a market-based solution work in an environment with many non-market features remains an important question for scholars and policy makers.

Given their similarities and differences, substantial opportunities for China–U.S. cooperation exist at both the micro and macro levels. China has strong political will and the ability to quickly put that will into action, but lacks experience, institutional capacity, and research and technical support from academia. The United States can help China overcome these deficits by collaborating on the design of a national trading system, including detailed rules to handle issues such as allowance allocation, entry and exit from the ETS, price ceilings and floors, and allowance banking and borrowing.

China also needs to improve its market environment at the macro level and reform policies that prevent market mechanisms from functioning as intended. Close communication between scholars in the two countries can also help China build its research capacity in a field that has been unfamiliar to many Chinese academics until recently. Other forms of collaboration—for example, to accelerate the transfer of low-carbon technologies and expertise—can help Chinese enterprises comply with new climate policies. (There has been considerable collaboration between the two countries on energy-technology innovation in the past; see bibliography at the end of this paper.) Meanwhile, quick action by China to launch regional and national

ETS programs can help motivate the United States to initiate more cap-and-trade systems and speed progress toward a more comprehensive national approach to climate mitigation.

There has already been considerable collaboration between the state of California and the various Chinese jurisdictions that are implementing the pilot ETSs discussed in the previous section, as well as some interaction between the national NDRC and California.[23] This collaboration has been useful, given that there are a number of similarities between the ETSs in China and the United States. The programs in both countries have shaped initial carbon markets and achieved certain policy goals, but are also imperfect in some respects. In both countries, issues have emerged with respect to specific design features and impacts (e.g., in terms of leakage, competitiveness, and barriers to linkage).

Finally, an important area for longer-term China–U.S. cooperation is direct linkage—that is, establishing trading connections between different national and sub-national policy systems that allow emission reduction efforts to be recognized and redistributed across systems. Linkage brings several potential benefits. It can reduce abatement costs across linked regions by allowing regions with higher abatement costs to take advantage of abatement opportunities in regions with lower costs. By expanding the geographic scope of an emissions trading system, linkage can also effectively reduce the influence of local market power in carbon markets and mitigate price volatility. Finally—by creating opportunities for regions with lower-cost abatement opportunities to benefit from investment from higher-cost regions—linkage can advance the goal of distributional equity, as exemplified by the UNFCCC's principle of "common but differentiated responsibilities," without sacrificing cost-effectiveness. However, effective linkage also requires coordination on a number of key issues, such as the definition of key terms and standards and procedures for emissions accounting.[24]

23 Kelley Hamrick, "California Moves with Chinese Provinces on Climate," *Ecosystem Marketplace*, March 10, 2015, www.ecosystemmarketplace.com/articles/california-moves-with-chinese-provinces-on-climate; Frank A. Wolak, "US and China Cooperation on Climate Policy Design," *Boao Review*, July 2014, http://web.stanford.edu/group/fwolak/cgi-bin/sites/default/files/Frank_Eng.pdf; Anne C. Mulkern, "California Air Board Partners with China Province to Share Cap-and-Trade Strategies," *ClimateWire*, June 19, 2013, www.eenews.net/climatewire/2013/06/19/stories/1059983101; California Air Resources Board, "News Release: California and Shenzhen, China, Sign Agreement to Cooperate on Fighting Climate Change," *California Air Resources Board*, June 18, 2013, www.arb.ca.gov/newsrel/newsrelease.php?id=445.

24 California's ETS completed a link with the Canadian province of Quebec in November 2014, and the province of Ontario has announced its intention to link to this system by early 2017. There have been discussions between Guangdong Province and the European Union about possible linkage, though a direct link is unlikely to be pursued in the near future.

3. COMPARING COUNTRY-LEVEL MITIGATION EFFORTS IN A NEW INTERNATIONAL CLIMATE POLICY REGIME

INDCs describe what a country intends to do to combat global climate change post-2020, including controlling GHG emissions, building climate-resilience, mobilizing financial resources, facilitating technology development and transfer, as well as enhancing institutional capacity for mitigation and adaptation, based on a country's own assessment of its domestic political and socioeconomic conditions—and its own capabilities and opportunities for mitigation and adaptation. Because there were only a few suggestions from COP decision 1/CP.20[25] on the form or content of INDCs, the INDCs submitted to date vary widely in terms of scope, strategies, timeframes,[26] and types of mitigation goals.

The United States and the European Union, among others, have adopted absolute, economy-wide emissions-reduction targets relative to a particular base year. Some countries have established target years by which their CO_2 or broader GHG emissions will peak, including China (2030), Singapore (2030), and South Africa (2025). A number of countries intend to reduce their emissions relative to a forecast business-as-usual level for the year 2030, such as Argentina, Indonesia, and Mexico. Another set of countries plans to reduce emission intensity, measured as the ratio of CO_2 emissions to GDP, including Chile, China, and India.

While assessment of other effort (e.g., for adaptation) is also needed, it is particularly important to ensure the comparability of countries' mitigation efforts. The ability to assess mitigation ambition—and compare it across different countries—is important for addressing equity and ambition concerns in the context of the UNFCCC and the Paris Agreement. Procedures for comparing effort could also facilitate—and indeed, make possible— enhancing clarification, transparency, and understanding of the INDCs. Comparison could facilitate linkage between and among the highly heterogeneous mitigation policies stated or implied in various INDCs, which could include both market-based policies and non-market regulatory approaches. Such procedures could even allow countries to link various non-market regulatory approaches. Finally, enabling countries to compare post-2020 mitigation targets and assess progress toward post-2020 mitigation commitments could help provide the basis for an equitable collaborative process through which individual parties increase their climate-change mitigation obligations over time.[27]

25 The Lima call for Climate Action, a decision of the UNFCCC Conference of the Parties in December 2014; http://unfccc.int/resource/docs/2014/cop20/eng/10a01.pdf#page=2.

26 Given their different historical emission trajectories, countries may prefer different base and target years to maximize the estimated impact of the mitigation policies they propose.

27 The Paris Agreement contains provisions for countries to update and increase the ambition of their INDCs every five years. However, research and dialogue are needed to fully realize the potential of these provisions.

It is difficult to compare highly heterogeneous mitigation commitments. Table 2 shows the 2020 and post-2020 (Paris regime) mitigation targets adopted by the European Union (E.U.), the United States (U.S.), and China—as well as the E.U.'s Kyoto Protocol commitments. As indicated in the table, the E.U. and U.S. commitments include economy-wide, quantified emissions-reduction targets. China prefers to calculate emissions reductions against a projected, business-as-usual (BAU) emissions trajectory—that is against a forecast of China's GHG emissions in the absence of any new mitigation polices. China's 2020 and post-2020 mitigation goals are expressed in terms of a reduction in carbon intensity (carbon emissions per unit of GDP), and China's INDC states that total CO_2 emissions will peak by 2030. In addition to these goals, China's INDC includes an increase in forest volume and in the share of non-fossil fuels in the country's overall energy mix.[28]

28 In addition to mitigation components, many countries also include adaptation, climate finance, technology development, and capacity building as part of their contribution (INDC) to addressing climate change. This further complicates comparisons among country-level efforts.

Table 2. Climate-change mitigation targets for the E.U., the United States, and China[29]

Party	KP (CP1;* 2008-2012)	KP (CP2;* 2013-2020)	2020 Target	Post-2020 (Paris Agreement INDC)
China[30]	——	——	Carbon intensity reduction of 40%-45% from 2005 level; Increase non-fossil-fuel share of primary energy use to 15%; Increase forest volume by 1.3 bn m3 from 2005	CO_2 emissions peak in 2030; Carbon intensity reduction of 60%-65% from 2005 level; Increase non-fossil-fuel share of primary energy use to 20% by 2030; Increase forest volume by 4.5 bn m3 from 2005 to 2030
EU-28	8% below 1990 level	20% below 1990 level (30% with sufficient commitments from other developed	GHG emissions 20% below 1990 level (30% with sufficient commitments from other developed countries)	"Binding" GHG emissions-reduction target of at least 40% below 1990 level by 2030. 27% of renewable energy in final energy consumption (binding on EU level)
U.S.[31]	——	——	GHG emissions 17% below 2005 level	26%-28% GHG emissions reduction below 2005 level by 2025

* "KP CP1/CP2": Kyoto Protocol first and second commitment periods.

29 Links to pledges:

China (2020): http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/chinacphaccord_app2.pdf;

China (post-2020): http://www4.unfccc.int/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf;

EU (2020): http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/europeanunioncphaccord_app1.pdf;

EU (post-2020): http://www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf;

US (2020): http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/unitedstatescphaccord_app.1.pdf;

US (post-2020): http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf.

30 China, as a non-Annex I party to the UNFCCC, had no binding mitigation obligations under the Kyoto Protocol.

31 The United States had a commitment inscribed in the Kyoto Protocol of 7% below the 1990 level (by 2012). However, the United States did not ratify the Kyoto Protocol.

Despite such disparities, techniques may be available—or possible to construct—for comparing disparate mitigation systems—for example, an emissions trading (cap-and-trade) system in one country and a performance standard in another.[32] Current research suggests four principles for evaluating possible metrics for comparing heterogeneous mitigation effort. First, an ideal metric should be *comprehensive*, capturing the entire effort undertaken by a country to achieve its mitigation commitment. Second, a metric should focus on *observable*—and preferably quantifiable—characteristics of effort. Third, individual countries or stakeholders should be able to *reproduce* a metric given (a) the inputs used by analysts, and (b) available public information. Finally, given the global nature of climate change, a metric should be *universal*, constructible by and applicable to as broad a set of countries as possible. Candidates are emission-related metrics (the historical norm), abatement cost, and carbon- or energy-price metrics. Each has its advantages, disadvantages, and appropriate potential applications in a system of voluntary, heterogeneous mitigation targets.

The first set of metrics concerns emissions or other emissions-related physical measures. Emissions-based metrics have several advantages. First, they are directly linked to the environmental outcome of concern—in this case mitigating climate change by reducing the accumulation of GHGs in the atmosphere. Emission levels are often known (though capacity to measure emissions varies from country to country) and are therefore not subject to major disputes.

On the other hand, it has been difficult to form an international consensus about the specific form of an emissions-based metric, since different choices with respect to base year, transient versus accumulated emissions, or absolute versus per capita or intensity-based emissions would give different countries an advantage. As such, the process of comparison—or specific methods or metrics—could be politically sensitive in individual countries, especially in the context of multilateral processes.

Moreover, absolute emissions can be affected by economic booms and recessions independent of mitigation efforts—in these situations, projected emissions relative to a BAU scenario may provide a better indicator of country-level effort. However, emissions relative to forecast values are not directly measurable, and BAU projections can bring a great deal of uncertainty. Comparison among individual countries' mitigation efforts based on emission related metrics may also encounter technical difficulties, such as different timeframes, types of GHGs, coverage of sectors, and accounting methodologies adopted by individual countries.

32 Much of the following discussion of metrics for comparing mitigation efforts is from Aldy and Pizer (2014). See also Aldy and Pizer (2015) and Aldy, et al. (2015).

A second set of possible metrics, drawn from research though not yet put into practice,[33] would focus on GHG prices. Prices could be explicit, as in the case of cap-and-trade systems or carbon taxes, or prices could be implicit, as in the shadow prices in a non-market regulatory system for reducing CO_2 emissions. Price-based metrics could also focus on net energy prices or changes in energy prices over time. One advantage of such metrics is that market prices are observable, and in countries that adopt cap-and-trade programs or carbon taxes, the explicit carbon price offers a relatively direct measure of the level of mitigation effort being undertaken by a country or region. Carbon prices are also a direct measure of the strength of incentives for long-term investment in mitigation and the deployment of low-carbon technologies. However, price-based metrics also have important downsides. Volatile exchange rates can make it difficult to compare across countries and a price-based approach cannot easily capture the level of effort associated with non-price policies, such as fuel standards.

A third set of potential metrics—again not yet implemented in the context of the UNFCCC process—involves the costs of mitigation. Such metrics could focus on an absolute measure of costs incurred to mitigate GHG emissions, or on costs incurred relative to GDP. Mitigation costs can be estimated by modeling the effect of actual policies, or by analyses that attempt to identify the least-cost option for achieving a certain emissions objective. The cost of implementing a given policy closely reflects the level of effort associated with that policy, which is an advantage of cost-based metrics. But an important drawback of these metrics is that mitigation costs are not directly observable and must be estimated using economic modeling. Moreover, if the cost of a policy is taken as an indicator of effort, the use of a cost-based metric could have the effect of rewarding costly but ineffective policies. In that case, estimating costs for both actual policies and the theoretical least-cost approach could help identify opportunities for improving on existing policies.

There is no single metric that satisfies all four design principles for an ideal metric (i.e., comprehensiveness, reproducibility, universality, and that the metric is based on observable data). Individual countries' preference for specific metrics that reflect their own interests—whether emissions-related, which have been implemented extensively in practice, or other proposed approaches—may result in a lack of consensus among national governments that are members of the UNFCCC. Some governments have such significantly divergent ideas on equitable effort sharing as to make official efforts to compare and assess mitigation effort in the INDCs under the UNFCCC regime infeasible. Therefore, academics could provide useful and informative advice by developing a suite of metrics to assess and compare the mitigation efforts of different countries to facilitate mutual understanding and encourage increased ambition, taking into account the transition of emission trajectories, historical

33 This approach has not yet been used to compare mitigation effort, but any two jurisdictions that wish to link their cap-and-trade systems (e.g., California and Quebec) will compare prices in the two jurisdictions as part of their assessment of overall design compatibility.

responsibility, cumulative emissions, national circumstances and capacity, and other factors. This is analogous to the approach commonly taken to evaluate the macroeconomic health of an economy, in which a set of metrics, such as GDP, unemployment rate, inflation rate, and interest rates may be considered. Similarly, using a suite of metrics rather than a single metric will better characterize the overall level of mitigation effort associated with a diverse set of climate policies.

Beyond cooperating to develop metrics that can be used to compare country-level climate mitigation efforts, China and the United States can work together to develop rigorous, transparent, and systematic mechanisms for collecting and analyzing data and monitoring policy implementation (Aldy 2014). Transparent mechanisms for evaluating policy implementation can speed the learning process among different countries by identifying best practices and common mitigation challenges. Such mechanisms may also be helpful in assessing collective mitigation efforts and evaluating the aggregate cost and efficacy of those efforts.

The participation of potentially neutral third parties, such as international organizations, non-governmental organizations, and academic researchers can support the gathering of accurate information, when desired by UNFCCC member governments. Experience with past non-climate agreements suggests that delegating responsibility for information collection and dissemination to such institutions can lower the costs of implementing an international agreement and enhance countries' technical and policy-making capacities. Analysis generated by such organizations could improve transparency and help provide a scientific basis for the review process under the Paris Agreement—helping build a basis for conversations and facilitated dialogues between governments interested in learning about policies and outcomes in other countries.

In particular, other existing international agreements and organizations, such as the International Monetary Fund, the World Trade Organization, the Montreal Protocol, the Organization for Economic Co-operation and Development, and the Convention on International Trade in Endangered Species (CITES), may offer experience and lessons in connection with collecting and processing data to help establish and operate a transparency system under the Paris Agreement. Some international organizations, such as CITES, formally rely on non-governmental organizations to review national reports and monitor implementation.

China and the United States could cooperate to identify the best approaches to building a transparent regime for review and assessment of progress under the Paris Agreement—conducted by national governments and perhaps supported by third-party organizations. The two countries will each bring strengths to bear on this important set of issues, yielding an outcome that will advance efforts to address climate change under the new Paris regime.

4. CLIMATE CHANGE POLICY AND TRADE POLICY

A third major area of opportunity for China–U.S. cooperation concerns the intersection of climate policy and trade policy. Trade is closely associated with GHG emissions; it has been estimated that approximately one-quarter of global CO_2 emissions are from the production of internationally traded goods and services (Peters et al., 2011).[34] Transportation associated with international trade is also a major source of GHG emissions.

Climate change policies can interact with trade policies in a number of ways. On the one hand, policies that change the relative prices of carbon-intensive goods and services, such as cap-and-trade programs or carbon taxes or subsidies, may have an impact on the competitiveness of these goods and services in domestic and international markets and thereby affect trade flows and the total volume of traded goods. On the other hand, many trade policies, such as export bans, anti-dumping policies, and tariffs can affect absolute or relative GHG emissions in various parts of the world. Trade barriers and policies to protect intellectual property rights can also influence the development and diffusion of climate-friendly technologies. For these reasons it is important to understand how China–U.S. trade might be affected by domestic and international climate policies and agreements (bilateral, plurilateral, and multilateral) and to explore how trade and climate policies might be coordinated to magnify possible benefits and reduce possible risks.

China and the United States, the top two GHG emitters, are also the world's top two nations in global exports. In 2012, exports from China and the United States accounted for 11% and 8% of global trade in merchandise, respectively.[35] The quantity of CO_2 emissions embodied in globally traded goods was estimated to total 5,551 million tons in 2007. Exports from China were estimated to account for 28% of this CO_2 total, while imports to China were estimated to account for 7%. U.S. exports were estimated to account for 11% of the emissions embodied in internationally traded goods, while U.S. imports accounted for 18% of the global total (Liu et al., 2015).

The two main existing frameworks for international trade and climate change policy are the World Trade Organization (WTO) and the UNFCCC, respectively. Each framework already includes some provisions that could help facilitate coordination with the other. For example, Article 3.5 of the UNFCCC states that "measures taken to combat climate change, including

34 See also Fu Sha and Zou Ji, " Trade and Climate Change Interactions: Opportunities for China-US Cooperation," presentation for workshop, "Bilateral Cooperation between China and the United States: Facilitating Progress on Climate-Change Policy," June 25-26, 2015, http://belfercenter.ksg.harvard.edu/publication/25678.

35 WTO database, US dollar at current prices. Figures include data from the EU Intrastat system of recording trade, which uses intra-EU exports in lieu of intra-EU imports (which are known to be under-reported). China here refers to mainland China; Hong Kong, Taiwan, and Macao are not included.

unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."[36]

Nonetheless, substantial potential for conflict exists under the two frameworks. This is primarily because the WTO and UNFCCC reflect fundamentally different assumptions about the appropriate role of markets and governments in trade and climate policy. The WTO was designed to promote the liberalization of markets and the free flow of goods and services across national borders. It adheres to the principle of non-discrimination in trade and includes various rules to protect intellectual property, address subsidies and countervailing duties, and discourage dumping.

The UNFCCC, on the other hand, is designed to address the global commons problem of climate change, and the Convention applies the principle of common-but-differentiated responsibilities in defining the obligations of various countries. Implicit in the UNFCCC is the assumption that governments should actively intervene to reduce GHG emissions, including by adopting various policies that are designed to influence the behavior of markets and industries, such as subsidies, taxes, regulatory requirements, and other measures to advance low-carbon technologies and practices. Some of these policies have the potential to conflict with WTO rules.

Recent conflicts concerning Chinese exports of renewable-energy technologies provide notable examples of the potential for future climate-related trade disputes. In 2011, the Coalition for American Solar Manufacturing filed an antidumping and countervailing duty petition requesting that the U.S. government impose special tariffs on imports of crystalline silicon photovoltaic cells (PV) from China. In late 2012, the United States imposed punitive tariffs on billions of dollars of solar panels from China. China, however, defends its subsidies to PV manufacturers as a strategy for promoting renewable energy production and reducing GHG emissions. Such conflicts between climate and trade policies illustrate the necessity and opportunity for China-U.S. cooperation.

China and the United States could pursue multiple avenues for coordinating trade and climate policies. First, the two nations can collaborate within existing multilateral frameworks, such as the WTO and UNFCCC, where both are important participants and carry considerable weight. More specifically, China and the United States could initiate reforms so that WTO rules treat environmental goods differently from ordinary goods and UNFCCC rules account for the trade impacts of climate mitigation efforts and policies. The WTO's dispute settlement process affords a number of opportunities, particularly in the consultation and implementation phases, for countries to settle disputes related to environmental policies without causing

36 Text of the Convention: http://unfccc.int/key_documents/the_convention/items/2853.php; quoted text on p. 10.

significant conflicts. Or China and the United States can agree to settle particular climate-related conflicts without resorting to the WTO Dispute Settlement Understanding.

Second, China and the United States can also cooperate at the plurilateral or regional level, through groups and agreements such as APEC. However, the Trans-Pacific Partnership of 12 countries reached in early October 2015 includes the United States but not China. Moreover, the negotiations to create a 16 country Regional Comprehensive Economic Partnership include China but not the United States. There may therefore, be new challenges to China-US cooperation in such large regional agreements.

More generally, though, because regional agreements typically involve fewer parties, they are more dynamic and flexible than the WTO and UNFCCC and might more readily accommodate new rules related to climate policy. The negotiations for an Environmental Goods Agreement (EGA), which involves 17 countries, including both China and the United States, provide a good example of a plurilateral approach. A proposed list of 2,000 products in 650 tariff lines, including wind and solar products, is currently being negotiated in Geneva; once it has been agreed among the 17 countries, the agreement is widely expected to be multi-lateralized within the WTO framework.

Thirdly, since each is such an important trade partner to the other, China and the United States have a substantial mutual incentive to engage in bilateral cooperation. Fruitful areas for such cooperation include cutting tariffs on environmental goods, such as wind turbines, solar panels, and solar water heaters, relaxation of the export ban on low carbon technologies, and coordinating policies for the protection of intellectual property rights related to environmental products. Successful bilateral cooperation in these areas can help both countries gain better access to the technologies and products needed for cost-effective climate mitigation, and accelerate the process of innovation and diffusion for green technologies. The prospects for such expanded bilateral cooperation have been given impetus by the 2014 and 2015 joint announcements by China and the United States.

Bilateral cooperation can also inform future efforts to integrate climate policies and frameworks with other plurilateral or regional frameworks that address trade and economic development. For instance, China-United States cooperation can facilitate efforts underway within the International Maritime Organization to address international governance issues involving both climate change and trade, such as international maritime shipping emissions of black carbon and methane. Further, China's new status as an Observer in the Arctic Council will create yet more opportunities for Chinese-US cooperation on the climate and trade issues on that organization's agenda.

5. SUMMARY AND CONCLUSIONS

Over the past two decades, disagreements between developing and developed countries have often frustrated efforts to reach consensus on an effective international response to the problem of global climate change. Key disputes have centered on the appropriate prioritization of economic development versus climate mitigation, responsibility for historic emissions versus contribution to current and forecasted emissions, and total emissions versus emission per capita. While differences between developing countries' perspectives and developed-country perspectives on these issues are unlikely to be resolved in the short term, the imperative to move beyond these disputes toward a more cooperative and coordinated approach to global climate mitigation is becoming urgent. At this critical juncture, the recent joint announcements between China and the United States concerning climate change actions represented an important development in global climate negotiations and were appropriately hailed as offering a new model for improved cooperation between emerging and developed economies. Given the size of the two countries' economies and their large contributions to global GHG emissions, the actions outlined in the joint announcements *per se* will have a significant impact on future mitigation efforts—and, indeed, did much to facilitate a successful outcome in Paris. By demonstrating these actions, China and the United States may encourage other countries to increase their climate mitigation ambitions.

This paper has identified three specific areas of international climate policy, namely market-based mechanisms, comparison of efforts, and trade policy and climate policy interactions, where China and the United States can deepen their cooperation. Cooperation on market-based climate policies, particularly cap-and-trade, is important, not only because market-based approaches offer the most cost-effective approach to mitigating GHG emissions, but also because emissions trading systems make it possible to address equity concerns by adjusting the level of the emissions cap and the allocation of emission allowances.

A logical focus for China–U.S. cooperation with respect to market-based mechanisms is capacity building. A functioning cap-and-trade system requires properly designed government and market institutions. At a micro level, the United States and China can exchange experience and expertise on topics such as allowance allocation, price ceilings and floors, allowance banking and borrowing, and other detailed emissions trading rules. At a macro level, both China and the United States confront challenges to implementing cap-and-trade systems—in the United States because of political polarization and in China because of features of the regulated electricity market and the power of state-owned enterprises. Cooperation and communication can help both countries overcome these barriers, while also advancing theoretical and empirical understanding of cap-and-trade and other market-based approaches.

Cooperation on standards and procedures for comparing mitigation efforts can strengthen the technical basis for other aspects of China–U.S. cooperation, particularly in the area of cap-and-trade systems, and facilitate the linkage of homogeneous or heterogeneous climate policies. Cooperation in this area can also increase transparency and consistency in climate negotiations, improve trust among parties, and advance efforts to track collective progress toward achieving global mitigation targets.

But China and the United States have different preferences and interests in terms of the scope and timeframe of mitigation efforts and other issues. Thus it will be important to recognize from the outset that no single perfect comparison metric is likely to satisfy both countries' needs. Instead, a suite of metrics is likely to offer the best option for comprehensively reflecting and comparing the mitigation efforts undertaken by each country. More broadly, it will be important to develop a rigorous, systematic, and transparent system for tracking domestic policy developments in the context of an international climate policy framework.

Interactions between trade and climate policy constitute a third important area for future U.S.–China cooperation. Reforms can be initiated within the WTO and UNFCCC, which currently provide the dominant frameworks for global coordination on trade and climate change. But China and the United States should also explore opportunities to advance progress in this area through more flexible plurilateral and bilateral relationships. Cooperation between the two countries to develop GHG standards and methods for comparing the impact of domestic climate policies would be particularly helpful in reducing the potential for future trade conflicts and facilitating the coordination of climate and trade policies.

Climate change has added a new dimension to a bilateral relationship that is already one of the most important of the twenty-first century. While China and the United States have different national interests in many areas, climate change represents an important area where their interests, and those of every other country interested in the wellbeing of its citizens and future generations, converge. But the success of the China–U.S. relationship in this arena will be determined less by the ability to find common ground than by the ability to find solutions that properly address the real socioeconomic and political differences that exist between these two nations. If an effective response to climate change eventually requires the participation of all countries, despite their different cultures, states of economic development, and political systems, successful China–U.S. cooperation under the hybrid Paris climate policy architecture may well prove crucial in paving the way for broader international cooperation to reduce the risk of global climate change.

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