China's national carbon dioxide emission trading system: An introduction

LAWRENCE H. GOULDER,[a,b] RICHARD D. MORGENSTERN,[c] CLAYTON MUNNINGS,[d] and JEREMY SCHREIFELS[e]

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1. OBJECTIVES OF THIS SYMPOSIUM

China is on the verge of launching what is expected to be the world's largest carbon dioxide (CO_2) emissions trading system (ETS). When fully implemented, this program will likely double the share of the world's greenhouse gases covered by cap and trade.[1] Under current plans, the facilities covered by the program will eventually account for over 50 percent of China's GHG emissions. Internationally, much seems to be riding on this program. If perceived as successful, it could serve as a model for other countries wishing to implement an ETS. If viewed as a failure, it could impede the adoption of emissions trading programs in many parts of the world.

China has learned a great deal from its experience with the seven pilot emissions trading programs it implemented starting in 2013 in major cities and provinces. At the same time, developing and operating an effective nationwide program is a huge challenge, given the country's sheer size, industrial and geographic heterogeneity, income disparities, and diverse institutional characteristics.

The significant presence of state-owned entities in the Chinese economy poses additional challenges. While market transactions have become increasingly prevalent in China in recent decades, state-owned enterprises are far more important in China than in the Western economies that have introduced emissions trading. These enterprises are especially important in the natural gas and electricity industries, where they have significant market power and where prices are administered rather than market-determined. Both monopolistic behavior and administered pricing can reduce the efficiency of the ETS by limiting the extent to which the costs of emissions abatement are reflected in the prices of goods and services. These features make the implementation of an effective ETS especially challenging.

This volume examines the goals, structure, and challenges of emissions trading in China. It is the product of a two-day workshop held in Palo Alto in January 2017, a gathering co-spon-

1. Currently, approximately 4 billion tons of CO_2 are covered by emissions trading programs worldwide, including 1.2 billion in the Chinese pilots. The national ETS in China is expected to add 5 to 5.5 billion tons at the start of the program. https://carbon-pulse.com/34223/.

[a] Corresponding author: goulder@stanford.edu.
[b] Department of Economics, Stanford University, CA 94305, USA.
[c] Senior Fellow, Resources for the Future (RFF), Washington, D.C., USA.
[d] Senior Research Associate, Resources for the Future (RFF), Washington, D.C., USA.
[e] Visiting Fellow, Resources for the Future (RFF), Washington, D.C., USA.

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sored by the Stanford Environmental and Energy Policy Analysis Center and Resources for the Future. The workshop brought together leading scholars and decision makers from China, the U.S., and elsewhere to discuss the design and implementation of ETSs in China to address climate change. Much of the discussion centered around five papers prepared for the workshop by leading Chinese and international experts in the field. Following the workshop, and taking advantage of comments from expert reviewers, the authors revised their papers to produce the articles contained in this symposium.

To serve as a springboard for the papers that follow, this introductory article offers background on China's climate goals, outlines key features of the pilot programs and likely elements of the forthcoming nationwide program, summarizes the findings of the subsequent articles, and indicates common themes across them. In addition, it identifies some important issues not given primary focus in the other papers.

We hope that the insights from this collection will contribute positively toward the success of China's very important emissions trading endeavor.

2. BACKGROUND

2.1 China's climate goals

In the 11th Five-year Plan (FYP) (2006–2010), China's national government adopted a number of progressively ambitious energy and air quality targets to address domestic environmental and energy challenges. The government issued these targets and established programs to achieve them through laws, FYPs, national guidelines, and local or provincial pilot programs (Schreifels et al. 2012). The first nationwide goal for CO_2 intensity (targeting a reduction of 17%) was established during the 12th FYP (2011–2015). Most recently, the 13th FYP (2016–2020) established several climate and energy targets, including: 1) reduce national energy intensity (energy/GDP) by 15 percent from 2015 levels, 2) cap total energy consumption, 3) increase non-fossil energy (e.g., renewable energy) to 15 percent of total primary energy, and 4) reduce carbon dioxide intensity (CO_2/GDP) by 18 percent from 2015 levels. These targets are intended to help the government achieve its broader strategic goals: restructure the economy, enhance energy security, address air pollution, and realize China's Copenhagen pledge of a 40–45 percent CO_2 intensity reduction from 2005 levels by 2020. The targets also establish a foundation for meeting China's more ambitious Paris pledge of a 60–65% reduction in CO_2 emissions by 2030, a pledge in line with China's goal of achieving peak CO_2 emissions in the same year.

In 2011, China's policymakers announced plans to implement domestic ETSs to reduce CO_2 emissions cost-effectively. This represented a significant shift from primarily command-and-control policies and administrative measures to a market-based approach, one that would give companies greater autonomy in determining how to achieve the emissions targets. Several factors contributed to this shift in policy approach. One was the experience of the effective, but costly and unsustainable administrative energy efficiency programs of the 11th and 12th FYPs (Yu et al. 2015; Z. Zhang 2015; D. Zhang et al. 2014). A second was a 2013 decision of the Third Plenum of the 18th Central Committee of the Communist Party that directed the government to prioritize the use of markets for allocating resources (Z. Zhang 2015). Another was encouragement from international organizations (e.g., the European Union and World Bank). A fourth was support for market approaches from domestic industry that had

benefited from experience with the market-based Clean Development Mechanism (CDM) of the Kyoto Protocol.

In China, the National Development and Reform Commission (NDRC) is the government planning organization tasked with responsibility for climate policy. To advance the nation's understanding of how emissions trading might function in the Chinese economic and institutional context, the NDRC selected five major cities—Beijing, Chongqing, Shanghai, Shenzhen, and Tianjin—and two provinces—Guangdong and Hubei—with different economic structures and development levels to introduce pilot CO_2 ETSs. As mentioned, implementation of these programs began in 2013. While each pilot program covered the primary heavy industries—electricity and steam, petrochemicals, iron and steel, nonferrous metals, pulp and paper, glass, and cement—the coverage of other industries differed substantially. Shenzhen, a major financial and high-tech center in Southern China, planned to include commercial buildings and road transportation in its pilot program; Shanghai included commercial buildings, railways, ports, airports, and aviation; and Beijing included hotels, universities, and medical facilities (D. Zhang et al. 2014). Observers hoped the diversity of the pilots might provide useful lessons that could inform a national trading program that would apply to all of China (Pang and Duan 2016), not just the more-developed coastal and central areas of the country.

Analysts have suggested that the success of the pilot programs is mixed (D. Zhang et al. 2014; Munnings et al. 2016; J. Zhang et al. 2017). Nonetheless, in 2015 a joint China-US presidential statement announced that China would implement a national carbon ETS beginning in 2017 (The White House 2015). Introducing a nationwide ETS will require new institutional capacity and infrastructure—well beyond what the pilots required. And the policies will need to be consistent across sectors and regions covered. Developing the foundations for implementing a CO_2 ETS in the course of only a few years poses great challenges for China's national and provincial governments.

An ETS creates an economic incentive to reduce emissions by pricing them—covered companies must submit allowances for every ton of emissions generated. Even companies that receive allowances at no cost face a price at the margin, since every additional ton of emissions either obliges the company to purchase an additional allowance or reduces the number of allowances a company can sell.

It is worth considering why the Chinese government committed to an emissions trading approach rather than a carbon tax, another form of CO_2 emissions pricing. Some Chinese policymakers, led by the Ministry of Finance, advocated a carbon tax, claiming it was a simpler and more efficient way to price carbon emissions. Indeed, in 2009 the Ministry of Finance released a comprehensive carbon tax proposal and in 2013 submitted a formal proposal to the State Council. However, there was concern by industry about the impact a tax would have on competitiveness and profits. Others were concerned that, rather than reduce emissions, companies would simply pay the tax (or avoid the tax altogether) and thereby hinder the government's ability to achieve its Paris pledge. A coalition of NDRC officials, CDM project developers, and environmental exchange companies successfully led a campaign for an ETS. The struggle over the form of emissions pricing was not simply a disagreement about the type of approach that would be most effective; it was also a contest for authority over climate policy. Given the defined institutional responsibilities, the NDRC would clearly have domain over an ETS. In contrast, authority over a carbon tax would reside with the Ministry of Finance. The NDRC prevailed in this contest.

2.2 Design of the national program

At the time of this writing, some details of the design of the national program remain in flux. However, enough features have been decided to give a good idea of the program's structure. What we know of the structure derives in significant part from interim guidelines published by the NDRC in late 2014, as well as from discussions in various meetings of the national carbon market task force that have been held since then. The final structural elements will be provided when the National People's Congress issues a CO_2 emissions trading law or the State Council issues a CO_2 emissions trading regulation. Provision of these final elements is likely to occur after 2017.

The NDRC interim guidelines lay out a cooperative arrangement for the design and implementation of the ETS, with responsibilities divided between the national and provincial governments. While NDRC takes the lead on program design, the provincial governments have the primary responsibility for program implementation, including distributing allowances based on national government guidelines, assessing emission verifiers' qualifications, validating emissions and production data necessary to assess compliance, and enforcing penalties for noncompliance.

The NDRC interim guidelines and subsequent discussions reveal important dimensions of the forthcoming national program, including its coverage; allocation methodologies; emissions measurement, reporting, and verification requirements; market rules; and non-compliance penalties.

2.2.1 Coverage

The national ETS is expected to cover approximately 7,000 companies when it is fully implemented, well beyond the 1,800 companies covered by the initial phase of the seven provincial- and municipal-level pilots. The national program will cover CO_2 combustion emissions from the burning of fossil fuels and CO_2 process emissions from manufacturing (e.g., chemical processes in cement production). Indirect CO_2 emissions—emissions attributable to the consumption of electricity or heat—will also be covered for large energy consumers. Indirect emissions are included, in part, because existing electricity regulations restrict the ability of electricity generators to pass through costs, including carbon emissions costs. This inclusion provides an economic incentive for large energy consumers to reduce electricity consumption (Munnings et al. 2016).

In January 2016, the national government released an official list of sectors that ultimately would be covered by the CO_2 ETS. The list included key industrial sectors such as iron and steel, power generation, chemicals, cement, glass, papermaking, and nonferrous metals. The May 2017 draft National Allocation Plans indicate that the trading program will initially focus on three sectors—power, cement, and aluminum. These three sectors account for approximately 40 percent of China's current CO_2 emissions.

Provincial governments will have the option of expanding the coverage of the program in their respective province to include additional sectors and companies that emit below the national applicability threshold.[2] The interim guidelines specify that prior to the start of

2. The governments operating CO_2 emissions trading pilots requested this authority out of a concern that the national program would cover fewer sectors and companies in the pilot jurisdictions than covered by the emissions pilots. Companies involved in the pilots that made significant CO_2 abatement investments would not have an opportunity to realize the benefit from those investments unless they were included in the national program.

the national program the provincial governments must submit the names of companies within their respective province that will be covered by the national program. If applicable, they must also submit to the NDRC any plans for the province's expanded coverage.

2.2.2 Emissions limits and the basis for distributing allowances

In a traditional emissions trading program, the government establishes a limit (or cap) on total emissions. Allowances—authorizations to emit a specific quantity of emissions (e.g., one ton)—are introduced so that the total emissions authorized in each compliance period add up to the cap, and the number of allowances introduced for a given period does not vary with the production levels of covered sources.

The process of determining the carbon limit under China's CO_2 ETS is different. Unlike most ETSs, in China's initial nationwide program the allowance allocation will occur in two stages within each compliance period. At the start of the compliance period, a covered company will receive a number of allowances equal to its output from the previous compliance period, q_{t-1}, multiplied by the sector's benchmark emissions-output ratio, $\bar{e}$, and an "initial allocation factor," α. Toward the end of the compliance period, a covered company receives the quantity of additional allowances needed to bring the ratio of total allowances to end-of-period output in conformity with the sector-specific benchmark emissions-output ratio. The needed quantity of additional allowances is indicated by the following formula:

$$a_t = \bar{e} \cdot q_t - \alpha \cdot \bar{e} \cdot q_{t-1}$$

The first term on the right-hand side is the total number of end-of-period allowances that would be consistent with the benchmark ratio. The second term is the number offered to the covered company at the beginning of the period. Thus, the difference between the two is the number of additional allowances needed. It is theoretically possible for a_t to be negative—for a company to receive excessive allowances at the beginning of the period. This can happen when qt is lower than $\alpha \cdot q_{t-1}$. However, the likelihood of this occurring is strongly influenced by the chosen value for the initial allocation factor, α. For example, if China used a factor of 60 percent, over-allocation would only occur if end-of-year output q_t were more than 40 percent below last year's output q_{t-1}—an unlikely result.

China's program allows for trades of emissions allowances. With the structure above and with trading, the resulting program is a tradable performance standard. Companies that emit at a rate higher than the performance standard must abate emissions and/or purchase allowances, while companies that emit at a rate lower than the standard can sell their surplus allowances. Trading of allowances can occur both within and across provinces. As with other tradable performance standard systems, the compliance obligation in China's system is defined in terms of an emissions-output ratio, not the absolute level of emissions.[3] A feature that distinguishes China's program from other performance standard programs and other types of ETSs the two-step within-period allowance-allocation procedure, where the second step involves end-of-period updating to provide companies with allowances equal to the performance rate multiplied by their output at the end of the compliance period.

3. Recent discussions among the nationwide program designers indicate that, at a later point, when the system's coverage is expanded, a traditional cap-and-trade program (rather than a tradable performance standard) might apply to some of the added sectors. That is, the number of allowances awarded to companies in these sectors could be fixed in each compliance period rather than depend on the level of output at the end of the compliance period.

A key attraction of issuing allowances based on a ratio of emissions to actual output during the compliance period is that it can more easily adapt to economic changes. If the economy is booming (and output is high), the allowable level of emissions increases, and when the economy is in a slump (and output is low) the allowable emissions are more limited. A disadvantage is that for sectors that produce a wide variety of different products it can be difficult to establish performance benchmarks for each type of product. A further difficulty is that there is uncertainty about the allowable amount of emissions until the end of the compliance period, because allowable emissions depend on end-of-period production levels. It should be noted as well that in China's program and other programs involving allocation based on a benchmark emissions-output ratio, the adjustment of allowances for levels of output creates an implicit subsidy for production, since the more a company produces, the more allowances the company will receive.[4]

The national government (NDRC) will determine the benchmarks and allocation methodologies, although the provinces will be responsible for providing the necessary data to the NDRC and distributing allowances to the companies according to the methodologies established by NDRC. The provincial governments will have the option of lowering the benchmarks (i.e., reducing the allocations) for specific sectors, but must receive approval from the NDRC to do so.

In concert with the provincial governments, the national government is working to define further the details of the program. At this writing the open design issues include: 1) how ambitious to set the sector performance benchmarks, 2) whether to offer unique benchmarks for different fuels and/or production processes, 3) how to adjust benchmarks over time and through what process, 4) what methodologies to use for sectors that are not amenable to benchmarks, 5) how to update allowance distributions to reflect actual production levels during the compliance period, and 6) whether provinces that expand coverage of the program will receive incremental allowances for the additional companies covered by the program. Several of these outstanding design issues are discussed in more detail later in this article as well as in the other articles in this symposium.

2.2.3 Emissions measurement, reporting, and verification

The credibility of an ETS depends crucially on the quality of the emissions data used to design the program (e.g., establish the emissions limits) and assess compliance. Mediocre data quality can lead to policy choices that can hinder the effectiveness of the program (Schmalensee and Stavins 2015). China's national and provincial governments have recognized data quality and availability as a significant challenge for the design of the ETS (Jotzo and Löschel 2014).

The national government has established guidelines for calculating CO_2 emissions from 24 sectors, including the sectors likely to be covered by the forthcoming national program. Covered companies will be responsible for developing monitoring plans based on the national guidelines and measuring emissions using the methodologies described in the monitoring plan. At the end of each compliance period, third-party verifiers will review the emissions reports and assess their accuracy.

Provincial governments will be responsible for implementing the measurement, reporting, and verification program, including collecting and reviewing monitoring plans from covered

4. See Fischer (2005) for a general analysis of how the links between allowances and output can generate an implicit subsidy to output.

companies, enforcing measurement and reporting rules, accrediting third-party verifiers, validating emissions reports, and reporting performance data to the national government. However, the national government's guidelines currently offer few clues regarding accreditation of third-party verifiers. Under current law, the NDRC does not have the authority to accredit verification companies nor to establish mandatory standards. Therefore, the provinces will likely have to take on those responsibilities. The result could be inconsistent rules and incentives for third-party auditors.[5]

2.2.4 Compliance and enforcement

To facilitate compliance assessment, the interim guidelines call for the national government to establish and operate a national allowance registry that serves as the official record of allowance ownership for all covered companies and other market participants. Provinces will use allowance ownership information from the national allowance registry, along with each company's verified emissions, to determine whether the company complied with the allowance holding requirements of the ETS.

The interim guidelines also describe the different type of violations, including: 1) failure to submit an emissions report, 2) submitting a false emissions report, 3) failure to submit a third-party verification report, 4) failure to submit allowances equal to total emissions, 5) providing a false emissions verification report, 6) issuing a materially-incorrect emissions verification report, 7) failure to publish transaction information, and 8) carrying out illegal market activities. The national level NDRC does not have statutory authority to issue financial or criminal violations for non-compliance. Therefore, each of these violations will result in administrative penalties (such as rejection of projects seeking government approval or ineligibility for loans from state-owned banks).

3. THIS VOLUME'S PAPERS

The four subsequent papers in this volume offer insights as to the nature of China's pilot programs, the challenges the national program might face, and the lessons from domestic experience with cap and trade that can guide the design and implementation of the nationwide program. Authored by leading experts on China's economy and environment, the papers suggest how the national program can be designed to best meet its important environmental, economic, and social goals.

The first paper, by Junjie Zhang, Zhenxuan Wang, and Xinming Du (2017), reviews the design and performance of China's seven regional CO_2 emissions trading pilots and draws lessons to inform the design of China's national ETS. The authors' review of pilot designs includes in-depth discussions regarding the different strategies for setting caps; allocating allowances; covering sectors and companies; ensuring compliance and enforcement; and monitoring, reporting, and verifying emissions. To gauge performance, the authors focus on secondary markets, presenting summary statistics regarding allowance prices, trading volumes, and turnover ratios for each pilot. Based on these analyses, the authors distill several recommendations for the design of the national system. Most notably, the authors recommend that the national

5. Research has shown that if the rules for third-party verifiers are not designed to create the proper incentives, it can significantly affect the accuracy of the data. See Duflo et al. (2013)..

system allow banking of allowances and establish longer compliance periods to stabilize the secondary market, while cautioning against linking regional pilots to the national system. The authors suggest that the pilot programs have had relatively weak monitoring, reporting, and verification procedures—less stringent than what is hoped for under the national program. This leads to the authors' concern that if the banked allowances from the pilot regions are applied to the national ETS, the environmental integrity of the national program would be significantly compromised.

The next paper, by Fei Teng, Frank Jotzo and Xin Wang (2017), gives focus to interconnections between power sector reform and the effectiveness of the national ETS. The authors point out that two features of the power market currently limit the ability of emissions trading (or, more generally, emissions pricing) to bring about reductions in CO_2 emissions at low cost. One is that electricity prices are often administered rather than determined by the market. As a result, to the extent that cap and trade leads to higher fuel prices and costs of electricity generation, these changes are not fully reflected in the price of electricity, limiting the incentives of electricity users to conserve. The other feature is that decisions on the dispatch of power plants are often determined by planners rather than based on relative cost considerations. The authors quantitatively assess the significance of these features for the costs of achieving CO_2 reductions. Their assessment involves econometric estimation of the impact of market reform on investment in new generation and on dispatch, and the associated implications for emissions reductions. They consider the emissions implications of reform alone, emissions pricing alone, and the combination of the two. Using a probabilistic discrete choice model, the authors find that market reform is critical to achieving emissions-reduction targets at low cost. In particular, they find that the carbon price needed to achieve China's 2030 emissions-reduction targets would have to be about twice as high in the absence of power sector reform as what would be required if the ETS were accompanied by such reform.

The remaining two articles consider a range of challenges that China faces in the design of its national ETS.

The paper by Maosheng Duan and Li Zhou (2017) delves into several challenges related to the division of responsibilities among different levels of government. The authors focus on the importance of developing a national system with unified rules that can avoid the need for frequent changes of various design elements: coverage and scope of the system; allowance allocation; cap setting; emissions measurement, reporting, and verification; and compliance. The authors also consider alternative allowance allocation strategies, including a call for a careful definition of industrial subsectors as a way of limiting cross-province equity-efficiency tradeoffs. They highlight the importance of coordination of the ETS with other environmental, energy, and economic/regulatory policies, both now and in the future. As with the Teng-Jotzo-Wang paper, the Duan-Zhou paper draws attention to connections between the regulation of the power sector and the effectiveness of the ETS, and it recommends pairing the design of the ETS with efforts to reform pricing in the power sector.

Valerie Karplus and Xiliang Zhang (2017) explore some of the factors that have limited the effectiveness of past environmental policies, with a focus on China's energy and environmental governance institutions. In particular, they point to the weak and inconsistent implementation and enforcement of environmental policies, a reflection of uneven capabilities and incentives at the local level. The authors explore two case studies—the national sulfur dioxide (SO_2) control policy and enterprise energy efficiency programs—and describe some of the lessons learned from those policies and how those lessons can be integrated into the national

carbon trading program. The authors focus on two main challenges—insufficient compliance incentives (e.g., low non-compliance penalties) and heterogeneous implementation and enforcement of national programs at the local level. Building on lessons from earlier programs and the experience of the Beijing pilot CO_2 ETS, the authors identify four institution-related objectives that will influence the success of China's ETS: a strong legal foundation; credible and consistent measurement, reporting, and verification rules; broad market reforms; and comprehensive program review and adjustment. While the importance of the legal foundation and ongoing market reforms echo Duan-Zhou and Teng-Jotzo-Wang, respectively, this paper focuses on the value of gradually expanding the program over time and improving the design through experimentation, evaluation, and adjustment as institutions evolve in parallel.

4. COMMON THEMES

Each of the four papers is distinct in its coverage and recommendations. At the same time, several common themes emerge from the collection. Here we comment on some of the common themes and offer some interpretations.

4.1 Heterogeneous capacities and national/provincial management responsibilities

China is an incredibly diverse country, both within and across provinces. As noted by Duan and Zhou (2017), average per capita income varies by at least a factor of three across provinces while average energy intensity differs by more than a factor of six. Since a significant portion of program operation will be done by provincial authorities, which vary widely in their capacity, familiarity, and context (that is, political and economic incentives), we expect significant heterogeneity in implementation, enforcement, and compliance. Generally speaking, the national authorities are responsible for formulation of the rules and the provincial-level authorities are responsible for implementation. In attempting to balance concerns from less-developed regions about potentially onerous requirements and, at the same time, avoid a "race to the bottom," China has generally adopted a principle of "common but differentiated" responsibilities for provincial-level authorities.

In formulating the allocation rules that apply nationwide, program designers have attempted to accommodate different circumstances among the provinces. For example, particular attention is being paid to the definition of sub-sectors in order to accommodate cross-provincial differences in fuels, technologies, or other factors. Some allowances are also being reserved for allocation to particular regions. At the same time, flexibilities are being granted to provincial authorities to use stricter allocation approaches than the national ones if deemed appropriate.

The availability and quality of data at the company level, not to mention at the product level, is a huge challenge for China, especially in the middle and western regions. In an effort to ensure that "a ton is a ton" throughout the system, NDRC has published guidelines for accounting and reporting of CO_2 emissions from companies in 24 sectors and has prepared eligibility requirements for third-party verifiers and technical guidelines for verification. These guidelines, when approved by the State Council, will form the legal basis for emissions measurement, reporting, and verification activities.

In preparation for the start of the national ETS, a number of steps have been taken to increase cross-provincial consistency in data measurement and reporting. The accounting and reporting guidelines were published in draft form, with the aim of educating program par-

ticipants at an early stage and allowing for clarifications as needed. Similarly, the eligibility requirements for third-party verifiers and verification guidelines have been issued in draft form to allow for local discussion and feedback. Although the costs of verification for historical emissions are generally born by the authorities to avoid possible conflict of interests, verification fees levied on companies for verification at the end of each compliance period may vary significantly across provinces, depending on the public bidding rules and financial capacities in each region. These differences, and the uneven supervision of third-party verifiers across provinces, has raised concerns about the resulting data quality and consistency. There are concerns that some of the local authorities do not have the incentive to enforce fully and effectively the environmental rules as they seek to protect the competitiveness of companies within their regions. The Central Government has provided some resources for training and capacity building, but the challenges are large.

Does the program offer the appropriate level of "federalism"? In other words, does the program grant the Central Government powers that are better left to the provinces, and vice versa? Do some of these misplaced powers create perverse incentives or unintended consequences? Arguably, the process of resolving issues relating to national versus provincial responsibilities has proven to be lengthy and difficult. Overall, considerable progress has been made in the push for a unified national system, although at the time of this writing various issues remain under discussion and some additional rulemaking is likely forthcoming.

4.2 Potentially unreliable data on emissions

Complete and accurate data are necessary for an effective ETS. Because of the intensity-based design of China's forthcoming national ETS, the government will have to collect data about emissions, industrial output (including inventories), and electricity consumption. In the past, these data have been subject to manipulation by companies (Lo 2016; Wang 2013) and local governments (Ghanem and J. Zhang 2014; Kostka 2014; Liu et al. 2015). As described above, the NDRC has published guidelines for measuring and reporting emissions, validating emissions reports, and assessing eligibility of third-party verifiers, but provincial governments will be responsible for assessing the eligibility of individual verification companies and enforcing verification guidelines. As discussed earlier, the provinces differ dramatically in their administrative capabilities, and this raises the possibility of inconsistent data quality, compliance verification procedures, and enforcement.

China's current statistical system is plagued with data quality challenges (Hsu 2013; Zhao et al. 2011), and it is these data that will form the basis for determining the emissions benchmarks and the initial allowance allocations for companies. As Duan and Zhou (2017) discuss, establishing a statistically verified system for historical data is a major challenge. In response to concerns about data quality, the program designers are aiming to require all firms to undergo third-party verified emissions reporting before the sector to which they belong can begin trading under the national system. However, it is unclear whether there will be a sufficient number of third-party verifiers to review all covered companies' emissions reports within the relatively short reporting window and at a reasonable cost (H. Zhang 2013).

The form of China's nationwide ETS could address some of these shortcomings. Although historical data on performance could influence the choice of benchmarks under the forthcoming tradable performance standard, more recent (and presumably better-measured) output levels are a key to determining the program's allowance allocations. Also, if the verification system is consistent across the provinces, it can be designed to minimize conflicts of interest and create

incentives for accuracy and quality assessments. For example, as Duflo et al. (2013) demonstrate, provincial governments can pay verifiers directly, using revenue from fees charged to covered companies, to minimize conflicts of interest, and subject a portion of emissions reports to two or more independent audits to assess the quality of the verification reports.

4.3 Weak penalties for non-compliance

As previously noted, the NDRC does not have statutory authority to issue financial or criminal violations of compliance. Therefore, under current laws and regulations, provincial authorities instead would have to issue a punishment pursuant to the People's Republic of China Law on Administrative Penalty, which limits financial penalties to 100,000 Chinese yuan (Duan et al. 2014). This limit is widely considered to be too low to yield significant incentives for compliance (Munnings et al. 2016; D. Zhang et al. 2014). Stronger financial penalties must be established under a law or regulation (Duan and Zhou 2017). The authority to introduce such penalties though legal and regulatory changes resides with the National People's Congress and State Council. In this connection, Karplus and Zhang (2017) recommend establishing a strong legal basis to mobilize the legal system to penalize non-compliance similar to that implemented in the Beijing pilot ETS, emphasizing that the National Emission Trading System Directive, which is under consideration by the State Council, would force non-compliant firms to face much higher penalties than under current law.

Yet it remains unclear whether stronger financial penalties are sufficient to ensure a high level of compliance. This motivates consideration of a strategy of also introducing administrative, non-financial penalties. Accordingly, Duan and Zhou (2017) support a variety of non-financial approaches to supplement financial penalties. These include publication of non-compliance information on public media, informing relevant authorities of non-compliance activities, and revoking the eligibility of non-compliant companies to enjoy preferential policies.

5. ADDITIONAL IMPORTANT ISSUES

In addition to the issues that the papers in this volume bring out, several other important issues were raised at the two-day Stanford Environmental and Energy Policy Analysis Center and Resources for the Future workshop and in subsequent discussions among workshop participants. Among those issues are concerns about low allowance prices; the potential role of an auction to implement an allowance price floor; the need for a transparent review process to assess the success of the program and, if necessary, identify modifications to improve the program; and the degree of government intervention in the emissions trading market.

5.1 Concerns about "low" allowance prices

One frequent criticism of some ETSs in other parts of the world has been that allowance allocations have been overly generous and that, as a result, allowance prices have been "unacceptably low." This criticism has been directed in particular toward the ETS in the European Union, where allowance prices are below $6 per ton. A similar criticism has been leveled toward the California program, where allowance prices are currently less than $15 per ton. Today, interested parties fear that the allocation of allowances in China's forthcoming nationwide system will be so large as to lead to low allowances prices.

The concern about low allowance prices begs the question: when is the price "too low"? One criterion is whether the allowance prices are at a level that economic efficiency would call for. In theory, economic efficiency would be maximized when allowance prices correspond to the marginal benefit from emissions abatement. The social cost of carbon (SCC) represents the marginal climate benefit, and in a well-functioning ETS the allowance price indicates marginal abatement costs. This implies that efficiency would be maximized if the supply of allowances were such as to yield allowance prices equal to the SCC. A current central estimate of the SCC by the U.S. Interagency Working Group on Social Cost of Greenhouse Gases (2016) is around $40 per ton; this might suggest that allowance prices near $40 (or 275 Renminbi using mid-2017 exchange rates) per ton might be a reasonable target on efficiency grounds.

There are very large uncertainties about the magnitude of the SCC, however.[6] One cannot be sure that an allowance price of $40 per ton is efficiency maximizing. Likewise, there remains the possibility that a "low" allowance price is in fact above the efficiency-maximizing value. Still, allowance prices less than, say, $15 per ton would seem to have little chance of being the efficiency-maximizing price, since the most of the mass of the probability distribution for the SCC is above $15. This suggests that it would be difficult to justify on efficiency grounds an allowance price of below $15 per ton, and that restricting the aggregate supply of allowances to make it consistent with maintaining a price of at least $15 per ton would be a reasonable objective.

Clearly, other considerations besides efficiency are relevant to judging the performance of China's nationwide program. These include fairness, transparency, flexibility, and simplicity. Still, interested parties are likely to consider efficiency—as suggested by the relationship between the allowances prices and central estimates of the SCC—in assessing the program's performance. Indeed, if prices in China's ETS were to persist at a level below the prevailing prices in the California and EU systems, it is very likely that the program would face the same criticisms about "unacceptably low" allowance prices that have been directed toward these other systems.

Introducing a price floor in the ETS could reduce concerns about the possibility of "unacceptably low" allowance prices. To enforce a price floor, China's ETS would need to have the potential to restrict or reduce the supply of allowances once prices threaten to go below some minimum level. However, as discussed below, in order to introduce a price floor the nation would need to overcome some significant distributional and institutional challenges.

5.2 Attractions and challenges related to instituting a floor price via an auction

An auction is a particularly useful mechanism for enforcing a floor on CO_2 allowance prices. While a large fraction of the allowances introduced into circulation in each period could be offered free, the auction could provide a flexible mechanism for an additional, marginal source of supply in each compliance period. Through its influence on the total supply of allowances, the auction could reduce the prospect that allowance prices would fall below the stipulated price floor.

Figure 1 above illustrates how the government could utilize the auction to enforce the price floor. It assumes that a certain number of allowances (a_{free}) are provided free without the auction. As the marginal source of supply, the auction would supplement the quantity of allowances that were already allocated without charge. Based on benchmarking and other

6. See the U.S. Interagency Task Force study (2016) and the recent and National Academy of Sciences (2017) report.

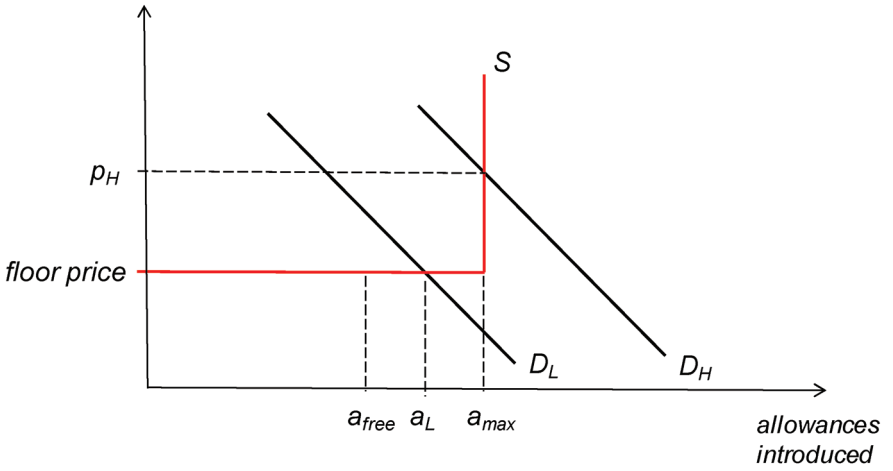

FIGURE 1
Instituting a floor price through an allowance auction

considerations, the government would determine the maximum total supply (free plus auctioned) for the current compliance period. This maximum is represented by a_{max} in the figure.[7] The government would then offer to sell up to a_{max}-a_{free} at or above the floor price. The figure indicates two possible scenarios for the demand for allowances. If the demand at the floor price is limited (as implied by demand curve D_L) the government would only sell a_L-a_{free} additional allowances—only enough allowances to meet demand at that price. On the other hand, if the demand at the floor price exceeds the maximum to be supplied a_{max} (as implied by the higher demand curve D_H) the government would offer only a_{max}-a_{free} additional allowances, and would sell them at the price that brings demand into balance with the supply. In the figure, this is the price p_H.

There are two important challenges to the implementation of an auction. The first is how to introduce an auction without raising the costs (relative to 100 percent free allocation) to allowance holders; higher costs could hamper political feasibility and raise issues of fairness. Under a simple auction, the covered companies would have to purchase some allowances rather than receive them all at no cost. An alternative auction design, which would impose lower costs on bidders, is a revenue-neutral consignment auction. Such an auction has the potential to enforce a price floor without imposing higher costs on emitters. Under a consignment auction, the government allocates the desired total allowances at no cost—this would correspond to amax in the diagram—but requires companies to submit (or consign) a certain percentage of their free allowances to auction. The submitters of the consigned allowances as well as other parties then bid on this limited supply of allowances. The government then gives all successful bidders allowances valued at the auction's market-clearing price. For successful bidders that had submitted allowances, the system introduces no net cost to the extent that they purchase no more allowances than the amount that they consigned to the auction, since the amount they are credited for the allowances they consign is also based on the market equilibrium price;

7. In the two-stage allocation process described earlier, a_{max} in a given compliance period is the aggregate supply of allowances implied by the current emissions-output benchmarks and the end-of-period levels of output.

thus, the amount they are credited equals the amount they must pay for the allowances they get back.[8]

The second challenge is institutional. Currently, the NDRC is the central government's authority over the operation of the national ETS. While the NDRC is authorized to determine the rules for the free allocation of allowances, it does not have explicit authority to run an auction or other measures that would raise revenues. The Ministry of Finance has domain over revenue collections and disbursements. It appears that the NDRC's control over the ETS would be weakened if the system included an auction, since the Ministry of Finance would be largely responsible for the revenue elements. This might reduce the NDRC's interest in including an auction as part of the ETS.

Thus, although an auction would be an effective mechanism for enforcing a price floor, the implementation challenges are significant.

It is worth noting that under an alternative form of emissions pricing—a carbon tax—there would be no need for concerns about unexpectedly low emissions prices: the emissions price in each compliance period would be the carbon tax rate for that period, which would be stipulated well in advance. In light of the competing institutional domains mentioned earlier and the associated desire by the NDRC to maintain authority over the program, one cannot realistically expect China to convert its emissions trading system to a carbon tax system in the near future. However, given the difficulties that a carbon tax system could avoid, such a conversion would seem to be a reasonable longer-term objective.

5.3 The importance of program review

In the past, China has taken a learning-by-doing approach to develop national policies. The government often starts with pilot programs to test the suitability of a policy approach for national implementation. The experience of the pilot programs can inform the initial design of a national program and/or help in the modification of programs over time.

Policy makers in China are following a similar approach for the national CO_2 ETS. The national government authorized several provincial and municipal pilot programs to assess how an ETS might be best designed in China. The pilots provided several useful lessons, some of which have been integrated into the design of the national program. However, given the short lead time to design the national program and build the institutions and infrastructure that it requires, it is likely that potential ways to improve the initial version of the program will become evident over time. For this reason, it is important that the program include a framework for its assessment and its modification in response to new information. The RGGI program involving nine U.S. eastern states used a formal review process to ensure that the program achieved emissions reductions at relatively low cost and in an equitable manner (Farnsworth et al. 2016).[9] A transparent, comprehensive program review process for China's national CO_2

8. For details on the structure and potential of a consignment auction, see Burtraw and McCormack (2017). Companies that consign some of their allowances might offer bids that are unsuccessful (below the equilibrium price). These companies will receive positive revenue for the allowances they submitted, based on the equilibrium price. The success of the consignment auction relies on the idea that no company will bid below the value of the allowances to the company, since in doing so it would risk not being a successful bidder. Symmetrically, it also relies on the idea that no company will bid above what allowances are worth to it; if it did, it would introduce the possibility that (a) the market equilibrium price ends up higher than what an allowance is worth to the company, and (b) the company nevertheless is a successful bidder. In this case, the company would be obliged to pay more for allowances than their value to the company.

9. Program review has been an important element of ETSs in other countries, allowing unforeseen difficulties in initial design to be addressed. See, for example, Klinsky et al. (2012).

ETS would provide stakeholders with information about the review's schedule, scope, and process as well as information about how the findings of the program review will be used by the government to modify the design and implementation of the ETS.

The program review can provide an opportunity to assess the performance of the program and resolve some of the initial uncertainties about the program's impacts. For example, the program review might 1) assess whether the ETS has been successful in achieving its environmental and economic goals; 2) explore how the program has influenced or been influenced by other national and local climate, energy, and environmental programs; 3) analyze how the allowance prices have affected the broader economy; 4) study the strengths and shortcomings of the emissions measurement, reporting, and verification system; and 5) identify capacity constraints that limit the implementation and enforcement of the program. The findings from the program review can inform discussions between stakeholders and policymakers about modifications to the ETS.

5.4 The gains from limiting government intervention

Provincial governments in China have experimented with emissions trading programs to control SO_2 emissions and water pollution discharges (B. Zhang et al. 2016; Yang et al. 2004; Karplus and Zhang (this volume)). Significant government intervention in the allowance market has often hindered the effectiveness of these programs (B. Zhang et al. 2016). An example of such intervention was the requirement in China's earlier provincial-level SO_2 trading programs that companies purchase allowances from or sell allowances to the government so that the government could exert control over allowance prices and transactions. In addition, cross-provincial trades were sometimes restricted out of a concern that such trades could restrict a provincial government's ability to meet other emissions control programs (e.g. total air pollution emissions control), or a concern that sufficient allowances might not be available within a province to meet future demand (B. Zhang et al. 2016; Tao and Mah 2009).[10]

ETSs harness market forces to achieve emissions goals at lower cost. To maximize the potential cost savings, the allowance market should enable companies with sufficient liquidity to exploit opportunities to trade allowances and flexibility to pursue cost-effective solutions wherever they exist. The government has an important role to provide oversight to the market to prevent abuse and fraud, but government intervention that inhibits trading or restricts flexibility just increases the overall cost of achieving the emissions reduction goals (Parsons et al. 2009).

6. CONCLUSIONS

The speed of policy development for China's ETS is impressive by any standard. It is especially impressive given the country's large differences in per capita income levels, industrial mix, energy intensity, and institutional capacities. China deserves enormous credit for addressing the key issues head on in the construction of its national ETS.

As this symposium reveals, significant challenges remain in determining how to deal with the heterogeneity of participants and determining the appropriate division of responsibilities between the central and local governments.

10. By restricting such trades, the provincial governments were able to reserve surplus allowances for use by new and expanded economic activity within the province.

The nation also will need to overcome significant challenges relating to emissions measurement, reporting, and verification, as well as limitations in the incentives for compliance. The pilot programs suffered from a lack of uniformity in the procedures for verifying carbon emissions data and from weak financial penalties for non-compliance. The nationwide program's performance would also benefit from more limited government intervention. Fully addressing these difficulties will require new laws passed by the National People's Congress or new regulations promulgated by the State Council. It seems important that these legal or regulatory changes occur soon, before the launch of the national ETS.

China faces the challenge of assuring that emissions allowance prices are high enough to bring about significant emissions reductions and generate strong incentives for investments in low-carbon technologies. Introducing an emissions price floor would help prevent allowance prices from falling to unacceptably low levels, and an allowance auction appears to be an especially suitable mechanism for implementing a price floor. However, it appears that important institutional hurdles would need to be overcome for a price floor to be introduced.

China's nationwide ETS will move the nation's climate policies into uncharted territory. This makes it important to have periodic review of the program and to build flexibility into the program's structure so that constructive modifications can be made when new information helps reveal the program's strengths and weaknesses.

We look forward to the launch of China's bold new venture. We hope for positive initial results while recognizing that the system will likely need modifications over time.

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