Incentivizing Firm Compliance with China's National Emissions Trading System

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Abstract

When it launches in 2017, China's CO_2 emissions trading system (ETS) will be the first to be implemented in a developing country and will cover the largest CO_2 emissions volume of any system to date. We evaluate the potential of an ETS to alter the emitting behavior of covered firms and support the achievement of national CO_2 intensity reduction targets at least cost. Specifically, we focus on two questions: 1) what factors have limited firms' past compliance with environmental policy in China, and 2) what can be done to strengthen compliance with China's national ETS? We argue that altering firm behavior will require strong institutions—in particular, a strong legal foundation for the system, a nationally unified set of monitoring and reporting requirements subject to independent third-party verification, and ongoing broader economic reforms to remove barriers to system operation. It will also require signaling a sustained commitment to experimentation, evaluation, and modification of the system based on performance, because system effectiveness will depend on expectations about its longevity and credibility, but will inevitably require adjustments. We illustrate the importance of these recommendations for firm compliance behavior by drawing on experience from the Beijing pilot ETS (2013-2015). Given vast heterogeneity across provinces, specific attention should be given to strengthening institutional foundations where they are least developed alongside the construction of a national ETS.

1. Introduction

Strong regulation "on the books" but weak implementation in practice is common in developing countries. As central policymakers prepare to launch China's national

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emissions trading system (ETS), an important question concerns the potential of this well-known form of market-based policy instrument to change firms' emitting behavior. Widespread evidence that implementation of past environmental policies in China has been uneven or incomplete across industries and regions makes this question especially salient. Given that China's ETS will be the largest by covered emissions volume and will be the first in a developing country, the stakes are high. China's political and economic institutions also differ from prior implementation contexts. Against this backdrop, we organize our analysis around two questions: will China's ETS succeed where past policies failed to elicit firm compliance? Are there policy design choices or enabling conditions that could improve its prospects for success?

Policy design choices such as coverage, stringency, abatement flexibility, and the form of rewards or punishments directly affect the behavior of covered firms. Many studies rightly focus on policy design. Designs that exclude some emitters could induce a shift in production to unregulated firms (leakage). Stringency determines the aggregate burden on emitting firms, while abatement flexibility affects marginal cost. If the consequences of non-compliance are too benign, firms may fall short of obligations, or ignore the policy altogether. These design elements are generally embodied in the policy itself.

While policy design is important, cost effectiveness of policy also depends on the complementarity and dynamic interactions between policy design and underlying institutions (Jenner et al., 2013; Vietor et al., 2015; Liao et al., 2016). Institutions are rules and norms that govern behavior (North, 1990). The institutional dimension is important for at least two reasons. First, the division of authority and implementation responsibility in governing bodies can influence policy credibility as well as enforcement capacity and incentives. This division exists for example horizontally across agencies responsible for various government functions, or vertically across layers of a multi-tiered governing hierarchy. Shared understandings of who can require whom to do what can affect the extent to which covered parties comply with regulations and the ability of monitoring, reporting, and verification systems to function successfully. Second, the alignment of policy design with the incentives embedded in the institutional context is

very important. Price formation in markets, rules of interregional exchange, and project permitting requirements all have the potential to interact with a policy aimed at encouraging cleaner production. A single environmental policy may bind on a wide range of institutional settings that vary by region or sector subject to various dynamic pressures, shaped by factors such as socioeconomic status, industry composition, market orientation, awareness, and resource endowments.

These institutional dimensions are likely to have consequences for how firms respond to a national ETS in China. For example, how the responsibility for execution is allocated across functional agencies and levels of the governing hierarchy will affect how firms respond (or not) to the requirements of the program. It will also affect the ability of the government to gather data on system performance and adjust as needed. Meanwhile, an ETS will vary in its complementarity with local institutions in different parts of China, raising the importance of assessing and addressing regional gaps as part of the process of establishing the system.

The aim of this paper is to identify the origins of past compliance challenges, and outline options for addressing them in the design of China's national ETS. Section 2 describes the historical context and evolution of environmental policy in China. Section 3 contains case studies of two policies, a binding policy targeting SO_2 control and a quasi-voluntary policy promoting industrial energy efficiency. In Section 4, we synthesize implementation challenges from the two cases and consider additional challenges of moving to a market-based instrument. We offer several recommendations and use the case study of the Beijing ETS pilot to illustrate their importance. Section 5 concludes.

2. Background

Since the late 1970s, reform and opening has transformed China's economy, reducing the role of central planning in favor of market mechanisms. This transformation has involved the complete or partial privatization of state assets, resulting in an increase in the number of private firms with wide variation across sectors. Market-based pricing has been introduced for most goods and services, although prices are still set administratively in strategic sectors such as energy. An influx of foreign-direct investment and growth of production for export fueled rapid economic expansion through

the mid-2000s. These developments have occurred unevenly across China's already-diverse regions and sectors.

Double-digit growth during the thirty years following the start of economic reforms, widely known as the "China miracle," lifted many out of poverty but also took a severe toll on the environment. By the mid-2000s, China had become the world's largest energy user and CO_2 emitter. Many areas of the country were suffering from severe air, water, and soil pollution. Emphasis on environmental alongside economic goals in national policy gradually increased during the reform period.

Broadly speaking, China's past environmental protection efforts have been comprised of command-and-control policies that impose requirements directly on firms, for instance, in the form of emissions limits or technology standards. These policies are designed to be consistent with overarching environmental policy goals outlined in the country's five-year plans. For example, the State Environmental Protection Administration (now the Ministry of Environmental Protection or MEP) set standards limiting water pollution concentrations and later controlled via absolute limits on waste; both approaches met with uneven success at the local level (Ma and Ortolano, 2000).

Market-based instruments, while less common, are not new to China. Emissions quotas for projects were first discussed in the 1980s (Yang and Schreifels, 2003). Many of the public and private supporters of an ETS in China previously benefited experience generating and selling offsets as certified emissions reductions into the European Union's Emissions Trading System (EU-ETS). China has also introduced environmental levies (pollution charges), although problems with collection were widespread. Pilot trading systems for SO_2 emissions also increase familiarity, and a national system was discussed. Far from the first attempt, an ETS for CO_2 would build on experience developed over decades in a range of different settings.

Command-and-control and market-based environmental policies alike have suffered from weak implementation in China. Firms often perceive new environmental protection directives as interfering with status quo operations and seek to avoid, delay, or minimize regulatory burdens. For instance, firms that installed SO_2 scrubbers did not operate them in order to save variable cost (Steinfeld et al., 2009). Prior to 2007, fines for

violating the SO_2 emissions rules were so low that many firms chose to pay fines rather than abate pollution (Xu, 2011; Schreifels et al., 2012). More than 80% of levy revenues were recycled to emitters to fund abatement, while the remainder was used to fund the operations of local environmental protection bureaus (Schreifels et al., 2012). However, some firms reportedly never remitted funds to the government, nor did they use funds for abatement (Ellerman, 2002). When the central government introduced environmental criteria into official evaluations, local governments were found to exaggerate or fabricate environmental performance data to improve their own evaluation prospects (Ghanem & Zhang, 2014). While the balance of evidence suggests that enforcement has improved over time (Van Rooij and Lo, 2010; Zhang et al., 2017; Lo et al., 2016), lapses still occur.

Weaknesses in policy implementation can be at least partially attributed to the status of supporting institutions. With a growing number of environmental policy initiatives and cleanup campaigns initiated throughout the 1990s and 2000s, the salience of environmental protection and the capabilities to mitigate pollution in industries and regions evolved as well. This evolution took place at different rates in different parts of the country, reflecting differences in stage and drivers of development as well as other factors, such as proximity, interaction, and alignment with China's central leadership. The introduction of the environmental responsibility system for government officials and the growing role of citizens, courts, and non-governmental organizations in environmental policy enforcement are two examples of institutional changes that varied across localities. Prior studies observe more frequent and higher punishments for polluters in the relatively developed East, compared to other parts of the country (Van Rooij and Lo, 2009). Uneven pressure to comply translated into uneven capabilities and incentives to enforce centrally-issued environmental regulations among local environmental protection bureau (EPB) officials.

These institutional differences also translate into variation in expectations over who should pay for emissions reductions targeted by environmental policies. Firms often look to the government to subsidize environmental cleanup. Consultation and bargaining between regulators and firms over required actions and sharing of compliance costs is common. Many firms expect to be reimbursed, or at least subsidized, for efforts to

upgrade facilities or abate pollution in line with environmental protection goals. This shared understanding has its origins in the primacy of economic growth as a policy goal, and shifting the compliance cost burden to firms has proven challenging.

3. Case Studies of Past Environmental Policy Enforcement

We focus on two policies—one targeting SO_2 control, the other targeting energy efficiency—to illustrate and analyze past policy implementation challenges. We consider how each implementation challenge reflects features of the policy design and institutions, and discuss whether or not these challenges have been, or could be, remedied in the design of the national ETS. In both policy cases, supporting conditions were as important as policy design choice to the outcomes, and outcomes improved over time when underlying institutions evolved in supportive directions. These experiences have implications for China's national ETS.

3.1 Case #1: SO_2 Control Policy (Ninth Through Eleventh Five-Year Plans)

Regulations focused on controlling SO_2 emissions in China have been on the books since the late 1990s. Enforcement was weak at the outset, and has grown stronger over time. The *Two Control Zones* policy, launched in 1998 and aimed at reducing SO_2 emissions, focused on controlling emissions in areas either heavily responsible for or affected by acid rain. Emissions increases driven by industrial growth in the early- to mid-2000s overwhelmed efforts to install controls in existing plants. While there is evidence that the targets had some effect on air quality and infant mortality (Tanaka, 2015), and the policy generally failed to alter firm behavior and reverse rising SO_2 emissions. During the Tenth Five-Year Plan (FYP, 2001-2005), SO_2 emissions increased 34% (and power sector emissions by 65%), despite a national reduction target of 10% (Schreifels et al., 2012).

In a second attempt to introduce a 10% reduction target for SO_2 in the Eleventh Five-Year Plan (2006-2010), policy makers paid greater attention to enabling conditions. An important difference was stronger central government leadership, and the introduction of environmental performance criteria in the evaluations of local officials. A dedicated program targeting firms was set up with the label "national control" or *guo kong*. Under

the program, firms were ordered according to emissions totals, and a cutoff was applied to include the largest point sources that accounted for 85% of aggregate industry-wide emissions. Firms that fell within the cutoff were subject to tough limits on annual emissions and were required to install continuous emissions monitoring systems (CEMS). The upward trajectory in national SO_2 emissions was reversed around 2006 and began to come down, ultimately exceeding the national reduction goal by realizing a 14% reduction in SO_2 emissions (Schreifels et al., 2012).

Several supporting measures laid the foundation for target achievement. First, the central government's leadership was critical to the success of the program. It resulted in a streamlined and uniform set of rules on program administration, backed by resources and implementation authority that many local governments lacked. Second, with the support of the Ministry of Environmental Protection, the National Development and Reform Commission introduced an electricity surcharge of 0.015 yuan per kWh to offset the cost of scrubber operation for compliant plants (Schreifels et al., 2012). This financial incentive proved effective, while stronger penalties for non-compliance were introduced in parallel (Xu, 2011). Third, the government required and invested in improvements to monitoring, reporting, and verification of SO_2 emissions. Continuous emissions monitoring systems (CEMS) were installed for SO_2 and later for NO_X and PM, providing a (relatively more) objective measure of firm emissions. The program targeted scrubber installation in the 503 largest SO_2-emitting facilities (Xu, 2011), which meant that the time and resources of government inspection teams could be spread effectively across a relatively small number of plants. Fourth, the policy was highly targeted toward large state-owned power generation firms with oversight at the central or provincial government level, and these linkages facilitated information exchange, training, and transmission of pressure to comply. As these firms outrank city governments, previous efforts by local city environmental protection bureaus to influence behavior met with limited success. Evidence suggests that during the Eleventh Five-Year Plan, post-policy SO_2 reductions in cities are associated with higher shares of state ownership (Karplus et al., 2016). Fifth, environmental performance was formally incorporated into performance evaluations for government officials in the Eleventh FYP. Non-compliance was even allowed to negate achievements in other areas, as it was assigned the status of a "one-vote

veto" evaluation criterion, although there is scant evidence of how often this actually happened. While some have questioned whether environmental criteria were given sufficient weight to affect promotion outcomes, it did increase attention enough to incentivize officials in some cities to manipulate air quality data (Ghanem and Zhang, 2014), suggesting that the policy did not go unnoticed.

In summary, the changes during the Eleventh FYP SO_2 policy that made it more effective were largely institutional, while the main changes to the policy itself involved streamlining and unifying program rules and introducing stronger economic incentives (electricity surcharge) to support compliance. Among them, central government emphasis and political accountability are often singled out as being particularly important in the Chinese context. Even as the SO_2 control effort succeeded, it also highlighted some significant limitations. Government support for the installation and operation of scrubbers was critical to the success of the program; it is not clear that without these carrots rising penalties alone would have induced a change in firm behavior. Expanding the program to include smaller power generators and other industrial emitters would bring new challenges, as many of the firms in these industries were not state controlled and therefore less responsive to political incentives. Pollution removal technologies for these industries are also less uniform, making a single output subsidy for compliance less appropriate. Political incentives had uneven impacts across provinces or regions, depending on local priorities and central-local ties. As a result, the National Control program succeeded in cleaning up the sectors and regions where administrative frictions and control costs were least problematic.

Early efforts to control SO_2 in the 1990s and 2000s involved emissions trading on a limited scale to strengthen implementation of national SO_2 targets. The effectiveness of pilot SO_2 programs was limited for several reasons. Enterprises facing strict SO_2 reduction limits and expectations of tougher future targets were reluctant to engage in emissions trading, preferring instead to hold on to excess allowances. Pilots also interacted with subsidies to support installation and operation of SO_2 control equipment, interfering with SO_2 trading's ability to discover marginal abatement cost. The pilots also covered only limited areas (in some cases, only a few firms), resulting in limited

opportunity for trading to improve efficiency. At the time, there was no legal framework for extending the program nationwide. There are both technical and institutional reasons why an ETS makes more sense for CO2 control: 1) existing incentives to reduce CO_2 emissions, such as the energy savings programs discussed below, are viewed as inadequate; 2) abatement opportunities are spread across sectors nationwide, offering potentially large cost reductions from trading; and 3) advances in central government support since the early 2000s have cleared a path to establishing a strong legal basis for a national ETS in China.

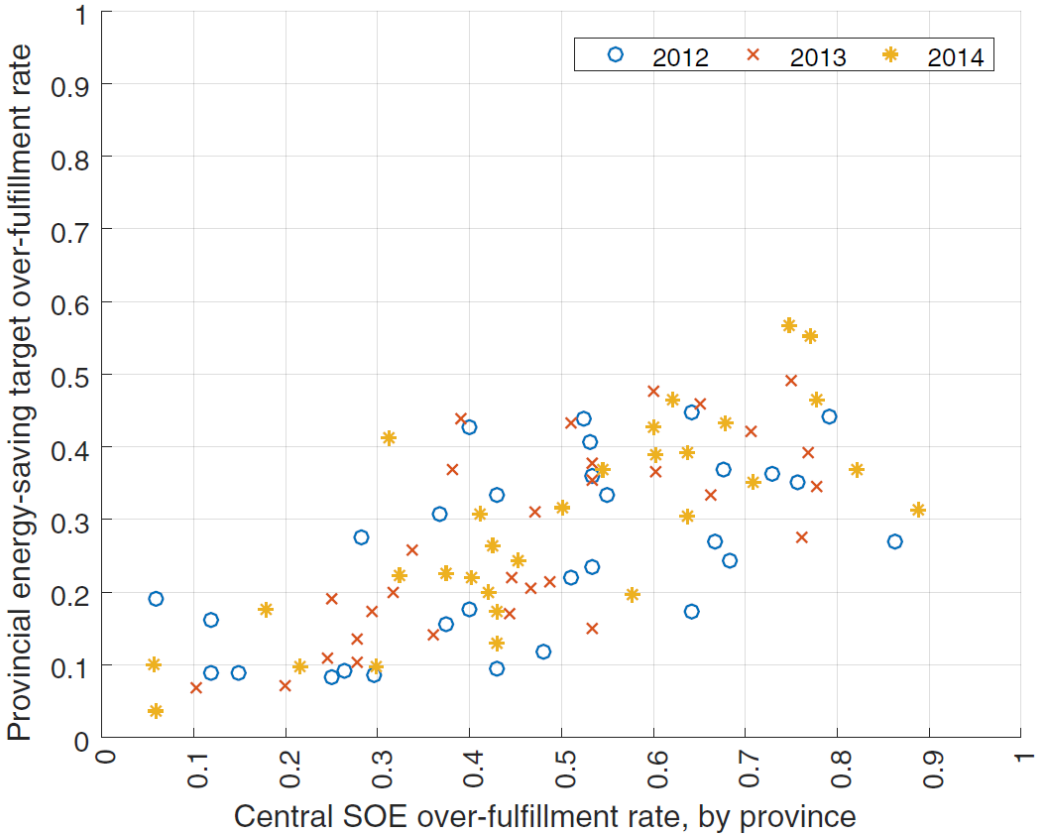
3.2 Case #2: Energy Saving Programs (Top 1000 and Top 10000 Firms Energy Saving Programs)

The 1000 Firms Energy-Saving Program (T1000P, Eleventh Five-Year Plan, 2006-2010) and the 10,000 Firms Energy-Saving Program (T10000P, Twelfth Five-Year Plan, 2011-2015) were nationwide efforts that enlisted firms exceeding an energy consumption threshold to adopt targets for reducing energy intensity. While targets were designed to be voluntary, target compliance was included in the evaluations of state-owned firm leaders, and thus particularly for state-controlled firms, compliance was essentially mandatory. It is thus perhaps not surprising that during the T1000P—when the majority of participating firms were state-owned—compliance rates were very high. When the program was expanded in the Twelfth FYP to include a broader set of sectors and ownership types, non-compliance rates increased substantially, from 2% in the T1000P to around 10% in 2012. Non-compliance rates then fell to 8% in 2013 and to 7% in 2014 (Karplus et al., 2017). Compliance was likely helped by the fact that in many cases, firms could apply for state funds to undertake authorized energy-saving retrofits.

The main drawbacks of the T1000P and T10000P were the lack of economic incentives to comply, reliance on self-reported data with no independent verification, and use of primarily political channels to incentivize compliance. Many firms had no incentive to undertake any costly measure unless they were reimbursed, for instance, through national energy saving subsidy programs, and even then firms incurred opportunity cost. As the programs were managed at the provincial level, central administrators in the National Development and Reform Commission (NDRC) had to

rely on subordinate levels of government, many of which had limited experience in developing energy inventories and quantifying savings. As a result, actions generally reflected adjustments to production practices at the margin to take advantage of new information or non-financial rewards that accompanied the program. State firms have a strong incentive to report compliance. However, they may also exaggerate or falsify compliance information if consequences do not deter it. Non-state firms by contrast were disproportionately non-compliant during the T10000P. This may reflect the fact that they were not financially penalized for failure to comply (Karplus, Shen, and Zhang, 2016). Reasons firms gave for non-compliance with the program were cost, difficulty to improve on savings delivered by prior large retrofits, and an unforeseen expansion in production or usage. One major reason why the T1000P and T10000P were not extended is that the Ministry of Finance stopped the energy saving allowance bonus program in 2013 as it concerned that a long-lasting heavy subsidy program would distort firms' resource allocation decisions and inadvertently undermining the phase out of excess production capacity in the wake of economic slowdown in China. As shown in Figure 1, central state-owned firm over-compliance (the extent to which SOEs exceeded their individually-assigned energy conservation target) was strongly positively correlated with provincial target over-fulfillment. Provincial target over-fulfillment refers to the extent to which each province exceeded its assigned CO_2 intensity target during the Twelfth Five-Year Plan. The fact that SOE over-compliance was strongly positively correlated with target over-fulfillment suggests that provinces relied heavily on SOEs to outperform in order to support provincial target achievement.

Figure 1. T10000P for Energy Saving: Central SOE over-compliance is strongly associated with provincial energy saving target over-compliance. (Over-fulfillment is a measure of the extent to which SOEs exceeded their target, equal to subtracting unity from firm achievement divided by targeted achievement and taking the provincial average; provincial over-fulfillment is calculated by subtracting unity from provincial energy-saving achievement divided by actual provincial target.)



Source: Data from NDRC (2015).

The ETS was in part an answer to increasing evidence that voluntary energy saving programs were reaching the limits of effectiveness, and imposing high and uneven costs on firms. Interest in improving energy and CO_2 emissions accounting was also growing as officials sought a basis for improving evaluation of progress on domestic and international climate policy. Seven pilot systems were established and operated during 2013-2015 to study the viability of emissions trading in diverse provinces and cities across China. These pilots paved the way for establishing a national ETS, and its

architects have attempted to address shortcomings observed in the energy-saving programs in ETS design.

4. Incentivizing Firm Compliance under a National ETS

4.1 Lessons from the two case studies

The case studies point to the origins of several challenges that have influenced the effectiveness of China's energy saving and environmental policy. These challenges are summarized in Table 1, below. Challenges included insufficient economic punishments for non-compliance, tensions between environmental protection and economic growth objectives, state-owned firm responsiveness to political rewards, poor quality and manipulation of firm emissions data, variation in ability to detect violators, and overcoming the expectation among firms that government should pay for environmental retrofits and upgrades. Each of these challenges has its origins either in policy design or in institutional context, as described in Table 1. Ways in which the design of the national ETS addresses each challenge to varying degrees is indicated in the rightmost column of Table 1. Among these challenges, several are partially or fully addressed by moving to a market-based instrument that relies on economic rather than political incentives. These include the challenge of altering firm behavior and formalizing the expectation that firms should pay for mitigation. However, a number of challenges remain.

Several recommendations could help to address challenges described in our two policy case studies. First, a strong legal basis for the national ETS will be crucial to establishing its authority and priority among local officials and covered firms in provinces and localities, and mobilizing the legal system to penalize errant firm behavior, such as data falsification or non-compliance. Currently, the National ETS Directive has entered into the State Council's approval process. The Directive would specify the obligations of the firms in terms of emissions control and emission data MRV, and allow non-compliant firms to face much higher penalties than that the General Administrative Punishment Law allows (no more than 100,000 yuan).

Second, monitoring, reporting, and verification procedures for CO_2 emissions data, energy use, and output should be standardized and coordinated at the national level. Independent verification of emissions and economic output data should be required for all

reports submitted by firms, given that permits will be set on the basis of CO_2 emissions and physical outputs. The central government should further provide either funds or capacity to support the cross-checking of third-party audits conducted at the provincial level. NDRC should be provided with specific instructions that include procedural and data formatting requirements to ensure consistency across provinces.

Table 1. Summary of challenges encountered in environmental policy implementation in the two case studies, their origins, and treatment in national ETS design.

Challenge	**Policy design and/or institutional origin**	**Status of and steps to implementation in national ETS design (as of April 2017)**
Unable to levy sufficiently high penalties for emissions exceeding allowances	Statutory limits on maximum environmental or administrative fines	**Partially addressed** – National ETS directive would allow penalties for non-compliance to substantially exceed those allowed by China's existing Administrative Punishment Law.
Salience of environmental directives vis-a-vis other policy priorities in firms and government	Decentralized policy enforcement and perceived tradeoffs between economic growth and environmental protection	**Addressed** – Centralization of policy design at the center under NDRC leadership establishes ETS authority.
Central state-controlled firms respond to political incentives more than private firms	Large emitters are more likely to be state-owned firms, which are more responsive to government requirements	**Addressed** – A uniform carbon price will send a clear economic signal. System will benefit from greater emphasis on an economic rather than a political reward system.
Poor quality or manipulation of firm emissions data	Managers did not systematically track energy use and emissions, and data quality varies widely	**Partially addressed** – ETS Directive would establish a nationwide standard for accounting, audits, and independent-funded cross-checking of reported emissions, subject to continuous evaluation and improvement.
Localities vary in their capacity to detect and prosecute policy violators	City/county governments vary in local incentives to promote environmental protection alongside economic growth.	**Partially addressed** – Centralize collection and verification of firm emissions data at the provincial level, with cases forwarded to the national level. Provide training across provinces to establish uniform level. Legal basis for national ETS will reinforce.
Firms expect government to pay the cost of implementing environmental control technology	Norm that promoting growth necessitates limiting undue regulatory burdens of firms	**Addressed –** By pricing CO_2, firms will face an economic incentive to switch to cleaner forms of energy.

4.2 Other challenges associated with an ETS

As first nationwide application of a market-based instrument for environmental control, an ETS also raises a number of unique challenges that prior command-and-control policies did not. These challenges and their origins point to a third important enabler of a national ETS—continued commitment to broad-based market-oriented reforms. For the ETS, particularly salient reforms include harmonizing trading rules to facilitate inter-provincial allowance trade, which is important for equalization of marginal abatement costs across provinces, as well as clarifying conditions under which provinces can restrict allowance trading (for instance, to avoid worsening of air pollution hotspots). Continued progress on energy price reform, emphasizing economic over political incentives for compliance, simultaneously reducing preferential treatment of state-owned firms, and increasing market orientation in sectors such as electricity will not be showstoppers to ETS operation, but over time will be important to supporting cost reduction.

A final institutional enabler that would address several past and anticipated challenges is clearly signaling longevity of the policy, while establishing a timetable for experimentation, evaluation, and adjustment that recognizes the policy is unlikely to function perfectly from the outset. Evaluation will require defining "success" in the context of the national ETS. Is success a carbon price at or above a particular level? Is it all firms surrendering allowances sufficient to cover annual emissions? Is it achieving a targeted aggregate level of emissions intensity or emissions abatement? Is it achieving this level at a sufficiently low or "least" cost? Initially, success might focus heavily on some intermediate milestones, such as obtaining and verifying benchmark emissions data for all firms, while over time, adjustments could be aimed at strengthening MRV or increasing flexibility. Establishing the longevity of the system will be important because the prospect of repeat business combined with the credible threat of being discredited through cross-checking will provide third-party verifiers with the right incentives to surface non-compliance behavior. Signaling eventual program scale up or coordinated coverage of non-ETS sectors with a carbon tax could help to discourage leakage as costs rise for ETS firms.

4.3 Institutions and Policy Design in the Beijing ETS Pilot

The case studies above pointed to four important categories of institutional enablers for the ETS: strong legal basis for the ETS, a unified set of monitoring, reporting, and verification rules subject to independent scrutiny, ongoing broader market-oriented economic reforms, and signaling the system's durability and flexibility to incorporate lessons learned along the way. To probe their importance in a real-world Chinese emissions trading scenario, we turn to the Beijing ETS pilot system. In many respects, the Beijing system offers evidence of how carefully-coordinated policy design and institution building efforts can result in a functional emissions trading program.

The Beijing pilot emissions trading system (Beijing ETS) was launched in 2013 and scheduled to operate from 2013 to 2015. As of 2015, the Beijing ETS covered 551 liable entities, with the accounting boundary set at the firm (not installation) level. Allowances for existing firms were allocated based on historical emissions intensity in 2009-2012, while allocations to new firms with capacity expansion were based on benchmarking. The system allowed banking of permits across (one-year) compliance periods, but not borrowing. The threshold for inclusion in the program was initially set at 10,000 tons CO_2. In 2015, it was lowered to 5,000 tons, increasing the number of covered entities by approximately 600.

National policy makers view the Beijing ETS as a success for several reasons. First of all, it resulted in absolute CO_2 emissions reductions of 4.5% in 2013, 6.0% in 2014, and 6.2% in 2015. During its operation, 12.5 million tons were traded in 2668 transactions between 2013 and 2015 (the market covers 50 million tons of CO_2, while Beijing's total emissions are approximately 180 million tons). The CO_2 price was relatively stable over the period at around 50 yuan/ton. Compliance rates among covered entities were also very high, at 97% in 2013, 100% in 2014, and 99.3% in 2015.

Evidence that the Beijing ETS affected the incentives of emitting entities comes from indirect observation of applications for energy saving subsidies provided by the Beijing government. Prior to the launch of the Beijing ETS, very few firms relative to those eligible applied for the latest round of energy conservation subsidies. Subsidies were intended to fund energy saving projects, including retrofits, equipment upgrading, and

operational efficiencies, among other efforts. The application process involved some cost on the part of the firm, as administrative and engineering effort was required to produce a design and ultimately a complete submission to the subsidy program according to rigid guidelines. At the end of the process, there remained some uncertainty over whether or not a firm's application would ultimately be accepted. Nevertheless, it remained a puzzle why firms appeared unwilling to submit funding applications. After the ETS was introduced, firms applying for energy conservation subsidies increased from near zero to a large share of total.

A major reason why Beijing's pilot ETS performed well was its strong legal basis. The top leaders in the Beijing government give more weight to the environmental protection than its department chiefs who are in charge of economic development issues. Given expectations that the Beijing ETS will deliver substantial air quality co-benefits in terms of smog control, the ETS has received special political support from the top leaders in Beijing. As a result, ETS has been given a priority in the registration process. The Decision on Beijing ETS Development passed by the Beijing Congress in 2013 laid a strong legal foundation for the ETS operations in Beijing together with detailed implementing regulations. With the legislation, the punishments for non-compliance are protected by law, creating a sense of certainty among firms that the ETS is both serious and unavoidable. This aspect of the Beijing system helps to ensure that all firm types, regardless of the strength of state linkages, feel sufficient enforcement pressure. Also, a strong legal foundation ensures that local government officials feel sufficient pressure to push for monitoring and enforcement, given competing priorities and demands. As each level of government in China is primarily responsible for implementation and performance evaluation of the level below it, a strong legal foundation amplifies the strength of directives to prioritize the building of local infrastructure to support an ETS and aligns local enforcement behavior more closely with national policy intentions.

A strong legal basis made it possible for the government to introduce strong and credible compliance incentives. One source of these incentives involved reputation. Once firms were included in the program, the Beijing government so strongly emphasized the importance of compliance that it would have been embarrassing for a firm to shirk. This

reputation risk was backed up with high costs for non-compliance: a penalty 3-5 times the average carbon price level over the last six months for every ton a firm exceeded its allowance allocation, disqualification from applying for energy conservation subsidies, delayed approval of new projects proposed by the firm, in addition to the image/reputation risk associated with being publicly listed as a non-compliant firm.

Another reason why the Beijing system worked well was the choice of approach and continuous adjustments made to the MRV system. Substantial effort went into determining the level of emissions from the covered firms, which meant that the cap was binding and resulted in a non-zero carbon price. The audits of third party verification organizations were further cross-checked for 20% of the firms on a randomly-selected basis by an additional auditing agency. Through 2015, audits were funded entirely by the Beijing government, rather than the firms themselves. The MRV process was supported by a comprehensive online infrastructure (also supported by the Beijing government) to register and solicit reports from firms. This system was also linked with the trading platform, rapidly updating allowance totals to reflect actual trades based on verified emissions volumes, strengthening the reliability, internal consistency, and responsiveness of the system.

What can Beijing's pilot emissions trading system tell us about the enabling conditions needed for an ETS in China? The positive outcomes noted above are in many ways dependent on Beijing's strong institutions and the importance political leaders assigned to its successful completion. As the national capital, Beijing is a showcase for new initiatives in China. Unlike the SO_2 trading program, the project of building a national ETS had the backing of arguably the most powerful organization within the Chinese government, the National Development and Reform Commission (NDRC), which develops the nation's economic policies and leads initiatives of strategic national importance. NDRC leadership translated into strong implementation through its vertical (central to local) reporting lines, and benefited from the strong interaction between the NDRC and the Beijing Development and Reform Commission. While it holds useful lessons, the success of the Beijing pilot may not easily or quickly transfer to other parts of the country.

5. Conclusion

By putting a price on CO_2, policy makers are eager for a national ETS to alter firms' expectations and behaviors in ways that achieve emissions reductions at least cost. This is a feasible and worthy goal, but will not be achieved overnight. Developing an ETS first and foremost as a mechanism for ensuring compliance with a tradable performance standard that is consistent with national climate change policy is an important step forward. Our discussion above of the complementarities between institutions and policy design suggests that efforts to develop strong supporting institutions will be at least as important as getting the ETS design right. We offered four recommendation on how to accomplish this: strong legal basis for the ETS, a unified set of monitoring, reporting, and verification rules subject to independent scrutiny, ongoing broader market-oriented economic reforms, and signaling the system's durability and flexibility to incorporate lessons learned along the way.

Beijing to some extent represents an exceptional case: relatively professionally managed large firms operating in a strong service-sector oriented economy faced with a clear and strong mandate to comply with the ETS coming from both the central *and* local government. Policy makers worked closely with academic experts to design the system. It is likely to be challenging to elicit the same degree of cooperation from firms operating in China's diverse localities, especially in places where the economy is much more dependent on energy-intensive industry, intellectual communities are less well developed and have limited engagement in policy design, and local government priorities are less closely aligned with national ones.

Among the four recommendations above, the first and second are perhaps the most important. Without a strong legal basis, establishing a nationwide CO_2 price and encouraging firms to trade to meet compliance obligations will be challenging, in part because there will be no basis for overriding conflicting policy mandates. Without a unified MRV system, ensuring the integrity of system operation will be very challenging, as fabricated emissions reductions will dilute CO_2 prices in the market without delivering additional abatement. Building a robust MRV system should be viewed as an important complementary but distinct effort that could be extended to firms beneath the emissions

cutoff for inclusion in the national program. It would further support development of a national emissions inventory that could be used when reporting progress towards international climate change mitigation goals, as well as to determine which firms to include as the system expands.

The third and fourth recommendations will be important for the long-term durability of the ETS. Market-based economic reforms will support the marginal abatement cost discovery function of the ETS. Inevitably, there will be some mismatches in the timing of ETS rollout and reforms as well as MRV system development, with consequences for system function. It is therefore very important that China's policy makers signal a long-term commitment to the ETS as a policy and institution-building project, which would allow for adjustment in rollout timing and design based on emerging information. Recognizing that conditions for ETS operation vary across sectors and regions, we recommend starting with a subset of sectors where MRV and other enforceability conditions are most conducive. For instance, the ETS could launch with power generation, cement, and aluminum production. Data in these subsectors is relatively well developed and abatement strategies and costs are relatively homogeneous. Potential for leakage, while perhaps less of a concern for these domestically-focused sectors, could be monitored closely. At the same time, policy makers could signal from the outset intention to include 7,000 enterprises in 20 subsectors across 37 provinces and cities by 2020, undertake necessary data and other preparations in parallel, with incentives for early action to certify data and limit emissions in these sectors. As the system is scaled up, the NDRC could serve a watchdog function by conducting facility comparisons to surface data manipulation. One strategy for surfacing data problems could involve establishing a peer supervisory mechanism, whereby firms could anonymously report suspected errant behavior for investigation by the National Enterprise Credit System of the NRDC.

Several questions will need to be answered as the national system is scaled up. For instance, will it be possible for the government to fund third-party verification and randomized checks of MRV quality for firms in the national system, as was the case in Beijing pilot ETS? The answer is likely to be no, given the size of resources and administrative effort required. Therefore, it will be critical to design an MRV system that

balances these resource constraints with the need to establish the cross-regional credibility of a firm's compliance activities. Prior work demonstrates the value of removing conflicts of interests (regulated firms paying for audits) and conducting cross checks to verify auditor performance (Duflo et al., 2013).

Defining success in the context of China's emissions trading system remains a tough but important challenge. This definition should be allowed to evolve as its architects gain experience and data in the early months and years of operation. Setting an expectation that the system is here to stay, and that future changes will be made in a regular and transparent manner, will go a long way towards establishing the confidence and credibility needed for the system to weather inevitable hiccups and become a mainstay of energy and climate policy in the world's largest emitting nation.

References Cited:

Duflo, E., Greenstone, M., Pande, R., & Ryan, N. (2013). Truth-telling by Third-party Auditors and the Response of Polluting Firms: Experimental Evidence from India. *The Quarterly Journal of Economics*, *128*(4), 1499–1545. (http://doi.org/10.1093/qje/qjt024)

Duggan, J. (2014). China's polluters to face large fines under law change. *The Guardian*. (https://www.theguardian.com/environment/chinas-choice/2014/apr/25/china-environment-law-fines-for-pollution)

Ellerman, D. (2002). Designing a tradable permit system to control SO2 emissions in China: Principles and practice. *The Energy Journal*, *23*(2), 1-26.

Ghanem, D., & Zhang, J. (2014). "Effortless Perfection:" Do Chinese cities manipulate air pollution data? *Journal of Environmental Economics and Management*, *68*(2), 203–225. http://doi.org/10.1016/j.jeem.2014.05.003

Hou, W. (2014) 环境违法"钉子户"需用重锤敲。To nail environmental polluters, a heavy hammer is required. (Chinese) *People's Daily*. (http://paper.people.com.cn/zgnyb/html/2014-08/11/content_1464466.htm).

Jenner, S., Groba, F., & Indvik, J. (2013). Assessing the strength and effectiveness of

renewable electricity feed-in tariffs in European Union countries. Energy Policy, 52, 385–401. http://doi.org/10.1016/j.enpol.2012.09.046

Karplus, V., Huang, Y., and Zhang, D. (2017). State Control as a Substitute for Environmental Regulation: Evidence from Chinese Cities. Submitted manuscript.

Karplus, V., Shen, X., and Zhang, D. (2016). *Scaling compliance with coverage? Firm level performance in China's industrial energy conservation program.* Cambridge, MA: MIT Joint Program on the Science and Policy of Global Change. (http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt303.pdf)

Liao, X., Dogan, E., & Baek, J. (2016). Does Corruption Matter for the Environment? Panel Evidence from China. (http://www.economics-ejournal.org/economics/discussionpapers/2016-43)

Ma,. X. and Ortolano, L. (2000). *Environmental Regulation in China: Institutions, Enforcement, and Compliance*. Lanham, Maryland and Oxford, England: Rowman and Littlefield.

North, D.C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge, United Kingdom: Oxford University Press.

Steinfeld, E. S., Lester, R. K., & Cunningham, E. A. (2009). Greener plants, grayer skies? A report from the front lines of China's energy sector. *Energy Policy*, *37*(5), 1809–1824. http://doi.org/10.1016/j.enpol.2008.12.018

van Rooij, B., & Lo, C. W.-H. (2009). Fragile Convergence: Understanding Variation in the Enforcement of China's Industrial Pollution Law. *Law & Policy*. http://doi.org/10.1111/j.1467-9930.2009.00309.x

Viétor, B., Hoppe, T., & Clancy, J. (2015). Decentralised combined heat and power in the German Ruhr Valley; assessment of factors blocking uptake and integration. *Energy, Sustainability and Society*, 5(1), 5. http://doi.org/10.1186/s13705-015-0033-0

Zhang, B. and Cao, C. (2015). Four gaps in China's new environmental law. *Nature*. (http://www.nature.com/news/policy-four-gaps-in-china-s-new-environmental-law-1.16736)

Zhang, X., & Schreifels, J. (2011). Continuous emission monitoring systems at power plants in China: Improving SO2 emission measurement. *Energy Policy*, *39*(11), 7432–7438. http://doi.org/10.1016/j.enpol.2011.09.011