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Assessing the Design of Three Pilot Programs for Carbon Trading in China

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RESOURCES
FOR THE FUTURE

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Abstract

China started seven carbon cap-and-trade pilot programs in order to inform the development of a future national cap-and-trade market. This paper assesses the design of three of the longer-running cap-and-trade pilot programs in Guangdong, Shanghai and Shenzhen. Based on extensive stakeholder interviews and a detailed literature review we formulate a series of recommendations to improve the design of these three pilots, including: strengthening the legal foundations for the cap-and-trade pilots, incorporating achievement of goals established by the cap-and-trade pilots into the performance reviews of participating government officials and executives of state-owned entities, further clarifying the cap-setting process, increasing the transparency of the cap, reducing or eliminating within-compliance period adjustments to enterprise-level allowance allocation, gradually moving away from free allocation toward auctioning, reforming enforcement policy, and adopting a symmetric safety valve to manage prices. By making these recommendations, we hope to shed light on ways that Chinese regulators might adapt cap and trade, a fundamentally market-based tool, to China's economy that has many non-market features.

Key Words: emissions trading, carbon, China

JEL Classification Numbers: Q48, Q54, Q58

Contents

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I. Introduction

China's explosive economic growth in recent decades has generated high levels of carbon dioxide (CO_2) emissions and local pollution, directly affecting human health. Since 2007, China has ranked as the world's largest CO_2 emitter, and its air, water, and soil have become polluted to alarming degrees. In response to these environmental issues, China is attempting to reign in its rampant CO_2 emissions growth with a variety of policies, including one promising but challenging approach: cap and trade.

China's State Council first announced plans to establish a cap-and-trade (C&T) system in October 2010, before listing carbon trading as a central part of the country's energy and climate policy in its twelfth Five-Year Plan, which covers the period from 2011 to 2015 (Zhang et al. 2014).[1] Following the State Council's decision in November 2011 to "gradually promote the establishment of a carbon emissions trading market" (State Council 2011), China's central planning agency, the National Development and Reform Commission (NDRC), selected five cities (Beijing, Chongqing, Shanghai, Shenzhen, and Tianjin) as well as two provinces (Guangdong and Hubei) to develop pilot C&T systems. Regulators authorized these pilots in an effort to accumulate experience and inform the design of a national cap-and-trade system, slated to come online between 2016 and 2020.

To date, all pilots have started operation. Table 1 summarizes the key features of each pilot. Taken together, the pilots substantially expand the portion of global emissions covered by carbon markets, bringing global coverage from less than 8 percent to more than 11 percent of the

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[1] The State Council is the chief administrative authority of China. It is chaired by the premier and includes the heads of each governmental department and agency.

world's total carbon emissions (Zetterberg et al. 2014). Moreover, current allowance prices in some pilots—Beijing and Guangdong, for example—are comparable or greater than those in other markets.

Table 1. Key Features of China's Cap-and-Trade Pilots

Pilot	Start date	Emissions coverage (million metric tons)[a]	Covered entities[b]	Allowance price (USD, current)[c]
Beijing	Nov 2013	50	~490	9.28
Chongqing	Jun 2014	125	242	4.92
Guangdong	Dec 2013	408	211	9.31
Hubei	Apr 2014	324	138	3.76
Shanghai	Nov 2013	160	~200	7.68
Shenzhen	Jun 2013	33	~635	8.96
Tianjin	Dec 2013	160	197	3.79

[a] World Bank (2014); Chen and Reklev (2014) for Chongqing
[b] ICAP (2014); Zhang et al. (2014); Guangdong DRC (2014 b, c).
[c] Tanpaifang.com as of 30 July 2014

Given these accomplishments, it seems China is making strides in moving toward a more market-oriented approach to mitigating carbon and building a foundation for a national program. But progress in the pilots need to be interpreted within a Chinese context. Designs in the pilots deviate from other C&T systems in important ways. In some instances, such deviations represent a reasonable tailoring of a fundamentally market-based policy to a socialist market economy. In other instances, deviations may adversely affect the performance of the system. Ultimately, an accurate assessment of pilot design requires a thorough understanding of the unique challenges China faces in pricing carbon.

In this paper, we assess the designs of three longer-running carbon trading pilots in Guangdong, Shanghai, and Shenzhen, which arguably have the best chance at being replicated in a possible national Chinese C&T system. Our present analysis contributes to the preexisting literature in three distinct ways. In conducting an in-depth analysis of the three pilots, we draw comparisons between the carbon dioxide pilots and the sulfur dioxide pilots conducted in China a decade earlier. Further, we examine the similarities and differences between the Chinese pilots and the subnational C&T systems in North America. Finally, we discuss and analyze several design options related to the pilots: the legal foundations of carbon trading in China, cap setting and updating, treatment of the electricity sector, allowance allocation, noncompliance penalties, provisions for entrants and exits, provisions to prevent market power, and policies that promote liquidity.

In reviewing the C&T systems in Guangdong, Shanghai, and Shenzhen, we translated and synthesized more than 50 publicly available documents originating from the State Council, regional branches of the NDRC, local governments, and carbon trading exchanges. This synthesis allowed us to understand the subtleties of each pilot's design and served as a foundation for meaningful suggestions for improving pilot design.

We then conducted extensive interviews with policymakers directly involved in pilot design and experts familiar with the pilots. Many of these interviews took place in November 2013 and January 2014, when delegations of Chinese pilot policymakers visited Washington, DC. Many others were conducted in March 2014, when three of the authors traveled to Beijing, Shanghai, and Shenzhen to meet Chinese academics, policymakers, and experts involved in the pilots. These interviews helped us understand the motivations for the pilot design features, some of which deviate dramatically from other C&T systems.

Our main recommendations are as follows:

1. Strengthen the legal foundation for the C&T pilots.
2. Incorporate achievement of goals established by the pilot C&T systems in the individual performance reviews of participating government officials and the executives of participating state-owned entities (SOEs).
3. Further clarify the cap-setting process.
4. Increase transparency of the cap by publicizing business-as-usual emissions and the emissions impact of complementary policies.
5. Reduce or eliminate adjustments in enterprise-level allowance allocations that occur within a given compliance period, especially those that alter market-level allocations.
6. Develop a long-term strategy to move away from free allocation outside of the electricity sector.
7. Improve monitoring of three variables in the electricity sector: electricity consumption, grid emission factors, and the quantity of imported electricity and its emissions factor. This will prevent overallocation and emissions leakage that result from covering both direct and indirect emitters.
8. Reform enforcement policy so that regulated firms are fined on a per-ton basis instead of per violation, with the fine being equal to a multiple of the average market price of allowances for each ton of excess emissions.

9. Adopt a symmetric safety valve to manage extreme price fluctuation.

The remainder of the paper is organized in the following manner. Section II presents a literature review. Section III elaborates the unique challenges China faces in its efforts to price carbon, which serves as a prerequisite for discussion and analysis of pilot designs. Section IV considers alternative definitions of success for carbon pricing in China. Section V presents the detailed designs of the three pilots we consider, while section VI provides an update on progress achieved by the pilots, including recent price, transaction volume, and compliance data. Section VII analyzes pilot designs and discusses options for improving them. Section VIII highlights important and unanswered research questions. Section IX concludes.

II. Literature Review

This section reviews the literature that analyzes C&T systems in China, at both the national and pilot levels. This literature broadly falls into three categories, which we elaborate on below: (1) ex-ante quantitative analysis of carbon trading in China at the pilot and national levels; (2) recommendations for carbon trading in China based off qualitative analysis before pilot designs were well known; and, (3) analysis of actual pilot designs. We review these three strands of literature in order below.[2]

A. Ex-Ante Quantitative Analysis

Studies that conducted ex-ante quantitative analysis of carbon trading in China generally use computable general equilibrium models. In general, this strand of literature tends to focus on the implications of establishing formal links between different hypothetical markets and choosing different types of allowance allocation strategies, as opposed to directing efforts at estimating precise overall macroeconomic costs. At least one exception, Hubler et al. (2014), estimates the impacts of a national C&T system that achieves a 45 percent reduction in carbon intensity by 2020 and covers 75 percent of the economy. The authors find a 1 percent decrease in

[2] An additional strand of literature informs our study. This strand focuses on analyzing the sulfur dioxide trading pilots implemented across China over the last decade. Papers in this strand focus on individual sulfur dioxide pilots in Taiyuan (Morgenstern et al. 2004, 2006) and Jiangsu (Zhang et al. 2013); they suggest designs for a national sulfur dioxide program (Jarvis and Xu 2006; Morgenstern et al. 2011); and more broadly, they review the collective efforts to reduce sulfur dioxide through emissions trading in China (Chang and Wang 2010; Schreifels et al. 2012; Hart and Ma 2014).

economic welfare for 2020, as well as moderate impacts on the output of most sectors, with greater impacts for the electricity and aluminum industries.

Three studies model formal links between different hypothetical carbon C&T systems. First, Hubler et al. (2014) model a formal link between the European Union Emissions Trading System (EU ETS) and a Chinese C&T system, estimating that a 300 million ton per year transfer of allowances would bring small gains in GDP to China. The authors warn that the presence of ambiguous terms-of-trade effects means that, theoretically, formal linking may slightly decrease welfare. Next, Dai and Masui (2012) split a national C&T system into two geographic regions, Jiangxi Province and the rest of China, and then estimate the impact of achieving a 45 percent reduction in carbon intensity by 2020 with and without formal linkage between the regions. The authors find that formal linkage would cut estimated GDP losses for Jiangxi Province by two-thirds compared to a non-linked scenario. Finally, Liu et al. (2013) models a formal link between the Guangdong and Hubei pilots, finding that linkage results in higher overall GDP and lower overall emissions compared to a non-linked scenario. The authors argue that general equilibrium considerations, especially terms-of-trade and tax interaction effects, importantly determine economic and emissions outcomes. Taken together, these three studies emphasize the importance of studying formal links with a general equilibrium approach and find modest benefits from formal linkage.

Three other studies investigate the impact of different allowance allocation strategies on the performance of a national C&T system for CO_2 emissions. First, Tang and Wu (2013) compare a mandatory emissions reduction target and a C&T system. The authors find that establishing a C&T system improves economic efficiency and argue that permit allocation can be adjusted to achieve inter-regional equity. Next, Yuan et al. (2012) model a national C&T system with a small auction but mostly free allocation. The authors model two scenarios that achieve the same level of emissions reduction. In one scenario, emissions intensity decreases proportionally across each industry. In the other, emissions intensity decreases proportionally across each region. Yuan et al. estimate that the first scenario results in substantial distributional impacts across regions, while the second scenario avoids such impacts. Finally, Cong and Wei (2010) construct an agent-based model and then estimate the impacts of a national C&T system covering the power sector. The authors find that such a system increases the average electricity price by 12 percent and that emissions-based allocation produces higher electricity and carbon prices relative to an output-based emissions allocation scheme. Taken together, these three studies illustrate the importance that scholars place on balancing the efficiency and equity implications of allowance allocation choices.

B. Qualitative Analysis before Pilot Designs Were Known

A second strand of literature makes recommendations for carbon trading in China on the basis of qualitative analyses carried out before specific pilot designs were well known. In general, these studies identify and describe barriers to using a market-based approach to mitigate carbon in China, which has been described as a "socialist market economy" (Lo 2013). The authors rely on economic theory and international experience, mostly from the EU ETS and Australia's carbon-pricing mechanism, to form recommendations for C&T design. Two main categories of analysis exist in this strand of literature: studies that recommend designs for a C&T system covering the electricity sector and those that recommend designs for a C&T system with broader coverage.

Two major studies discuss a hypothetical C&T system for China's electricity sector. Jotzo (2013) first argues that electricity prices in China are largely fixed and likely will not increase to reflect a carbon price. Given this context, the author then recommends pricing of direct emissions, which result from electricity production, and indirect emissions, which result from electricity consumption, and finally outlines a number of strategies to achieve this recommendation. Baron et al. (2012) conduct economic analysis and draw off experiences from the EU ETS and Australia's carbon-pricing mechanism. The authors recommend that Chinese regulators allow for a limited electricity price increase for generators that participate in carbon trading. Further, based on an observation that a large number of small and inefficient coal plants still operate in China, the authors recommend a complex but deliberate allowance allocation strategy for the electricity sector. Under this strategy, the authors recommend that smaller plants receive free allocations while new plants receive a number of free allowances well below their likely emissions levels. According to the authors, such an arrangement would prompt smaller plants to sell allowances to new plants and consequentially reduce emissions from small and inefficient plants. Taken together, Jotzo (2013) and Baron et al. (2012) represent a first attempt at reconciling China's highly regulated electricity market with the use of a market-based mechanism for controlling carbon pollution.

Several other studies make recommendations for a carbon-trading program in China that covers a broader range of sectors. Cheng and Zhang (2011) and Li et al. (2012) endorse an intensity-based cap rather than an absolute cap—although for slightly different reasons. The former authors cite China's low per capita GDP as a reason to support an intensity-based cap, while the latter argue an intensity-based cap is better for GDP growth. Qi and Wang (2013) contribute to the literature by carefully describing the sheer size of state-owned entities relative to competitive entities and emphasizing the potential for SOEs to exercise market power over carbon markets in which they participate.

Two areas of consensus emerged in our review of this second strand of literature. First, authors generally endorse the idea of starting off with more free allocation and gradually moving toward more auctioning. Second, authors largely agree that China's allowance price should be controlled. The precise mechanism, though, is a subject of disagreement. Drawing off experience from the EU ETS and Australia's carbon-pricing mechanism, Jotzo (2013) recommends a range of options, including price collars, variable permit supplies, or a fixed price that is later allowed to float. In contrast, Qi and Wang (2013) recommend that the government act as a bank, buying and selling allowances from polluters.

C. Qualitative Analysis of Pilots after Designs Were Known

A third strand of literature analyzes actual pilot design, with studies generally considering either all pilots or one or two in particular. Research that falls into the former category either uses a political economy lens or focuses more narrowly on describing common pilot designs before making recommendations. Studies that fall into the latter category typically focus on the design of the Guangdong, Shanghai, or Shenzhen pilot, with a handful of studies conducting initial quantitative analysis.

Three studies analyze the pilots as a whole through a political economy lens. Lo (2013) investigates the political economy of China's decision to pursue carbon trading, arguing that the outcome of these efforts will allow scholars to see whether a liberal market is necessary to produce environmental benefits through carbon trading. Lo and Howes (2014) highlight the role of China's "socialist market economy" by questioning whether the pilots should truly be considered market based, given a high degree of government involvement. And Kong and Freeman (2013) conduct a series of interviews with Chinese stakeholders to identify three weaknesses in pilot design: an inability for environmental goals to trump local economic goals; incomparability that originates from a lack of consistent practices for monitoring, regulating, and verifying carbon emissions; and incompatibility with important national institutions. These weaknesses lead the authors to conclude that even a national C&T system "would be unlikely to contribute more than other factors to carbon emissions reductions in China" (Kong and Freeman 2013, 210).

An additional two studies analyze the pilots as a whole from a market design perspective. Zhang et al. (2014) provide a high-level overview of the designs for all seven pilots and make numerous recommendations for transitioning from the pilots to a national program, including strengthening national laws surrounding carbon trading and penalties for failure to comply with environmental laws. Quemin and Wang (2014) also provide a high-level overview of pilot designs and provide initial recommendations for establishing formal links between pilots.

Two studies focus specifically on Shenzhen. Jiang et al. (2014) briefly report on major design features of the Shenzhen pilot. Importantly, the authors describe a complex game theory approach for allocating allowances and present the actual outcomes of that game in terms of the number of allowances local regulators allocated to certain industrial subsectors. Chai (2013) provides an early quantitative assessment of the Shenzhen pilot. The author finds that the pilot risks overallocation, stemming from its provisions for estimating emissions from purchased electricity and adjusting allowance allocations. Taken together, these studies highlight a number of features in Shenzhen that are unique designs relative to other C&T systems.

The remaining studies focus on Shanghai, Guangdong, or both. Wu et al. (2014) briefly describe major design features of the Shanghai pilot, such as precise estimates of the portion of Shanghai's total emissions covered by the C&T system. RAP (2013) provides a comprehensive list of direct feedback to the initial designs published by regulators in Shanghai and Guangdong. The authors use examples from California and the Regional Greenhouse Gas Initiative to highlight alternative designs. Zhang (2013) conducts an initial analysis of the pilots and predicts the Guangdong pilot might have to reduce the most emissions from its business-as-usual scenario.

Taken together, these studies address various issues that may arise when designing a market-based mechanism in an economy that still harbors many non-market features. While the political economy studies seem relatively pessimistic about the chances that carbon trading will make a large impact, the more narrow studies that address the design of pilots generally outline pragmatic next steps to achieving a degree of operational success.

III. Pricing Carbon in China Brings New Challenges

Distinctive aspects of China's economic, regulatory, and legal structures—as well as China's capacity to measure, report, and verify carbon emissions—present difficult challenges that pilot regulators must overcome by crafting design features that depart from those of other C&T programs. Understanding whether these pilot policies represent deftly tailored designs—or, instead, indicate design deficiencies—requires a solid understanding of China's political economy. We therefore introduce the main features of China's political economy that are relevant to carbon trading. These include China's rapid economic growth and heavily regulated electricity sector; the prominence of energy intensive and trade exposed (EITE) industries; interactions between state-owned entities and competitive firms; carbon trading's status relative to complementary policies; and efforts to measure, report, and verify carbon emissions.

A. Rapid Economic Growth

China's total GDP has increased on average 10 percent annually since 1978 (NBSPRC 2014) This sustained economic growth has made China's economy the second largest in the world and lifted more than 500 million people out of poverty.[3] Economic growth is anticipated to continue, albeit at a slower rate, with China's GDP growing nearly in 2013 and expected to grow at a similar rate in 2014 (NBSPRC 2014). Carbon emissions are expected to increase accordingly.

Other carbon pricing programs exist in countries with GDP and carbon emission growth rates that are lower than in China. Thus, pilot regulators might need to consider new policies—for example, for setting caps and formulating provisions for price management—that might be more appropriate in the context of China's high growth rates.

B. Heavily Regulated Electricity Sector

China accounts for nearly half of global coal consumption, with coal accounting for two-thirds of China's total energy consumption in 2012 (NBSPRC 2013; US EIA 2014b). Pilot regulators therefore must regulate coal power plants, and more generally the electricity sector, to substantially reduce carbon emissions.

But the government heavily regulates both the price and dispatch of electricity in China. As a result, pilot regulators cannot necessarily rely on the electricity market to communicate the carbon price onto electricity consumers, as the electricity market automatically does in some C&T programs. The government's control of the electricity market therefore complicates pilot regulators' efforts to cover electricity generators and promote reductions in electricity demand.

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[3] http://www.worldbank.org/en/country/china/overview (accessed on 16 May 2014).

C. Prominence of Energy Intensive and Trade-Exposed Industries

China produces more steel, cement, and aluminum than any other country. Moreover, these three EITE industries constitute a large portion of China's total energy consumption. While bringing these industries under a cap might help China meet its economic restructuring objectives, the economic and trade consequences of such action could be significant (Lo and Wang 2013).

If pilot regulators include such industries under the cap, they may choose to carefully craft allowance allocations that protect EITE industries' overall competitiveness while maintaining incentives to reduce emissions. While other C&T systems face similar issues, the prominence of EITE industries in China's overall economy may place particular pressure on pilot regulators to not adversely impact production.[4]

D. State-Owned Enterprises

The Chinese carbon-trading pilots represent perhaps the first large-scale attempt to include SOEs and private enterprises under a C&T system. Yet SOEs in China are fundamentally different than private enterprises in many ways, and this mismatch complicates program design.

SOEs are typically very large compared to private firms. For example, ten SOEs own nearly 60 percent of electricity generation assets, and two SOEs own virtually all electricity distribution infrastructure (Baron et al. 2012). In addition, SOEs' goals are not simply to pursue profit maximization. Government mandates in the electricity sector, for example, require SOEs to secure electricity supply for sustained and equitable economic and social development and to remain financially sustainable (Baron et al. 2012). And unlike private firms, the government, not the market, judges the performance of SOEs in fulfilling these mandates. For example, governments appoint key SOE personnel and conduct performance assessments that determine whether such SOE employees receive a promotion or demotion (Lo 2012; Qi and Wang 2013).

Another difference is that SOEs have better access to financing and advanced technologies relative to private enterprises—which may effectively allow them to abate pollution at comparatively lower costs (Qi and Wang 2013).

[4] To the extent that regulators want to reduce reliance on EITE industries in general, or at least to move production of such industries out of the eastern part of the country as a means of improving local air or water quality, adverse impacts on these industries might not be an issue.

Given these differences, pilot regulators face an interesting decision of whether to place SOEs and private firms in the same carbon market and, if so, whether to treat them differently. If pilot regulators choose to cover the branches of an SOE within their jurisdiction, it is still unclear that they have the regulatory authority to punish SOEs for not complying with carbon trading rules. Traditionally, a national commission authorized by the State Council holds these rights (Qi and Wang 2013). Therefore, pilot regulators must work to reconcile any discrepancies and ensure that they have the right to punish SOEs under their program.

A second issue is that large SOEs may be able to exercise considerable market power over the carbon market—given their comparatively larger size, emissions, and (presumably) allowance allocations (Qi and Wang 2013). If pilot regulators do choose to include SOEs and private firms in the same market, a wide range of options exist for addressing market power in emissions trading markets. For example, California's Assembly Bill 32 program uses both auction purchase and holding limits in an attempt to control market power (Schatzki and Stavins 2013). Moreover, a vein of academic literature employs economic theory to describe the origins and behaviors of firms that use market power in emissions trading programs (Hahn 1984; Malueg and Yates 2009; Montero 2009).

E. Complementary Policies

China employs a large number of non-trading policies to reduce carbon emissions that may interact with a cap-and-trade program in complex ways. These policies include nationwide and provincial goals to reduce conventional air pollutants, carbon intensity, energy intensity, and coal consumption (MEP 2013; State Council 2013; Zhang 2014; Zhang et al. 2014). In addition, more than 10,000 enterprises in China now face energy conservation targets imposed by the national government (Lo and Wang 2013).

Such complementary policies have at least two impacts on C&T pilot programs. At the firm level, a facility under a carbon-trading program may forego an opportunity to buy an allowance because an additional ton of carbon emissions would put that facility out of compliance with an energy conservation goal. At the market level, complementary policies that reduce emissions at the same sources covered by the cap can lower demand for allowances and therefore lower allowance prices. If, in aggregate, the complementary measures already achieve the reductions that the cap intends to achieve, then the overall carbon market will be nonbinding and allowance prices will drop to zero (Schatzki and Stavins 2012). Pilot regulators therefore face a difficult but important task of ensuring that a cap binds in the presence of complementary policies.

In China, a C&T system must also generally compete with complementary policies in a legal setting because complementary policies generally enjoy higher legal and administrative status than C&T—issues we address more fully in subsequent sections below. Thus, in effect, complementary policies can make the prospects of compliance with C&T less likely. Such competition might occur if compliance with a C&T system would jeopardize compliance with a complementary policy that carries stronger penalties for noncompliance.

F. Legal Status of Cap and Trade

Environmental law in China is hierarchal, with national laws superseding local laws in most cases. The National People's Congress holds the highest authority, followed by the State Council and, finally, local laws and regulations promulgated by provincial legislatures and governments (Deng 2012). While the State Council broadly authorized the C&T pilots, local laws and regulations—the lowest level of Chinese law—underpin the entirety of each program's goals and design.

As a result, no national law has yet to explicitly enshrine goals relating to C&T for carbon. The highest legal body that has explicitly addressed carbon is the State Council, which broadly authorized the concept of C&T but did not enshrine any goals—for example, that pilots must cap carbon emissions at a certain level of tons. The explicit mention of pilot C&T goals by the State Council or National People's Congress would likely make the pilots more politically binding.[5] Until then, the pilot regulators must operate largely in a politically uncertain environment.

A related complication is that preexisting laws with greater legal strength may prevent pilot regulators from creating well-designed C&T systems. This interaction is most easily observed in the case of noncompliance penalties. China's Environmental Protection Law, enacted by the National People's Congress, only authorizes a one-time fee for noncompliance with environmental laws (NPC 1989). China's Prevention and Control of Atmospheric Pollution Law seems to limit the amount of any fee to RMB¥100,000 or roughly USD$16,000 (NPC 2000). Compared to the more common practice of penalizing non-compliance without limit and on a per ton basis, the non-compliance penalties enshrined in these laws seem far too lax to

[5] Schreifels et al. (2012) observe that the explicit inclusion of sulfur dioxide reduction goals in China's **11th** Five-Year Plan and remarks on the topic by China's president marked two watershed moments in the effort to reduce sulfur dioxide in China.

ensure significant compliance within a carbon trading system—a conclusion also reached by Hart and Ma (2014). Although no current national laws in China explicitly mention carbon, let alone explicitly discuss fees for non-compliance with carbon rules, it seems that many scholars generally interpret the maximum levels for non-compliance fees in the Environmental Protection Law and the Prevention and Control of Atmospheric Pollution Law as applicable to carbon (Hart and Ma 2014; Zhang et al. 2014). Pilot regulators therefore do not seem to have the legal authority to impose strong non-compliance fees.

Two exceptions may grant pilots stronger legal authority to ensure compliance. First, the National People's Congress has recently adopted amendments to China's Environmental Protection Law that seemingly would allow a higher level of fee to be levied more than once on enterprises not complying with environmental regulations (NPC 2014).[6] These amendments take effect in early 2015 and may prove valuable if pilot regulators can successfully convince companies that the amended rules for penalties implicitly apply to carbon. Second, some local jurisdictions have the authority to overrule aspects of national environmental law. Shenzhen has this authority because it is a special economic zone. As a result, pilot regulators in that city may have the authority to pass a local law that supersedes and improves the current shortcoming in the relevant national laws.

G. Administrative Status of Cap and Trade

The administrative status of C&T in China is uncertain, for at least two reasons. First, C&T's success does not explicitly impact the careers of government officials and executives at SOEs. By contrast, the failure of officials to achieve carbon or energy intensity targets can impact whether that cadre of officials receives a promotion or demotion (NDRC 2014; Zhang et al. 2014). Similarly, under the sulfur dioxide trading pilots, the NDRC and Ministry of Environmental Protection (MEP) pegged the achievement of goals to the performance reviews of SOE executives—a policy that improved the level of reductions (Schreifels et al. 2012). Pilot regulators must therefore create a way to ensure that governments and SOEs comply with the C&T systems.

A second problem is misalignment between the NDRC and Ministry of Environmental Protection (MEP). The MEP typically has the authority to impose environmental fines in China.

[6] A proposed amendment to the Prevention and Control of Atmospheric Pollution may make similar amendments (State Council 2014; Zhang 2014).

Yet the MEP is essentially absent from carbon pilot development. Instead, the NDRC leads pilot development. Whether the agency can collect noncompliance fees and other fines associated with the C&T program is an open question (Chang and Wang 2010).

H. Monitoring, Reporting, and Verifying Carbon Emissions

Each pilot is pursuing its own protocols for measuring, reporting, and verifying carbon emissions, and this heterogeneity will likely prevent the accurate comparison of emissions levels between pilot regions (Kong and Freeman 2013).

In addition, each protocol suffers from issues with data quality and quantity. For example, bottom-up and top-down calculations of emissions are not always equal in the pilots, and pilots lack complete historical emissions data (Liu and Nan 2012; Wang 2013a). Some of the contributing factors for poor data quality in China are small penalties for obstruction of inspection and falsification of data (Wang 2013), as well as vague and ineffective rules to fight “statistical corruption” (Liu and Yang 2009). Beyond national level emissions data, regulators at local levels have not collected data at the facility level for very long.

Designing pilots that are effective even in a sparse data environment is a challenge that especially complicates cap setting and allowance allocation—two key pillars of any C&T system.

IV. Defining Success in China’s Carbon Trading Pilots

Experts suggest that the success or failure of the pilots “will to a large extent determine the future of carbon markets development in China” (Han et al. 2012, 34). Yet, given the numerous barriers China’s political economy imposes on pilot regulators, the introduction of pilot C&T systems that substantially reduce emissions will take time and should therefore be viewed as a long-term effort. Along the way, though, shorter-term definitions of success may help measure progress and inform the formulation of China’s national carbon market.

For example, in the short run, success might be defined as the mere introduction of a carbon price. A successful carbon price might impact investment or innovation before substantially reducing carbon emissions, providing potential markers of progress. Short-run success might also be defined as the emergence of a carbon market, where participants understand the rules and seek out trading opportunities at healthy volumes and prices.

From an even more pragmatic view, success might be defined as the improvement of processes that measure, report, and verify carbon emissions. Currently, many enterprises lack the capacity to complete each of these steps. So by improving the quality and quantity of China's carbon emissions data, the pilots can contribute significantly to the success of future carbon trading and climate policy in general.

Another important version of success might be for regulators to place heavier reliance on carbon trading to reduce emissions. Currently, it seems that complementary measures may achieve many, if not all, carbon reductions required by the pilot programs—although this question has not been formally and extensively studied in any of the three regions we consider. Moreover, a greater shift toward trading would likely bring improvements in the cost-effectiveness of total reductions.

V. Pilot C&T Systems in Guangdong, Shanghai, and Shenzhen

In this section, we describe the design of three longer-running C&T pilots that we believe are most likely to serve as models for a national program: Guangdong, Shanghai, and Shenzhen. While the three pilots share some design features, they differ in important ways. They have distinct incentives for compliance and strategies for cap setting and allowance allocation, for example. They also cover different sectors, offer a range of provisions for entrants and exits, and manage allowance price differently. In the sections that follow, we discuss each of these differences, and we summarize our discussion in Table 2. Our observations are based on our translation and synthesis of more than 50 publicly available documents that outline each pilot's design. We also draw on more than a dozen interviews with policymakers directly involved in pilot design and experts who analyze the pilots.

A. Incentives for Compliance

Each pilot has its own strategies that attempt to enforce compliance under China's weak legal and administrative structure for carbon trading.

In Guangdong, regulators have designed a noncompliance penalty that fines a firm three times the average allowance price for any positive difference between its carbon emissions and retired allowances (Guangdong Government 2013). Guangdong regulators have included two additional strategies to bolster the odds of compliance. First, regulators try to reward compliance (in addition to punishing noncompliance) by granting priority for national low-carbon development funding to firms in compliance with the carbon market. Second, regulators intend to periodically publicize the compliance status of firms to create social pressure for compliance (Guangdong Government 2014).

In Shanghai, if a firm fails to retire sufficient allowances by the deadline, it faces a penalty between ¥50,000 and ¥100,000 (Shanghai Government 2013a). For serious violations—where a firm fails to rectify mistakes in monitoring emissions, verifying emissions, and surrendering allowances within specified deadlines—Shanghai regulators may impose several sanctions. First, they may record unlawful acts into the credit records of the firm, including those of the individuals chiefly in charge. They also may publish unlawful acts on a government website or through the media. More drastically, they may cancel that firm's ability to access special funds for energy conservation and emissions reductions for two years (Shanghai Government 2013a).

In Shenzhen, a firm that fails to retire sufficient allowances must pay a noncompliance fee equal to three times the average market price of allowances over the prior six months and then make up the deficit through allowance purchases or forfeitures within a specified time. If the firm fails again, the competent department can deduct its current year and then future years' allowances from their registered account (Shenzhen Congress 2012; Shenzhen Exchange 2013; Shenzhen Government 2014). Shenzhen's situation, however, is quite different than Guangdong's or even Shanghai's because the city is part of a special economic zone. Given this designation, as mentioned previously, Shenzhen's Congress can supersede some aspects of national law, including the national limit on fees for environmental noncompliance. Because Shenzhen's Congress authorized its noncompliance penalty, the limit on the noncompliance fee can (and does, by a large margin) exceed ¥100,000.

B. Cap Setting

To the extent that relatively high levels of GDP growth means greater uncertainty of future GDP levels, China's economic growth makes the choice of whether to choose an absolute cap (denoted in tons of CO_2) or an intensity cap (denoted in terms of CO_2 per unit of GDP) especially important. Under an absolute cap, uncertainty in GDP translates into uncertainty in emissions intensity. Under an intensity cap, uncertainty in GDP translates into uncertainty regarding overall emissions. If GDP ends up higher than expected, an absolute cap will involve more abatement and therefore higher costs. The opposite is true if GDP ends up lower than expected; in this case, an intensity cap requires less abatement and lower costs (Ellerman and Sue Wing 2003). The ranking of absolute versus intensity caps varies by region and strongly depends on the correlation between carbon emissions with GDP (Newell and Pizer 2008). Pilot regulators must therefore weigh their preferences for certainty in emissions and costs when choosing between an absolute and intensity cap.

Each of the pilots seems to strategically link its cap to regional carbon-intensity goals, which has more legal power and stronger enforceability than a separate C&T cap would (Liu and Nan 2012). While possibly a clever political and legal strategy, such an arrangement complicates cap setting. Specifically, pilots tend to self-impose a constraint that their systems must help achieve a carbon intensity target, denoted in tons of carbon per unit of GDP. Choosing an intensity-based cap represents the most straightforward way to address regulators' need to achieve a regional carbon-intensity target because the cap level could simply be set equal to the regional carbon-intensity goal. Still, regulators might prefer an absolute cap for a variety of reasons. Under an absolute cap, regulators must make an ex-ante projection of growth in GDP. If their projections prove wrong, regulators must then adjust cap levels to achieve their regional carbon-intensity targets. A pessimistic assumption—that is, if GDP turns out lower than projected—forces regulators to take allowances out of the market to avoid breaching the regional carbon-intensity goal, while an optimistic assumption leaves regulators with two choices: accept over-compliance or issue additional allowances.

Each pilot addresses this self-imposed constraint differently by choosing unique designs regarding the type of cap adopted, cap schedules and flexibility to adjust cap levels.

Guangdong regulators have announced a cap equal to 350 million tons for 2013 and set aside an allowance reserve of roughly 17 million tons to correct an optimistic assumption on growth in GDP if necessary (Guangdong DRC 2013c; Guangdong Government 2014). Guangdong DRC increased the cap and the allowances reserve to 208 million tons and 38 million tons, respectively, for 2014 (Guangdong DRC 2014b).

In Shanghai, regulators have yet to announce an absolute cap. Instead, regulators have initially allocated all allowances up front and at once for the 2013–2015 period. In other words, each covered entity has received its allowance allocation for all three years and has allowances with vintage years 2013, 2014, and 2015 (Shanghai Government 2012; Xinhua News Agency 2013).[7] However, Shanghai regulators can issue additional allowances to certain covered entities—or take them away—before the end of each compliance period, based on an individual entity's production compared to a benchmark (Shanghai DRC 2013a). If an entity produces lower emissions than expected, allowances will presumably be taken away—and vice versa.

[7] Regulators designed this unique approach as a way to promote price discovery through trading, in the absence of future vintage-year allowance markets.

While the sum of initially allocated allowances represents an absolute cap, if not a certain one, the ability to adjust individual allowance allocations without limit has caused some observers to describe the Shanghai cap as a hybrid (Schreifels 2014).

Shenzhen assigns carbon-intensity targets to individual covered entities and also issues an overall cap on carbon intensity and absolute carbon emissions for the whole pilot period, between 2013 and 2015. The absolute cap between 2013 and 2015 equals approximately 132 million tons, the sum of a 120 million allowance cap and a 12 million offset cap—corresponding to an approximate cap of 44 million tons each year (Shenzhen Exchange 2013). Superimposed on this cap are specific annual carbon-intensity targets, which equal 81.1 tons per ¥1 million, 75.4 tons per ¥1 million, and 70.7 tons per ¥1 million for 2013, 2014, and 2015 respectively (Schreifels 2013). It is unclear whether both, one, or neither of the caps will be binding. In any case, allowances are allocated up front and at once but can be adjusted upward, by no more than 10 percent, or downward, with no limit, in any one year.

C. Emissions Coverage

Compared to other C&T programs, each of the three pilots covers a high percentage of total emissions. Also notably, each pilot covers important EITE industries. But aside from the electricity sector, which is covered in all three pilots, emissions coverage and thresholds for compliance vary substantially across programs.

The Guangdong pilot covers companies in the electricity, cement, steel, and petrochemical industries that emitted more than 20,000 tons of carbon emissions (or had more than 10,000 tons of coe energy consumption annually)—as well as companies in the commercial sector (including hotels, restaurants, finance, business, and public institutions) emitting more than 5,000 tons of carbon emissions annually (Guangdong DRC 2014b; Guangdong Government 2014). Taken together, the pilot currently covers 211 companies, mostly from the electricity, cement, and petrochemical industries (Guangdong DRC 2014b). In the future, the pilot may expand to cover industrial producers in the textile, non-ferrous metals, plastics, paper, and ceramics sectors—although this expansion likely will not take place until after 2015 (Chen 2014; Guangdong Government 2012a; Guangdong DRC 2014b). If and when these sectors join, the pilot will include an estimated 827 industrial emitters, accounting for approximately 42 percent of Guangdong’s carbon emissions (Jotzo 2013). In addition, there is some discussion of expanding further to include the transportation sector.

The Shanghai pilot currently covers the electricity, industrial, commercial, and transportation sectors. Companies in the power and industrial sector that emitted more than 20,000 tons of carbon emissions in 2010 or 2011 are included, while companies in the commercial and transportation sector that emitted more than 10,000 tons of carbon emissions in 2010 or 2011 are covered. Shanghai's coverage of the industrial sector is quite comprehensive, encompassing steel, petrochemical, chemical engineering, non-ferrous metals, building materials, textile, paper, rubber, and chemical fiber. Transport through airlines, airports, and ports also fall under the pilot's coverage (Shanghai Government 2012). Taken together, the pilot currently regulates 197 companies (Shanghai DRC 2012).

The Shenzhen pilot covers electricity, manufacturing, and water supply companies that emit more than 3,000 tons of carbon emissions annually (Shenzhen Government 2014). The pilot also covers certain large public buildings and state offices that exceed 100,000 square meters in size (Shenzhen Government 2014). The comparatively low emissions thresholds were deemed necessary in order to cover a substantial portion of Shenzhen's carbon emissions, particularly because Shenzhen has limited heavy industry. Regulators considered two aspects in determining the initial list of industrial enterprises to be covered by the pilot: the company's value added, provided by the Municipal Bureau of Statistics, and the company's energy consumption data. These criteria resulted in an initial list of 635 companies and 197 large public buildings (ICAP 2014). The pilot may expand to cover more industrial companies, more large building buildings, and bus and taxi companies (Shenzhen Exchange 2013).

Because the Chinese government heavily regulates both the price and dispatch of electricity, the introduction of C&T to China's electricity sector provides particularly unique challenges. Elsewhere, C&T programs might require only electricity producers to retire allowances for emissions, under the assumption that those producers will pass the cost of allowances on to distributors and consumers in the form of higher electricity prices. RGGI in the US Northeast relies on this approach, for example. Such an arrangement aligns the entire economy under a single carbon price and therefore guarantees efficient abatement through equalizing marginal costs, in theory. But this approach is not appropriate in the context of China.

The NDRC sets wholesale and retail electricity prices and adjusts them rather infrequently (US EIA 2014a)—twice, in 2009 and 2011, in the last five years (NDRC 2009, 2011). Moreover, the price of coal, which is largely deregulated, has at times increased dramatically. The interaction between these regulatory restrictions and market prices has at least two implications for pilot designs. First, regulators would likely have to lobby the national government to allow electricity prices to reflect costs associated with carbon prices or invent a way to communicate the carbon price to distributors and consumers. Failure to do so would risk inefficient and unnecessarily costly abatement. It seems highly unlikely, however, that the NDRC will allow electricity prices to reflect carbon costs, at least at this point in time. This is true even in spite of recent policies established by the State Council that allow for electricity producers to recoup a portion of their costs associated with increased coal prices under certain scenarios (see Zhang 2014). Second, regulators will likely have to tailor pilot design to maintain a reliable electricity supply while achieving emissions reductions because of a need to not repeat historical power outages caused by high coal and low electricity prices (Baron et al. 2012).

The NDRC also regulates electricity dispatch in China, which can hamper the ability of distributors to pass through carbon costs to consumers. Instead of basing dispatch on least cost, local governments in China allocate roughly the same annual operation hours to each coal plant. This strategy ignores a plant’s energy consumption and emissions factor, thereby unduly favoring less efficient plants (Baron et al. 2012; Kahrl et al. 2011). Although some regions have piloted “energy-efficient dispatch,” the resulting savings and likely emissions reductions seem small, and substantial barriers hamper national adoption (Kahrl et al. 2013). Pilot regulators again risk inefficient and unnecessarily costly abatement if generators cannot respond to carbon prices. As is the case with essentially fixed electricity prices, regulators have a limited set of options: lobby the NDRC to change its dispatch regulations or develop a mechanism that allows distributors to react to carbon prices.

Facing these choices, each of the pilots requires that regulated entities retire an allowance for emissions associated with electricity at both the points of production and consumption. In this way, pilot regulators have developed a mechanism that communicates the carbon price to consumers of electricity.

D. Allowance Allocation

Each pilot allocates virtually all allowances for free. In the case of the electricity sector, this choice likely reflects a desire to keep electricity generators financially sustainable, given that they cannot pass costs associated with carbon prices onto consumers. Similarly, freely allocating allowances to the EITE sector might represent a preference to avoid disrupting production at these sources. But pilots also allocate allowances freely to consumers of electricity, including large buildings in some cases. This choice seems less justified than free allocation to the electricity and EITE sectors because large buildings likely can pass costs through to consumers.

In the cases of Guangdong and Shenzhen, a small fraction of allowances are auctioned off rather than given away. Auctioning is a method of selling allowances to polluters. The main consequence of switching from free allocation to an auction is to shift the burden of the carbon market from consumers to producers. Neither approach is more efficient than the other—at least in a competitive market. In such a context, the opportunity cost of a purchased allowance is the same as one that is freely allocated.

While each pilot distributes all or nearly all allowances for free, the methods differ. These distinct choices can have important distributional and efficiency consequences. Two main methods exist for free allocation: grandfathering and output-based allocation. Under a grandfathering approach, the regulator awards a regulated company allowance equal to a historical benchmark, typically emissions levels or product output in some previous year. Such an approach does not account for changes in a company's output over time. Output-based allocation, on the other hand, introduces an element of dynamism. In this case, a firm's allocation is updated over time to reflect a particular benchmark. For example, a firm's output—measured in industrial value-added or units of product—might be used to update the number of allowances it receives. As is well known, however, firms that receive allowances based on output-based allocations have an incentive to increase production and, correspondingly, emissions.

i. Guangdong

Participants in Guangdong's market will receive a substantial amount of free allocation but are also required to purchase a small number of allowances at auction. For 2013, the minimum ratio of freely allocated to auctioned permits for each firm is 97 to 3 (Guangdong DRC 2013c). This ratio is slated to increase to 90 to 10 in 2015 (Guangdong DRC 2013c). Auctions to firms in the electricity sector raise more quickly, however. The minimum ratio of freely allocated to auctioned permits for each firm in the electricity sector increased to 95 to 5 in 2014 (Guangdong DRC 2014b). Previously, auctions included a floor price of ¥60 per ton (Guangdong DRC 2013c). However, regulators fixed the floor price for each quarterly auction at ¥25 per ton, ¥30 per ton, ¥35 per ton and ¥40 per ton, respectively (Guangdong DRC 2014b). Instead, the Guangdong Development and Reform Commission (DRC) generally works in conjunction with relevant governmental departments to set the reserve price, leaving the government discretion to change future reserve prices (Guangdong Government 2014). The government plans to recycle auction revenues to support low-carbon and energy-saving investments (Guangdong DRC

2013a). It is expected that a significant portion of the auction revenue would go back to the covered entities, with ongoing studies to identify exactly how this will occur (Chen 2014).

Each of the existing companies currently covered—including those from the electricity, cement, steel, and petrochemical industries that exceed emissions thresholds—receives free allowances for 2013 based upon a formula unique to their sector. For 2013, these formulas often relied on a company's historical average emissions or production from 2010 to 2012. For 2014, these formulas relied on historical emissions or production from 2013. . Allowance are allocated to this emissions or production data—as reported by that company—such that allocations are tailored to firms' individual circumstances (Guangdong DRC 2013b; Guangdong DRC 2014c). Guangdong's allowance allocation formulas follow a grandfathering, output-based updating, or combined approach.

For power plants, allowance allocation is the product of three factors: an abatement coefficient, which equals one for 2013 and 2014; the average historical output of that plant, denoted in kilowatt hours (kWh); and a benchmarking level, denoted in grams of CO_2 per kWh. As depicted in Table 3, four benchmarking levels exist for coal and two for gas generation units for 2013 allowance allocation, with higher levels for smaller plants (Guangdong DRC 2013b, 2013c). The Guangdong DRC implemented a more detailed benchmarking levels in 2014, as shown in Table 4 (Guangdong DRC 2014c). This allowance allocation strategy represents grandfathering based on output levels because benchmarks are not pegged to production or emissions within the compliance period.

Table 3. Benchmarking Levels (2013) for Existing Power Plants in Guangdong

Type	Coal				Gas	
Installed capacity (megawatts)	≥1000	600–999	300–599	< 300	≥390	< 390
Benchmark (grams of CO_2 per kilowatt hour)	770	815	865	930	415	482

Table 4. Benchmarking Levels (2014) for Existing Power Plants in Guangdong

Type	Coal				Gas	
Installed capacity	≥1000	600–999	300–599	< 300	≥390	< 390
Benchmark (grams of CO_2 per kilowatt hour)	770	850-880*	905 or 927*	965 or 988*	390	440

*Depending on technology.

For cement producers, Guangdong applies a different allowance allocation formula to four unique processes: mining, grinding, clinker production, and "other grindings." Taken together, allocation follows a combination of grandfathering and output-based approach approaches.

For mining and other grindings, allowance allocation equals the historical average carbon emissions and thus represents a grandfathering approach based on emissions (Guangdong DRC 2013b).

For clinker production, allowance allocation equals historical average output multiplied by a benchmark of the same type of production line. These benchmarks vary based on production-line output, favoring smaller production lines (Table 5). This approach therefore primarily follows grandfathering based on output. But it does contain some elements of output-based updating because the amount of allowances a clinker producer receives can change with its level of production within the compliance period (Guangdong DRC 2014c).

For grinding, allowance allocation equals the historical average annual cement production multiplied by a single sector-wide benchmark that equals 0.027 tons of CO2 per ton of cement produced (Guangdong DRC 2014c). This form of allocation represents output-based updating because the number of allowances depends on production during the compliance period.

Table 5. Benchmarks for Clinker Production

Scale of clinker production (tons/day)	≥ 4,000	2,000–4,000	< 2,000
Benchmark (CO_2/ton)	0.893	0.937	0.950

For steel companies, allowance allocation differs based on whether the production uses a long or short process. Total allocation for the long process equals the product of coke, limestone, and steel production—each of which are multiplied by a benchmark and an abatement coefficient. Benchmark levels vary by product. This type of allocation represents output-based updating because allowances depend on production during the compliance period. Total allocation for the short process equals the historical average annual carbon emissions multiplied by the abatement coefficient, thus following a grandfathering approach (Guangdong DRC 2013b; Guangdong DRC 2014c).

For petrochemical companies, allowance allocation equals annual average historical carbon emissions multiplied by an abatement coefficient—and therefore represents grandfathering based on emissions. The coefficient equals one for some companies except for non-oil and non-ethylene petrochemical plants and oil/ethylene petrochemical plants whose energy consumption exceeds the provincial average. In this case, the abatement coefficient equals 0.99 for 2013 (Guangdong DRC 2013b) and 1 for 2014 (Guangdong DRC 2014c).

ii. Shanghai

Shanghai freely allocates all allowances for the 2013–2015 pilot phase. However, a guidance document from the Shanghai government in 2012 recommends the timely introduction of methods that require firms to pay, leaving room for possible auctioning later on.

Shanghai adopts two methods to allocate allowances for the pilot: grandfathering and output-based allocation. The grandfathering method mainly applies to the industrial sector and buildings associated with the commercial or rail sector, while the output-based updating method applies to the electricity sector and buildings associated with airlines, airports, and ports (Shanghai DRC 2013a).

For companies receiving free allocation via grandfathering, annual allowances for 2013–2015 will be distributed at one time. For those using an output-based updating method, the annual pre-allowances for 2013–2015 will be distributed all at once based on the average service volume from 2009 to 2011. Before each year’s allowance surrender, the Shanghai DRC will adjust the annual emissions allowances for each benchmarking enterprise based on its service volume for that year, in order to rectify any gap between an enterprise’s pre-allocation and its adjusted number of allowances. Such rectification can include distributing additional allowances or retracting previously distributed allowances (Shanghai DRC 2013a).

The process of adjusting allowance allocation will take place during March 15–31 of each year (Shanghai DRC 2013b). This process essentially compares a regulated firm's level of pre-allocation with the number of allowances calculated by a benchmarking formula that accounts for that firm's annual output. Although the possibility of adjustment makes Shanghai's regulations more complex, regulators deemed these rules necessary. As mentioned earlier, regulators hope that allocating allowances for the entire 2013–2015 period up front will increase price discovery in the absence of a proper futures market for allowances. At the same time, they want to maintain an output-based allocation method for certain industries, which can require updating allowances each year based on the prior year's output. The adjustment process therefore represents a compromise.

Numerous covered enterprises will receive allowances based on a strategy of grandfathering tied to emission levels. These covered enterprises generally fall into two categories: industrial and buildings associated with the commercial or rail sectors. Allowance allocation rules for these two categories are very similar. Both base allocation off of a firm's average annual emissions for the period of 2009–2011. Alternatively, if a firm's carbon emissions increased by more than 50 percent between those years, the allocation equals a firm's carbon emissions in 2011. New projects undertaken by industrial participants will receive free allocation, and new projects undertaken by participants in the building sector will be completely exempt (Shanghai DRC 2013a).

For covered enterprises in the electricity sector, the Shanghai DRC initially allocates allowances based on historical electricity output, representing a grandfathering approach. It then takes an output-based updating approach, recalculating the allowance allocation using equation 1 and adjusting for discrepancies by awarding additional allowances or taking away pre-allowances.

Equation 1: Number of Allowances $= E_t * B * CF * A$

- E_t is a power company's annual integrated electricity output, based on power generation and heat supplied and denoted in kilojoules.
- B is a benchmarking level for power companies that varies across generating units, depending on unit type and installed capacity and denoted in CO_2 per kWh (Table 6). The baseline levels vary between 2013 and 2015, favoring smaller power plants.
- CF is a conversion factor that varies for coal and gas power plants, denoted in kilojoules per kWh.

- *A* is an adjustment coefficient that accounts for the relative capacity factor of coal and gas plants. It equals one for coal plants, with the specific number for a gas plant depending on its performance and annual production rate (Shanghai DRC 2013a).

Table 6. Benchmarks Levels for the Power Sector in Shanghai

Type		Capacity (kilowatts)	Benchmark (CO_2/10,000 kilowatt hours)		
			2013	2014	2015
Combustion gas			3.800	3.800	3.800
Coal	Ultrasuper critical	1,000,000	7.440	7.403	7.366
		660,000	7.686	7.647	7.609
	Super critical	900,000	7.951	7.911	7.871
		600,000	7.954	7.914	7.875
	Subcritical	600,000	8.155	8.114	8.074
		300,000	8.218	8.177	8.136

Source: Shanghai DRC 2013a.

For covered entities in the airport sector, regulators use equation 2 to allocate allowances (Shanghai DRC 2013a). This allocation strategy represents output-based updating.

*Equation 2: Number of Allowances = S * B + P*

- *S* is the amount of service given that year, confirmed by relevant governmental departments.
- *B* is the annual benchmark for service carbon emissions, based on an enterprise's average 2009–2011 emissions intensity and particular energy savings requirements.
- *P* is the number of previous abatement allowances, which may be awarded if an enterprise took early actions to reduce emissions.

For covered entities in the port sectors, regulators use equation 3 to allocate allowances (Shanghai DRC 2013a). This approach represents output-based updating.

*Equation 3: Number of Allowances = H * B + P*

- *H* is the amount of handled cargo in a given year.
- *B* is the annual benchmark for unit cargo-handling capacity, based on average emissions intensity in 2010 and particular energy saving requirements.
- *P* is the number of previous abatement allowances, which may be awarded if enterprises took early actions to reduce emissions.

iii. Shenzhen

Regulators in Shenzhen can choose to auction as much as 3 percent of total allocation but have yet to commit to doing so. Like Shanghai, Shenzhen pre-allocates allowances up front all at once and may adjust allowances later. Regulators can award companies additional allowances or buy back pre-allocated allowances based on companies' actual emissions and production data during the first quarter of each year. Any adjustments must be completed by May 31 of the year following emissions. Regulated companies must fulfill obligations based on their adjusted allowances, not their level of pre-allocated allowances (Shenzhen Exchange 2013).

The allocation method for the electricity and water sectors in Shenzhen is based on benchmarks, but details remain scarce. For industrial firms, Shenzhen applies a game theory approach to allocate the majority of allowances, citing serious information asymmetry for future output in manufacturing. Under this approach, allowance allocation becomes a game between firms instead of a game between firms and the government. The government announces a sector-wide cap and sets historical and target carbon-intensity benchmarks for each sector. Then firms submit emissions demand and projected output to compete with other firms for free allowances. Under game rules, firms with higher historical intensity must achieve larger reductions, and firms with low historical intensities or large intensity reductions will be encouraged. This game is repeated, with each stage offering a firm the chance to accept or reject its proposed allocation and exit the game. Such exits deduct from the total amount of allowance and therefore reduce the cap for the next round, which will be played out by the remaining firms (Jiang et al. 2014).

E. Provisions for Exits and Entrants

Each pilot treats entrants and exits quite differently. In Guangdong, new projects expected to emit more than 10,000 carbon emissions annually are covered and receive free allowances from an estimated 20 million ton reserve[8] when they purchase enough auctioned allowances (Guangdong Government 2014). In addition, emitters that are not covered can voluntarily apply to the pilot. Firms that exit the program must forfeit all allowances (Guangdong Government 2014).

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[8] Guangdong reserves 38 million tons for market adjustments and new, expanded, or retrofitted projects. Decree 197 (Guangdong Government 2014) states that the current allocation for market adjustment equals 5 percent of the total amount for regulated entities. For 2013, the total is 350 million tons, so the current allocation equals 17.5 million tons. Subtracting 17.5 million tons from 38 million tons leaves us with an estimate for reserved allowances intended for new, expanded, or retrofitted projects that equals 20.5 million tons.

In Shanghai, only new projects from already-covered firms can enter the pilot, but new projects in the commercial sector are exempted (Shanghai DRC 2013a). Firms that exit the program only forfeit 50 percent of their future allowances (Shanghai Government 2013b).

In Shenzhen, new fixed asset investment projects are covered if they are expected to emit at least 3,000 tons of CO_2 annually (Shenzhen Government 2014).[9] Two percent of the total annual allowances are reserved for these new projects, which would receive pre-allocation upon the start of production. Allocation would then be subject to adjustment based on actual production (Shenzhen Government 2014). Freely allocated allowances come from a 2.4 million allowance reserve (Shenzhen Exchange 2013). Firms can voluntarily join the program.

F. Price Management Provisions

Each of the pilots manages their allowance prices differently. In Guangdong, regulators designated a price floor for auctioned allowances (Guangdong DRC 2013c). Moreover, an exchange regulates allowance prices so that they cannot vary more than 10 percent in one day (Guangzhou Exchange 2013).

In Shanghai, the only restriction on allowance prices is that they cannot vary more than 30 percent in one day (Shanghai Exchange 2013).

Shenzhen most thoroughly manages prices of the three pilots, guarding against extreme highs or lows using a symmetric safety valve composed of two components. Regulators have kept an allowance reserve that equals 2 percent of total allocation, amounting to 2.4 million allowances for currently regulated companies, to protect against high prices. In the event that regulators determine that prices are too high, they will issue these allowances for sale at a fixed price. These allowances can be used only for compliance and cannot be traded on the market. Regulators also can buy a number of allowances back from the market if they determine prices are too low. The number of buyback allowances is limited to 10 percent of total allocation, or 12 million allowances for currently regulated companies. Funds for buybacks would come from auction proceeds, fines and donations (Shenzhen Exchange 2013).

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[9] In a previous draft, the Shenzhen government (2013) stated that rules for new entrants would "involve an investment exceeding ¥200 million."

G. Provisions for Carbon Offsets

Each pilot allows for the use of Chinese Certified Emissions Reductions (CCERs), which are largely composed of carbon offsets from the Clean Development Mechanism that have been repurposed for use in a Chinese context. Pilots do place restrictions on the use of CCERs, however.

Companies in Guangdong cannot use CCERs to comply with more than 10 percent of their annual emissions, and 70 percent of the CCERs a company uses must come from within the province (Guangdong Government 2014).

In Shanghai, companies can use CCERs to satisfy up to 5 percent of their obligation in any given year (Shanghai Government 2013a, 2013b).

In Shenzhen, companies can use CCERs for as much as 10 percent of their obligations, and the government plans to issue geographic restrictions and limits on the type of offsets that might be used (Shenzhen Exchange 2013).

Both Guangdong and Shanghai acknowledge that the NDRC will have to first issue CCERs, with Shanghai explicitly mentioning that the national government must verify that each CCER equals one ton of carbon emissions allowances (Shanghai DRC 2013a).

H. Provisions that Address Market Power

Two of the three pilots we consider, Shanghai and Guangdong, establish holding limits that might help prevent market power.

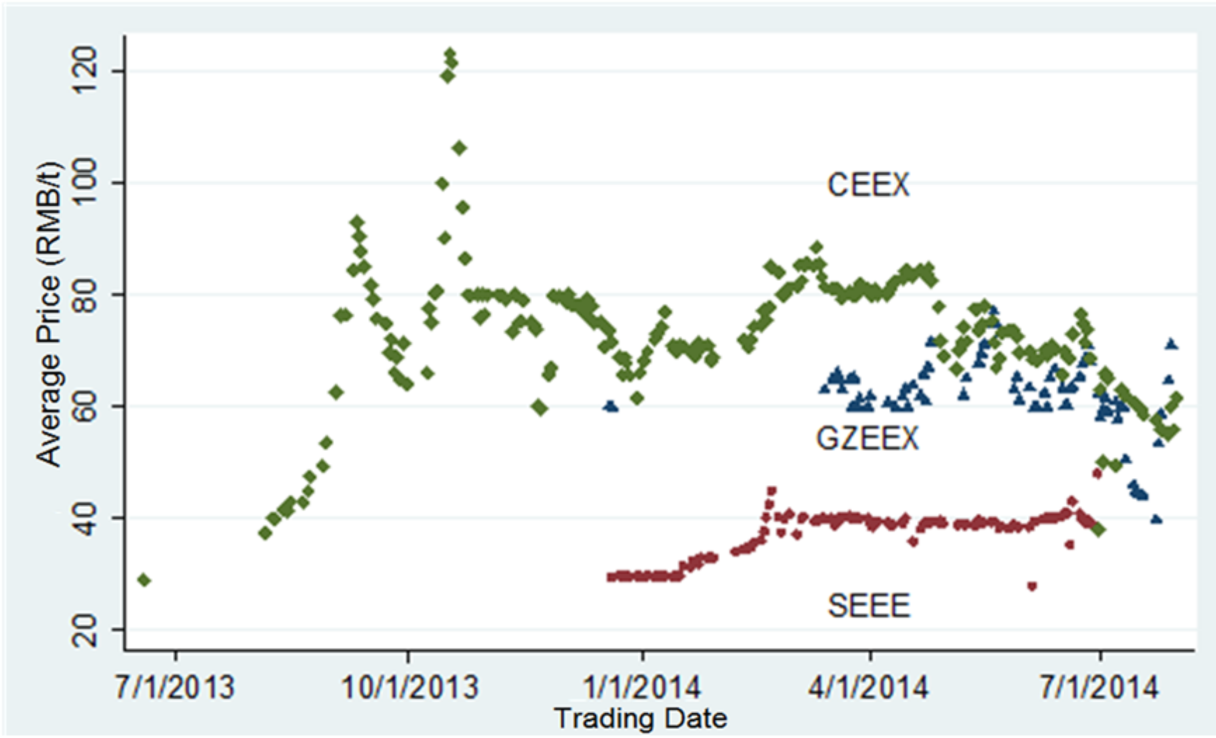
I. Provisions that Address Linking

One of the pilots we consider, Guangdong, may consider interprovincial trading with Hubei and other provinces (Han et al. 2012; Qian 2011). Indeed, the Guangdong pilot regulators have called for further research on linking and set a goal of designing an interprovincial market before 2020 (Guangdong Government 2012a; Guangdong Government 2012b).

VI. Progress Achieved by the Pilots

How have the pilots progressed thus far? In this section, we present data on allowance prices, trading volumes, and compliance rates as of 1 August 2014. Figure 1 presents daily average allowance prices over time for Guangdong (red), Shanghai (green), and Shenzhen (blue). Figure 2 presents daily trading volumes over time.

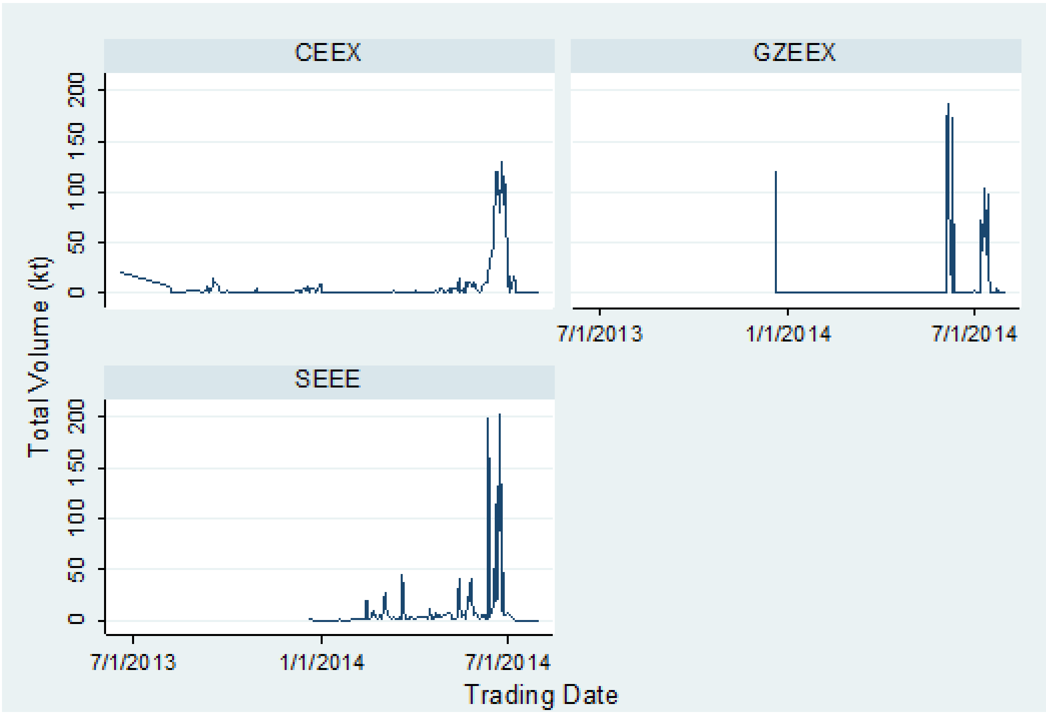
Figure 1. Allowance Prices in Guangdong (SEEE), Shanghai (CEEX), and Shenzhen (GZEEX)



Source: Tanpaifang.com, as of 30 July 2014.

The figures show that allowance prices are relatively stable, with Guangdong generally having the highest carbon price of around ¥60, or USD$10. Volumes of traded allowances remained very low until right before compliance deadlines, when they only briefly rose. And the total number of traded allowances constitutes a small fraction of the total number of available allowances. For example, the most active market—Shenzhen—traded a total of 1.6 million allowances throughout its first compliance year, equal to nearly 4 percent of the total allowances available in the market. This indicates a very low liquidity market.

Figure 2. Daily Trading Volume in Guangdong (SEEE), Shanghai (CEEX), and Shenzhen (GZEEX)



Source: Tanpaifang.com, as of 30 July 2014.

Two of the three pilots, Shanghai and Shenzhen, met their compliance deadline of 30 June 2014 (Shanghai Government 2013b; Shenzhen Government 2014). Shanghai had a 100 percent compliance rate, while in Shenzhen four industrial firms (out of 635) failed to comply by the deadline (21st Century Business Herald 2014). Guangdong finished the first compliance period on 15 July 2014, after postponing the initial compliance deadline of 20 June 2014 (Guangdong DRC 2014a). Two firms out of 184 failed to comply by the later deadline.[10]

As was typical of other pilots in China, the three pilots we consider faced difficulties in fulfilling the compliance requirements within their original deadlines. Guangdong regulators not only postponed the compliance deadline but also initiated a fifth and unplanned auction on 25 June with nearly two million allowances (China Emissions Exchange 2013). Shanghai regulators

[10] A total of 202 firms were initially regulated (Guangdong DRC 2013c), but later 18 were qualified to transit from regulated companies to report companies. In the end, 184 firms were regulated companies that should have complied (http://www.gddpc.gov.cn/xxgk/gzdt1/gzdt/201407/t20140715_250335.htm).

allocated more than 500,000 additional allowances for auction on 30 June, 7,220 tons of which were bought by two firms (Shanghai DRC 2014; Shanghai Exchange 2014). And in Shenzhen, regulators extended the transaction time during the period from June 23 to June 30 (Shenzhen Exchange 2014a; Shenzhen Exchange 2014b).

Similar phenomenon exists in other pilots. Beijing pushed back its compliance deadline from 15 to 27 June. Beijing DRC published a list of incompliant companies (257 in total) and asked them to comply before June 27 without punishment. If they failed to comply, Beijing would have tried to impose a penalty of 3 to 5 times of the average market price for each ton of the CO2 exceeded.[11] Tianjin postponed its deadline twice, from 31 May to 10 July and finally to 25 July. [12,13]

VII. Discussion of Design Challenges Surrounding the Pilots

The carbon trading pilots in Guangdong, Shanghai, and Shenzhen face challenges at every level of program design that we outlined in the previous section. In this section, we discuss those challenges and provide suggestions for overcoming them.

A. Legal and Administrative Status of C&T

The difficulties faced in achieving compliance indicate that the pilots may not have strong legal or administrative status. In many instances, local governments had to go through significant effort to ensure full compliance with the program—sometimes at the expense of the environmental integrity of the programs. A strong legal and administrative status serves as a prerequisite for a successful C&T system.

Such an improvement would put the pilot C&T systems on equal legal footing with complementary policies that these higher bodies of law have explicitly addressed, including carbon intensity targets and energy intensity targets. This could avoid complications that arise from pilot regulators' attempts to orient their C&T programs to carbon intensity goals with stronger legal status.

[11] http://www.bjpc.gov.cn/tztg/201406/t7863548.htm

[12] http://www.tjzfxxgk.gov.cn/tjep//ConInfoParticular.jsp?id=49132

[13] http://www.tanpaifang.com/tanjiaoyisuo/2014/0710/35049.html

One way to improve compliance is to incorporate performance under the pilot C&T systems into the review of participating government officials and the executives of SOEs. The National People's Congress or the State Council could ensure this by passing a national law or executive notice, respectively. Tying the achievement of environmental goals to the possibility of promotion and demotion helped China achieve its sulfur dioxide reduction goals in the late 2000s (Schreifels et al. 2012). Such an improvement would place C&T on equal administrative footing with complementary policies such as carbon- and energy-intensity targets—which are already incorporated into performance reviews.

B. Cap Setting

A thorough understanding of an absolute cap level requires estimating two variables: business-as-usual emissions and the emissions impact of complementary policies. To our knowledge, none of the three pilots have conducted the economic assessments required to estimate either variable. Indeed, on a conceptual basis, it remains unclear how caps were chosen at all—except that they may have been aggregated from individual entity's allocations. Without such analysis, regulators and the regulated firms cannot reliably predict whether cap levels will be binding or convincingly project future allowance prices. As a result, regulated entities and the public may not have faith in the legitimacy of the cap-setting process. Likewise, prospective linking partners would likely view an opaque cap-setting process as a strong barrier to trading because they could not easily predict the stringency of the cap or the direction and magnitude of cash flows. Taken together, these negative impacts constitute one of the greatest challenges facing successful carbon trading in China. We therefore suggest that pilot regulators improve the clarity and transparency of their cap-setting process.

Other carbon trading programs have estimated business-as-usual emissions and the emissions impact of complementary policies, providing a possible template for regulators in China. In California, for example, regulators have gone through substantial effort to produce and publicize their caps. Given this information, stakeholders can easily assess that the cap is projected to be binding: they can observe a positive emissions reduction associated with the cap while recognizing that C&T, overall, is only responsible for about one-fifth of the overall emissions reductions California expects to achieve by 2020. At least from a conceptual point of view, replicating California's process should be straightforward for the pilots and could bring substantial benefits.

Moreover, the degree of complementary policies in China is typically quite high for air pollution policies—including climate policy. As an example, Zhang et al. (2013) find that four policies complementing a sulfur dioxide trading pilot in Jiangsu reduced over 90 percent of the potential cost savings associated with emissions trading. We suggest that pilot regulators calculate and publicize business-as-usual emissions and the emissions impact of complementary policies.

C. Determining the Duration of the Cap

While striking a balance between certainty and flexibility is a challenge to C&T regulators worldwide, to the best of our knowledge, only the Chinese pilots have single-year schedules or within-period adjustment of caps. Without more certainty in these caps, a variety of adverse outcomes may occur, ranging from stunted appetite for trading to a lack of long-term price signals to shift away from carbon-intensive production. We outline a number of detailed suggestions in this section that are specific to Shanghai and Shenzhen, as Guangdong does not contain such provisions.

We suggest regulators in Shanghai consider the possibility of dropping within-period adjustments to electricity companies, which is seemingly an important determinant of overall cap levels. As described in previous sections, the level of these adjustments depends on a benchmarking formula that accounts for actual output during the compliance period and can result in allowances being awarded to, or taken away from, individual entities. The result is that entities only know their final allocation in the last quarter or so of a compliance period—and likely will not aggressively trade allowances until the last quarter of the compliance period. Such compressed trading is observable in the first compliance year and hampers liquidity and price discovery.

Dropping within-period adjustments may be difficult for Shanghai to undertake: given its choice of a hybrid system that contains some elements of an absolute cap, it needs flexibility to ensure that unexpected changes in GDP growth do not prevent it from complying with regional carbon-intensity targets. As previously mentioned, tying Shanghai's cap to a carbon-intensity target may allow regulators to stand on firmer enforcement grounds when trying to ensure compliance. This challenge would be greatly simplified by an explicit mandate—either a national law from the National People's Congress or an administrative notice from the State Council—that the carbon pilots are on equal legal and enforcement footing as other nationally mandated environmental policies, including carbon-intensity targets.

For similar reasons, we suggest that regulators in Shenzhen do away with the adjustment process they have outlined for many of their regulated entities. However, for reasons in addition to those in Shanghai, Shenzhen regulators may find it difficult to drop such provisions. Shenzhen has chosen largely intensity-based targets and need not worry as much about whether its pilot complies with similar regional targets, but regulators may be reserving the right to adjust allocations within period if firms have (intentionally or unintentionally) underreported or overreported their carbon emissions.

In the event that regulators in Shanghai and Shenzhen choose to retain within-period adjustments, we suggest they strive to design a policy that changes allowances at the market level instead of the entity level. For allowance additions, the government could hold an auction. For allowance buybacks, the government could hold a reverse auction, where firms submit bids to voluntary retire allowances back toward the government. This would help eliminate uncertainty over individual allocations (and thus not hamper an entity's willingness to trade) and could be achieved in a variety of ways.

D. Treatment of Direct and Indirect Emissions

All pilots require entities to retire an allowance for emissions associated with electricity at both the points of production and consumption. As discussed earlier, electricity generators likely will not be able to pass through the costs associated with carbon allowances to electricity consumers. This constraint, under a scenario where entities only have to retire allowance for electricity generation, would preclude a carbon price signal from reaching electricity consumers—leaving unrealized opportunities to reduce emissions resulting from decreased electricity consumed. Ultimately, this will result in an increase in allowance prices. The decision to require retirements for emissions associated with electricity production and consumption allows communication of the carbon price signal to consumers—bringing cheap reductions online and helping to restore the overall efficiency of the program.

Several potential issues may hinder the effectiveness of this approach. To avoid complications, including overallocation and emissions leakage, regulators might closely monitor three variables by collecting specific data from the electricity grid. Two of these variables—electricity consumption and the emissions factor assigned to electricity purchased by regulated firms—are uncertain and subject to year-to-year variation that may lead to a miscalculation of compliance responsibility. For example, Chai (2013) argues that the Shenzhen pilot is overallocated and that one of the main causes is the use of a dated default emissions rate that is higher than the actual default rate. Accurate and timely data on these two variables are critical. Third, tracking the quantity of imported electricity and the emissions rate of those imports would allow regulators to require entities to retire allowances for the carbon emissions associated with imports. Such a policy could significantly eliminate one issue facing the pilots: emissions leakage. California's program, for example, collects such data from electricity importers and regulates carbon emissions from electricity imports.

We also note the importance of aligning incentives for self-generation with those from purchasing electricity from the grid. Current rules lack clarity in terms of whether and how the programs cover self-generation from regulated entities. If self-generation is not covered by the program, this provides an incentive for regulated firms to switch from purchasing electricity to self-generation—which may increase overall carbon emissions. If the emissions rate is not accurately estimated, this may lead to unintended consequences.

One decision facing regulators is whether to allow trading of allowances between direct and indirect sources. While we do not have any specific suggestions, we do advise considering some important trade-offs. In principle, enabling such trade will reduce emissions at lowest total cost. But allowing trade between the two sources would lead to one allowance price and therefore may prohibit a deeper understanding of the abatement cost differences between direct and indirect sources. On the other hand, the value of knowing the abatement costs of the two sources may not be particularly high. Regulators may choose to sacrifice the efficiency gains from a joint market for the information gained from a segmented market. In any case, including an identifier that distinguishes between direct and indirect emissions in an allowance's serial number might prove useful—if regulators want to preserve the option of regulating these allowances differently or collecting information about them.

E. Free Allocation of Allowances

Overall, we suggest that pilots develop a strategy to carefully and gradually move away from free allocation in the long term. There are several potential advantages to increasing the portion of auctioned allowances. For example, auctions can help avoid windfall profits and limit dynamic incentives for firms to maintain emission levels that free allocation may promote. Auctions also promote price discovery. Most importantly, perhaps, auctions allow regulators to collect carbon revenue that might be used for a variety of purposes including reducing pre-existing distortionary taxes on labor, capital or consumption, returning dividends to constituents, reducing government deficits or subsidizing covered enterprises in EITE industries (Carbone et al. 2013; Nielsen et al. 2013). Indeed, many existing C&T programs auction allowances and invest the associated revenues in a multitude of ways (Burtraw and Sekar 2013). In China, revenue neutral tax swaps may also decrease overall tax evasion and can therefore increase economic welfare (Liu 2013).

But minimizing free allocation has at least two potential downsides. First, free allocation allows regulators to determine the distribution of costs associated with a C&T program and help governments gain political acceptability for carbon pricing by creating tailored formulas and categories for free allocation. As a result, decreasing free allocation may require regulators to forfeit some amount of political capital. Second, regulators must pay heed to the ability of firms to pass along carbon prices to consumers. Firms that can pass through costs can simply transfer a majority of costs to their consumers, making an increase in auctions for these sectors desirable. However, certain industries in China, including electricity and EITE industries, cannot as easily pass along costs—so auctioning should be introduced more slowly.

We suggest allowing regulated electricity generators to pass through costs associated with carbon allowances along to consumers. Such a change would likely require that the NDRC allow electricity prices to increase because of carbon pricing, which would represent a substantial change in current policy. We note that if such a policy change does occur there would be no need to regulate both direct and indirect emissions, and regulators may have to start auctioning allowances to electricity generators instead of freely allocating to avoid windfall profits. If this change cannot occur, it may make sense to continue free allocation in the electricity generation sector.

If the system of regulating direct and indirect emissions remains, the pilots should consider eliminating free allocation for those purchases of electricity that can easily pass costs along to consumers. In particular, we suspect that owners of buildings regulated by certain pilots may be able to easily pass along costs and would therefore be able to earn windfall profits—insofar as they believe allowances have an opportunity cost. Some sectors, however, have more limited ability to pass through costs. These include EITE industries, such as steel, aluminum, and cement, where prices are importantly determined by a global market—although likely to a lesser extent than EITE industries located in other parts of the world. In these instances, we suggest output-based updating until a credible international carbon pricing regime is established. This form of allocation provides free allocation of emissions allowances to the most affected sectors. If these free allowances, or rebates, are updated on the basis of recent output levels as prescribed, for example, in the California system, firms would be able to maintain sales in the face of policy-induced cost increases while sustaining incentives created by the emissions cap to reduce the carbon intensity of production. Importantly, in California, the per-unit allowance allocation is not be based on the firm's emissions but on a sector-based intensity standard, thus creating incentives for within-sector market shares to shift toward firms with low emissions intensity.

F. Allowance Allocation Formulas

At some point, the process of earning acceptability through complex free allocation formulas comes at the cost of simplicity. When firms cannot understand an overly complex allocation approach, problems could occur. These issues may be avoided if regulators attempt to simplify particularly complex allocation formulas—such as proposed allocations in Shanghai that allocate to the industrial sector based on product-specific benchmarks. Greater simplicity can be baked into complex allowance allocation formulas, which rely on enterprise-specific factors as opposed to the industry-level criteria used in western cap-and-trade systems.

G. Non-Compliance Penalties

To ensure compliance, we suggest that lawmakers state in a national environmental law that regulated firms should be fined on a per ton—instead of a per violation—basis. This fine should be equal to a multiple of the average market price of allowances for each ton the firm failed to retire an allowance for. Moreover, we suggest that this national environmental law explicitly mention that such penalties apply to C&T systems for carbon.

H. Opt-in and Voluntary Entities

With the high number of new entrants potentially joining the pilots, care must be taken so that their participation doesn't increase overall carbon emissions. A conservative estimate of an entrant's historical emissions can help ensure that that entrant cannot receive free allowances by manipulating its business-as-usual emissions. Where possible, the specific formula regulators use could require new entrants to submit data before the carbon trading program started to avoid moral hazard, which is a purposeful ramping of carbon emissions to receive a large number of free allowances. At this stage, many of the rules surrounding opt-in and voluntarily regulated entities remain unclear.

I. Price Management Provisions

Given the uncertainty regarding economic growth, the implementation of a symmetric safety valve may guard against allowance prices that fall too low or rise too high (Burtraw et al. 2010; Fell and Morgenstern 2010). However, only the Shenzhen pilot has constructed a symmetric safety valve—potentially leaving the other two pilots at risk of dramatic price swings.

J. Provisions to Prevent Market Power

We suggest the pilot regulators investigate whether market power is present in the pilot C&T systems. The issue of market power has to do with the amount of allowances allocated to each firm just as much as the size distribution of emitting firms (Morgenstern et al. 2004). If regulators detect market power issues, several options might be considered. First, SOEs and competitive enterprises might trade allowances in a separate market. Second, regulators could impose holding limits. Third, regulators could try to improve liquidity through increasing the number of participants.

K. Improving Liquidity

Liquidity is currently quite low in the C&T pilots, for a number of possible reasons. One explanation might be that complementary policies have negated the need for trading—having already effectively achieved the emissions reduction imposed by the pilots (Zhang et al. 2013). Another explanation might be that the regulated entities face some barrier that prevents them from trading, including transaction costs that might stem from a lack of familiarity with trading. Indeed, during the sulfur dioxide trading pilots, most trades required government intervention (Chang and Wang 2010).

A healthy level of liquidity acts as a prerequisite to an allowance price that reflects marginal abatement costs. While there are numerous potential definitions of what conditions constitute a healthy liquidity level, authors have used bid-ask spreads and trading volumes to investigate liquidity in renewable energy credit and C&T markets (Frino et al. 2009; Schmalensee 2012). We recommend regulators try to identify the sources of low levels of liquidity before trying to increase trading activity. Chinese regulators at the national and local have expressed interest in formally linking the pilot programs (Wang 2013b), although such links may not establish if a national program starts in 2016.

L. Facilitating Formal Linkage

Formal linkage ensures that reductions are achieved at the lowest overall costs—an important economic goal. In order to prepare for the possibility of formal linkage, we recommend that pilot regulators begin the process of aligning program designs—a process known as linking by degrees—so that any linkage would not cause adverse consequences (Burtraw et al. 2013). Linking by degrees can also capture political and administrative benefits in the short term, even before two pilots would initiate a formal link (Burtraw et al. 2013). In this way, linking by degrees can complement formal linkage by facilitating formal linkage in the long-term and capturing political and administrative benefits in the short term (Mansell and Munnings 2013).

VIII. Future Research

We see two principal areas for further research on the pilot trading programs. First, we view conducting further rigorous ex-ante research as crucial to ensure the success of local pilots. Second, we view ex-post assessments of the carbon trading pilots as a necessary step for a successful transition to a national carbon market. We elaborate on these future areas of research below.

A. Ex-Ante Assessments

Further ex-ante research on methods for allowance allocation, provisions for price management, and the impact of carbon trading pilots on carbon emissions and local economies will help support the pilots as they evolve over time.

i. Allowance Allocation

Regarding allowance allocation, we hope that this initial report—and the work of other researchers—will be expanded to more specific advice on improving allocation design in certain pilots. How can regulators move away from within-in compliance period allowance adjustments, for example, while maintaining a pilot's ability to comply with regional carbon-intensity targets? In addition, Shenzhen's game theory approach to allowance allocation in a data sparse environment seems promising but likely needs refinement. A carefully designed process for transitioning to greater auctioning of allowances would likely aid regulators in all pilots. Thorough qualitative, and possibly quantitative, analysis in these areas could substantially improve allocation methodologies and, ultimately, the success of each pilot.

ii. Provisions for Price Management

The design of price management provisions likely will play a significant role in allowance price levels and therefore be especially important for successful carbon trading pilots. Given the heterogeneity of pilot approaches, researching the design of symmetric safety valves for each pilot might be beneficial. Such research would identify optimal price floors, price ceilings, and quantity of allowances to be kept in reserve. Well-designed symmetric safety valves can build confidence in a healthy allowance price while providing a level of protection for the local economy.

iii. Potential for Linking

The extent of trading among the pilots also will affect allowance price levels. From an efficiency point of view, the benefit of linking carbon markets is clear: achievement of overall emissions reductions at least cost. There are numerous barriers to linking—distributional, legal, and environmental in nature—that require alignment of certain design features across C&T systems. A key piece of future research will be to assess which pilots are ready to link with one another—and how some of these pilots may either link or transition into a national carbon market.

iv. Modeling on Competitiveness and Leakage Impacts

Data constraints have importantly contributed to a dearth of rigorous and transparent economic modeling conducted for the pilots. Nonetheless, ex-ante modeling will likely be important for researchers to pursue and will become easier to conduct as regulators collect more data on the carbon emissions and economic activity of regulated entities.

Anticipating and conducting ex-ante modeling of the emissions leakage and competitiveness effects of a C&T system is central to demonstrating the effectiveness of the policy at reducing total emissions—and to compensating adversely affected industries. Various approaches have been adopted to estimate the extent and magnitude of adverse impacts of cap-and-trade systems around the world. For example, standard ex-ante economic analysis—buttressed by a number of international modeling studies from the United States, European Union, and other nations—have estimated small but non-trivial output losses over both the short and long time horizons for the sectors facing higher energy costs (Atkins et al. 2012; Böhringer et al. 2010; Böhringer et al. 2012; Fischer and Fox 2007; Fischer and Fox 2010; Makato et al. 2012).

A key challenge for policymakers is to devise policies to limit the harm imposed on EITE industries while maintaining the incentives for reducing energy intensity. The most effective approach to reduce adverse competitiveness and leakage impacts is to ensure that other countries or regions take comparable carbon pricing actions. Until more universal action occurs, however, other options are available for addressing concerns in EITE industries.

The most commonly used option is to introduce rebates to firms tied to their output levels. Such rebates are typically given in the form of free allowances. Important research questions surround three factors: the breadth of eligibility for the rebates—i.e., the number of industries that should be covered; the size of the initial rebates; and whether and how they should be phased out over time. As a point of reference, it is noteworthy that some systems—for example, the European Union—have emphasized broad coverage of industries with relatively small rebates. Other systems,—for example, the Waxman-Markey legislation passed by the US House of Representatives but not ultimately enacted into law—would have covered fewer industries with relatively larger rebates.

In California, the legislation establishing the state's C&T system directs the implementing agencies to minimize leakage to the extent feasible. To comply with this goal, the state has developed a relatively simple, category-based methodology to identify those industries most at risk of emissions leakage. The method is based on industry-level measures of emissions intensity and trade share. These metrics provide a very useful point of departure. However, it is widely recognized that more sophisticated metrics and tools will be needed to credibly detect any policy-induced changes in output, employment, and import flows, and to measure any associated emissions leakage.

Ex-ante modeling studies that estimate the competitiveness and leakage impacts of the carbon pilots on regulated entities and assess the relative effectiveness of the suite of policies available for remedying these impacts would likely contribute to the success of the pilots.

B. Ex-Post Assessments

Ultimately, an ex-post evaluation of the pilot programs likely would best inform China's transition to a national carbon price. Such an evaluation could include survey, empirical, and qualitative methodologies (described next).

The execution of such an evaluation would be made much easier if regulators collect at least two types of data. First, we suggest regulators collect data during a baseline, or prepolicy, period. Experience with the US Acid Rain Program and the EU ETS has demonstrated the importance of this step. Such data can inform the construction of a credible and well-substantiated estimate of what would have happened in the absence of the policy. This counterfactual benchmark is an essential component of any ex-post analysis—but particularly so for more quantitative analysis.

Second, we suggest regulators collect data on the output and emissions of both regulated and unregulated entities, within pilot regions and outside of pilot regions. Such data would allow for thorough comparisons of the performance of regulated entities relative to unregulated entities.

i. Constructing a Survey

Surveys can play an important role in understanding how stakeholders have responded to public policy. Several researchers have conducted surveys of regulated entities in the EU ETS in an attempt to gauge understanding of the carbon market and the markets impact of innovation and investment. Krupnick et al. (2013) provides an alternative, and equally valid approach, of surveying large groups of stakeholders on their general views and specific concerns with shale gas development in the United States—an approach that might be adapted for carbon trading. Jotzo et al. (2013) undertook a similar, but less comprehensive, approach to ask a limited set of questions regarding carbon trading in China. In a data sparse environment, and for research questions that require a more qualitative approach, such surveys can play a useful role.

ii. Informing a National Program

A comprehensive report that details the lessons learned from all carbon trading pilots in China will be a crucial step toward informing China's national carbon market. Such a report could compare approaches to national the existing local efforts, including which pilots have excelled in which design areas. In addition, such a report can assess whether pilots are ready to link to one another.

IX. Conclusion

The pilots in Guangdong, Shanghai and Shenzhen have made significant progress in building a cap-and-trade market. Some aspects of pilot designs represent a deft tailoring of a fundamentally market-based instrument to a socialist market economy. Yet potential design deficiencies remain. We have made nine main recommendations in an attempt to strengthen the programs, but a large number of unanswered research questions remain. Further analysis would improve the prospects that the pilots operate successfully and the degree to which the pilots can ultimately inform the design and operation of a national carbon price in China.

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