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Crossing the River by Feeling the Stones: The Case of Carbon Trading in China

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Summary

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Keywords: Pilot Carbon Trading Schemes, Low-carbon Development, Environmental Taxes, Market Stabilization Mechanism, Carbon Offsets, Enforcement and Compliance, China

JEL Classification: H23, O13, P28, Q43, Q48, Q52, Q54, Q58

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Crossing the river by feeling the stones: The case of carbon trading in China

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Abstract

Putting a price on carbon is considered a crucial step for China's endeavor of harnessing the market forces to reduce its energy consumption and carbon emissions. Indeed, aligned with China's grand experiment with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities, the Chinese central government has approved the seven pilot carbon trading schemes. These pilot trading schemes have features in common, but vary considerably in their approach to issues such as the coverage of sectors, allocation of allowances, price uncertainty and market stabilization, potential market power of dominated players, use of offsets, and enforcement and compliance. This article explains why China turns to market forces and opts for emissions trading, rather than carbon or environmental taxes at least initially, discusses the five pilot trading schemes that have to comply with their emissions obligations by June 2014, and examines a wide range of design, implementation, enforcement and compliance issues related to China's carbon trading pilots and their first-year performance. The article ends with drawing some lessons learned and discussing the options to evolve regional pilot carbon trading schemes into a nationwide carbon trading scheme.

Keywords: Pilot carbon trading schemes; Low-carbon development; Environmental taxes; Market stabilization mechanism; Carbon offsets; Enforcement and compliance; China

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1. Introduction: China in a different context

The Third Plenum of the 18th Central Committee of Communist Party of China in November 2013 strongly signaled the Chinese leadership's determination to embark upon a new wave of comprehensive reforms in China. This is clearly reflected by the Plenum's key decision of assigning the market a decisive role in allocating resources. To have the market to play that role, putting a price on carbon is considered a crucial step for China's endeavor of harnessing the market forces to reduce its energy consumption and carbon emissions and genuinely transiting into a low-carbon economy. Indeed, aligned with China's grand experiment with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities, the Chinese government has approved the seven pilot carbon trading schemes in the capital Beijing, the business hub of Shanghai, the sprawling industrial municipalities of Tianjin and Chongqing, the manufacturing center of Guangdong province on the southeast coast, Hubei province, home of Wuhan Iron and Steel, Shenzhen, the Chinese Special Economic Zone and across the border from Hong Kong (NDRC, 2011) (see Figure 1).

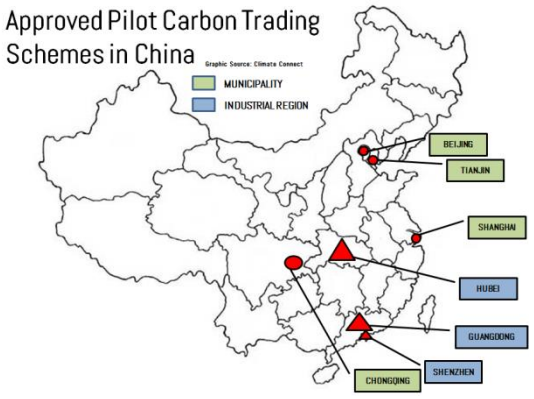

Figure 1 The seven pilot carbon trading schemes in China

In addition to almost no or very little experience in market-oriented instruments and lack of human capacity, China differs significantly from those countries or regions that have established emissions trading schemes. First, China's absolute emissions caps are still expected to grow rapidly for quite some time to come, even if some energy-saving policies and measures have been factored into such projections. The IEA (2009), in its *World Energy Outlook* 2009 projection, assumes very high energy-saving rate for China than what China has experienced in recent years, and has incorporated many polices under consideration into its underlying baseline projection. Even in this very ideal

case, China's baseline carbon emissions in 2020 are projected to be 4.36 times their 1990 levels, and will continue to grow afterwards, climbing to 5.27 times their 1990 levels in 2030. A recent joint Tsinghua-MIT study suggests that China's carbon emissions under the baseline would not peak until 2040 (Qi et al., 2015). Even under the very stringent 450 parts per million (ppm) of CO_2 equivalent scenario, which requires all countries to take coordinated action, CO_2 emissions in China in 2020 are allowed to increase by 223% relative to their 1990 levels (IEA 2009).[1] While energy use in China is projected to grow somewhat slower in the 2020s than in the 2010s, China's carbon emissions would be still on the climbing trajectories beyond 2030, even if some energy-saving policies and measures have been factored into such projections. This suggests that China's commitment to cap its carbon emissions around 2030 under the joint China-US climate statement announced by the Presidents of China and the US on 11 November 2014 in Beijing is ambitious.[2]

By contrast, emissions levels of industrialized countries have reached either their peaks or are not expected significant near-term growth. Even in the case, the EU has experienced significant over-allocation of allowances (European Commission, 2012c), which is widely considered to be a key factor attributed to a collapse of the EU allowance

[1] This is an exceptionally ideal case. In reality, not all countries will commit to a 450 ppm target and act in a coordinated manner. This suggests that China's emissions will continue to grow even higher than the allowed level derived from the exceptionally ideal case and beyond 2020.

[2] With increasingly stringent energy-saving and carbon intensity goals, China started experimenting with low-carbon city development in the batch of five provinces and eight cities on 19 July 2010. This experiment is further expanded to the second batch of 29 provinces and cities on 5 December 2012 (Wang et al., 2013).while it is not mandated by the central government, all these pilot provinces and cities set CO_2 emissions peak in 2030 or early.15 pilot provinces and cities even aim CO_2 emissions peak in 2020 or early, with Shanghai publicly announcing its peak year in 2020, Suzhou in 2020 and Ningbo in 2015, respectively (Zhang, 2014b). Zhang (2009, 2010b, 2011a,b) argue from six angles that China could cap its greenhouse gas emissions around 2030. The practice and ambition of these piloted regions set the good examples of keeping their emissions under control, make the positive contribution to the overall low-carbon development in China, and thus could make China's carbon emissions peak occur even earlier than the aforementioned timeline. This suggests that China's recent commitment to cap its carbon emissions around 2030 is ambitious but achievable.

prices. Despite the European Commission's tough position in limiting the Member States' initial generous allocations for the second phase, this period ended up with a huge volume of unused emissions allowances that can be banked forward into the third phase. Estimates of this surplus differ. The Commission's own estimate suggests that this surplus potentially represents the equivalent of 2.4 billion tons of allowances by 2020 (European Commission, 2012a), while other estimates put this surplus at 3.1-4.5 billion tons of allowances (Morris, 2012; Jones, 2014).

Second, all existing emissions trading schemes are operating under the given condition of a mature market economy (Han et al., 2012). While three decades of economic reforms have shifted China away from a centrally planned economy, China is still not a mature market economy yet.

These different contexts have led to the marked variations in design, implementation and enforcement features between China's carbon emissions trading pilots and other existing emissions trading schemes in the mature market economies. Indeed, for countries like China whose emissions are expected to grow rapidly, whose economy has not been a mature market, and whose environmental institutions and enforcement of rules and regulations are very weak, and is lack of reliable, dependable data on emissions, fuel uses and outputs for installations, it would pose a daunting challenge to decide which sectors are to be covered under emissions trading, how to set their emissions caps and allocate permits among companies within the sectors covered, and how to enforce the compliance of regulated entities, just to mention few.

Since Shenzhen launched its first trading in June 2013, Shanghai, Beijing Guangdong, and Tianjin, in turn, launched their first trading prior to the end of 2013. These five pilots have to comply with their emissions obligations for the year 2013. Thus, this paper will focus on these five pilot trading schemes. Section 2 discusses why China turns to market forces and opts for emissions trading, not carbon or environmental taxes at least initially. Section 3 briefly discusses the aforementioned five pilot trading schemes that have to comply with their emissions obligations by June 2014. Section 4 examines a wide range of design, implementation and enforcement issues related to China's carbon trading pilots. Section 5 draws some lessons learned and discusses ways to move regional pilot carbon trading schemes forward a nationwide carbon trading scheme.

2. China's changing stance on emissions trading: from strong opposition to active experiment

2.1 Even if so beneficial, why had China refused even to discuss participation in international emissions trading?

China is now very active in experimenting with pilot carbon trading. However, not long ago China had opposed to emissions trading, although many economic studies by Zhang (2000a and 2004) and examined by Stanford University's Energy Modeling Forum (Weyant, 1999) show that China would reap significant benefits from participating in a global emissions trading regime. Zhang (2003, 2007) gauge at least five reasons for China's stance.

First and most importantly, participating emissions trading requires countries to implement emissions caps. However, developing countries including China and India consider it unfair to impose on emissions caps on developing countries until Annex 1 countries give clear signs that they have taken the lead in cutting their own greenhouse gas emissions. Second, China and India had been skeptical to international emissions trading. They were not convinced that international emissions trading would lead to actual reductions in emissions. Third, China may perceive an inflow of clean development mechanism (CDM) investment in China to be much less politically sensitive than the exports of emissions permits to the United States. In practice, CDM investment is most likely to be a climate component added to existing and future foreign direct investment (FDI) projects. Binding with FDI, an inflow of CDM investment in China would be made itself less explicit for those who regard CDM as "foreign aid".[3] Fourth, China is concerned about the implications of "lock in" to an emissions cap, in particular because there are no established rules and principles for setting emissions targets for the commitment periods subsequent to Kyoto. Fifth, although many economic studies show that China would reap significant benefits from participating a global cap-and-trade regime, they do not really address the complex undertaking of setting emissions caps for developing countries.[4]

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[3] Rep. Bill Archer (R-Texas), Chair of the House Ways and Means Committee, for example, said that "It is another form of foreign aid" (*Congressional Quarterly*, 29 November 1997).

[4] This point is somewhat related to the aforementioned first point, but they discuss different issues. The first point focuses on why China should take on greenhouse gas emissions caps – a prerequisite for international emissions trading, whereas this point touches on the technical difficulty in setting emissions caps for countries like China. The first issue is more fundamental and this one is of technical nature.

2.2 Why does China turn to market forces?

While China has not completely changed the aforementioned views, some changes in domestic and international contexts have prodded China to embrace market-based instruments at least in the domestic context.

China had relied mostly on administrative means to achieve its 20% energy-saving goal for 2010 (Zhang, 2010 and 2011a,b). Qi (2011) shows that during the 11th five-year plan period, the total CO_2 reduction in China amounted to 1.25 billion tCO_2e through mandatory regulations and auxiliary financial stimuli, while only 0.035 billion tCO_2e were reduced as a result of market-based instruments. In the end, the country has had a limited success in meeting that goal. Learned from this lesson in the 11th five-year plan period and confronted with increasing difficulty in further cutting energy and carbon intensities in the future, China has realized that administrative measures are effective but not efficient. The country cannot continue to rely on costly administrative measures to honor its carbon intensity pledge in 2020 and to drive its future energy use and carbon emissions below the projected baseline levels to the extent possible. It is becoming increasingly crucial for China to harness market forces to reduce its energy consumption and cut carbon and other conventional pollutants and genuinely transit into a low-carbon economy. In the meantime, evidence suggests that environmental tax reforms and greenhouse gas emissions trading schemes in the OECD work (Andersen et al., 2007; Andersen and Ekins, 2009; Ellerman et al., 2000 and 2010).

The Chinese leadership is well aware of this necessity. This is clearly reflected by the key decision of the Third Plenum of the 18th Central Committee of Communist Party of China in November 2013 to assign the market a decisive role in allocating resources. This will serve as the overcharging guidance on mapping out the 13th five-year (2016-20) plan, and calls for increasing use of market-based instruments to complement currently dominated use of administrative measures.

2.3 Carbon/environmental tax versus emissions trading

Environmental taxes and emissions trading are the two most common market-based instruments to internalize externality costs into the market prices (Baumol and Oates, 1988). The added abatement costs will be imposed on polluting companies as part of production cost that can be reduced by cutting pollution. This is seen to increase not only cost-effectiveness but also flexibility in complying with the set environmental regulations. Once China opts for market-based instruments, the question then is which instrument, environmental taxes, emissions trading, or both, will be its choice. This is not a choice that only China has to face. Indeed, the U.S., the European Union (EU), and Australia all

had confronted with it, and there have been debates in these countries, although they are in the different context and for reasons very different from those for China.

In the run up to the negotiations of the Kyoto Protocol, the EU was in favor of environmental taxes and other measures and policies to curb greenhouse gas emissions, and put forward a proposal for ceilings on the use of emissions trading.[5] By contrast, the U.S. climate negotiators not only fought for the inclusion of emissions trading in the Kyoto Protocol, but also were opposed to any restrictions imposed on its use. With the U.S. withdrawal from the Kyoto Protocol, the EU dropped its previous insistence on a cap on the use of flexibility mechanisms. The final wording at the Bonn Agreement is that "domestic action shall thus constitute a significant element of the effort" by each Annex 1 country. This is a very important and positive development because it will allow countries and businesses to reduce their emissions wherever it is cheapest to do so. Ironically, it is a development that the U.S. had lobbied intensively for during previous rounds of international climate negotiations. The EU also changed its attitude towards emissions trading. In the end, it was the EU that put into operation the world's largest multi-country, multi-sector carbon dioxide emissions trading scheme since January 2005.

In China, the Environmental Protection Law was enacted since 1989 and continues to be in place onwards (Zhao, 2012). Under this law, polluting sources only pay emissions charges for any amount of emissions that exceed the allowed levels. Along this line, the imposition of environmental taxes will be lack of legal basis because such taxes, if imposed, will levy on each unit of emissions, not only those above the allowed levels. Even if the law is amended to require polluting sources to report their emissions and pay charges on any unit of emissions, this is just one step towards the imposition of environmental taxes. China still needs to promulgate environmental tax law to authorize the levy of such taxes.

The Chinese legislature has been considering the amendment of existing environmental law. With decades of efforts, the amended environmental law was finally got the passage of the legislature in April 2014 and will take into effects since 1 January 2015 (National People's Congress, 2014). The legislature is considering the promulgating of environmental tax law. Clearly, this whole legislation process of amending the existing

[5] Using the model based on marginal abatement costs of 12 regions, Zhang (2001) analyzed the economic effects of the EU proposed concrete ceilings both on the U.S. and on developing countries. That study was the first to quantify the implications of the EU proposal for restricting the use of emissions trading on the basis of 35 individual national communications to the United Nations Climate Convention Secretariat.

environmental law and promulgating environmental tax law takes time, and until it is completed, there is no legal basis to authorize the levy of these taxes. In the meantime, there is the pressing need to meet with the energy and emissions targets in a cost-effective way. I believe that a combination of these considerations motivates China to go for emissions trading. In late October 2011, National Development and Reform Commission (NDRC) (2011) approved seven pilot carbon trading schemes. Sections 3 and 4 discuss these pilots in great detail. Based on these piloted schemes, China aims to establish a national carbon trading scheme as early as in 2016.

However, carbon trading and environmental taxes are not substitute. As discussed in conclusions, China needs both to level the playing field.

3. China's pilot carbon emissions trading schemes

Lunching pilot carbon trading has been one of key work tasks to control China's greenhouse gas emissions in the 12th five-year plan period. In late October 2011, China's NDRC approved the seven pilot carbon trading schemes. The seven regions are given considerable leeway to design their own schemes.

These pilot trading schemes have features in common. They all run from 2013 to 2015. While broadening an emissions trading scheme to cover all the greenhouse gases would provide maximum opportunity for the regulated entities to find those sources where the costs of abating greenhouse gases are lowest and thus maximize their cost savings, a workable emissions trading scheme requires that emissions of whatever a pollutant to be included have to be measured with reasonable accuracy (Tietenberg et al., 1999; Zhang, 2000b). This requirement implicitly precludes including all gases in the pilot trading scheme. As would be expected, only CO_2 are covered. Differing from the emissions trading scheme (ETS) of the EU and California, in which emissions sources are targeted at installations or facilities, the covered emissions sources are enterprises in all the pilot schemes in China. Also unlike the EU ETS, indirect emissions from both electricity generation within the pilot region and generated from the amount of imported electricity from outside pilot regions are covered in all the pilot schemes. During the pilot phase, banking is allowed, but allowances cannot be carried forward beyond 2015, the ending date of the pilot period. Borrowing is not authorized to improve the liquidity of the carbon market. As shown in Table 1, all regimes allow to a different degree the use of the China Certified Emission Reductions (CCERs) that meet the requirements of China's national monitoring, reporting and verification (MRV) regulation, ranging from 5% of

their CO_2 compliance obligation in Beijing and Shanghai to 10% in Guangdong, Shenzhen and Tianjin.

Table 1 The allowable Use of CCERs in the seven carbon trading pilots

	Maximum allowable use as percentages of the caps (%)	Local origin requirements
Beijing	5	No[a]
Chongqing	8	No
Guangdong	10	70%
Hubei	10	100%
Shanghai	5	No
Shenzhen	10	No
Tianjin	10	No

Note: [a] In the Circular released in November 2013, the Beijing pilot scheme requires that at least 50% of that CCERs have to be generated from Beijing (BMDRC, 2013a), but this local requirement is not specified in the Measures promulgated in May 2014 by the Beijing Municipal Government (2014).
Sources: Beijing Municipal Government, 2014; BMDRC, 2013a; CMDRC, 2014; HPG, 2014; PGGP, 2014; SMDRC, 2013a; SZMG, 2014; TMG, 2013a.

The seven pilot regions are given considerable leeway to design their own schemes. The pilot schemes have different coverage of sectors, ranging from four sectors in Guangdong to 26 sectors in Shenzhen (GPDRC, 2013; SMLAO, 2013). The threshold to determine whether an emissions source is covered differs across pilots, ranging from 5000 tCO_2 equivalent per year in Shenzhen from 2013-15 to 60000 tons of coal equivalent (tce) in Hubei (SMLAO, 2013; HPG, 2014). A combination of the two factors leads the number of covered entities to differ significantly, from 114 in Tianjin (TMDRC, 2013b) to 635 in Shenzhen. Consequently, the share of covered emissions in the total emissions in each pilot region varies significantly, ranging from 36% in Hubei and 38% in Shenzhen to 57% in Shanghai (SMDRC, 2013b; Zhao, 2013; Qi et al., 2014). Regimes differ regarding the origin of CCERs. Shenzhen specifies that all CCERs have to be generated inside China but outside the city, but Hubei requires that all have to come from inside the province (see Table 1).

Ways to allocating allowances differ across pilots. While all pilots allocate all or the majority of allowances for free, such allocations are based on grandfathering,

benchmarking or in both. Even if allowances are grandfathered on a historical basis, Chongqing is based on the highest emissions in any of the years from 2008 to 2012 to reduce the effect of whipping the fast ox to the extent possible (CMDRC, 2014), while other pilots are based on the average emissions levels over the period 2009-12. In one given pilot, for some sectors grandfathering is based on their historical emissions, while for other sectors it is based on their historical emissions intensities.

Pilots also differ when coming to compliance. While Beijing opts out the auction to provide the last opportunity for those enterprises of shortfall allowances to meet their compliance obligations, some pilots like Shanghai and Shenzhen auction additional allowances for enterprises of shortfall allowances at the end of that trading day to comply their obligations for 2013 (Zhang and Li, 2014a). Even if Shanghai and Shenzhen opt for the last auction for enterprises of shortfall allowances, they reason and accordingly set their reserve price differently (China Emissions Exchange, 2014; Tanpeifang, 2014b). While all pilots impose a fine on non-complying entities, compliance rules vary across pilots, ranging from deducting a certain amount of shortfall allowances from the amount to be allocated to non-complying enterprises in the following year to charging the non-complying entities at 3-5 times the prevailing average market prices for each shortfall allowance (BMDRC, 2014a; PGGP, 2014). Non-complying entities in the Hubei pilot face both fines and deduction of shortfall allowances. They are charged at 1-3 times the yearly average market prices for each shortfall allowance, with the amount of penalty imposed on them capped at Yuan 150000, and two times the amount of their shortfall allowances are deducted from the amount to be allocated in the following year (HPG, 2014).

Since Shenzhen launched its first trading through China (Shenzhen) Emission Exchange on 18 June 2013, Shanghai, Beijing Guangdong, and Tianjin, in turn, launched their first trading prior to the end of 2013. These five pilots have to comply with their emissions obligations for the year 2013 before the first compliance deadlines, which are set in the end of the first half of 2014. Thus, our paper will focus on these five pilot trading schemes.

3.1 Beijing pilot carbon emissions trading

Of China's provinces and municipalities, Being Municipal Government is the first to submit options to implement a planned pilot carbon emissions trading over the period 2013-15 for an approval of the NDRC. This pilot scheme covers the manufacturing sector and other industries, the service sector, power generation and heat supply, and mandates the participation of those entities both directly and indirectly emitting 10000 tCO_2

equivalent per year or above over the period 2009-12 (BMDRC, 2013a,b). As a result, 415 entities meeting the threshold for the combined direct and indirect emissions are covered in the scheme (Wang and Wang, 2013; Tanpeifang, 2014c). Entities consuming 2000 tce or above per year are not mandated to participate in emissions trading, but if those entities opt for voluntary participation, they will then be regulated similarly to those mandated participants. All entities consuming 2000 tce or above per year are mandated to report their carbon emissions annually, which need to be verified by the third party (BMDRC, 2013a). Of the seven pilots, this threshold for reporting is the second lowest, just higher than one for Shenzhen. Unless entities either are mandated to or voluntarily participate in carbon trading, the remaining entities are not covered by the pilot ETS and thus have no compliance obligations. The reporting requirements are only to improve the management of carbon emissions at this stage, although they help to expand the initial scope to these existing uncovered entities in the future.

Allowances are allocated for free year by year and differently across sectors. The pilot scheme also treats existing emission sources and new entrants differently. While the allowances are granted to new entrants based on benchmarking, which is similar to the practice in the EU ETS[6] and is set at advanced levels and is applied to all enterprises in a given sector, allocations to existing emissions sources are based on historical emissions or emissions intensities depending on sectors. Allocations to existing emissions sources in the manufacturing sector and other industries and the service sector are based on their historical emissions, and the amount of their allocated allowances is adjusted downwards sector-wide annually to meet the increasing stringent sectoral caps. Allocations to existing emissions sources in the power and heat sector are based on their historical emissions intensities. Unlike the same benchmarking set for all the enterprises in the same sector, historical levels-based grandfathering differs from one enterprise to another

[6] For sectors that are not identified to be at a significant risk of carbon leakage, the revised EU ETS Directive 2009/29/EC suggests that 80% of allowances are handed out for free in the initial year of the third phase (2013-2020), with the share of free allowances declining to 30% by 2020, the end year of the phase. Such free allocations are based on the *ex ante* benchmarks that are set at the average performance level of the 10% most efficient installations in a given sector or subsector in the EU in the years 2007-2008 (European Commission, 2009). This suggests that such benchmarks represent a challenge for some installations because they are set at the level of the best performers, but they are achievable by definition because they are derived from real practice in recent years.

in the same sector. Moreover, the pilot scheme allows the mandated entities to apply for adjustments in allowances in case a significant shortage of allowances occurs under the specific conditions (BMDRC, 2013a).

During the pilot 2013-15 phase, banking is allowed, but allowances cannot be carried forward beyond 2015. Borrowing is not authorized to improve the liquidity of the carbon market. In addition, in the Beijing pilot scheme, the Municipal Government sets aside up to 5% of total annual allowances for auctioning whenever necessary for cost containment purposes. When the average price of allowances over the ten consecutive trading days are above Yuan 150 per ton, some of the reserved allowances could be auctioned. But when the average price of allowances over the ten consecutive trading days are below Yuan 20 per ton, the government can purchase some of the allowances in surplus from the carbon market (BMDRC and BMBFW, 2014). A combination of the two actions certainly helps stabilize the prices of allowances.

For compliance purposes, the Beijing pilot scheme authorizes the use of the CCERs that meet the requirements of China's national MRV regulation. The pilot scheme allows the use of the CCERs up to 5% of annual emissions allowances, but CCERs generated in Beijing cannot be used for the offset from fossil fuel combustion of immobile fixed facilities, from industry production processes and collective waste disposal in the manufacturing industry or from electricity consumption from the mandated or non-mandated entities (BMDRC, 2013a). In the Circular released in November 2013, the scheme requires that at least 50% of that CCERs have to be generated from Beijing (BMDRC, 2013a), but this local requirement is not specified in the Measures promulgated in May 2014 by the Beijing Municipal Government (2014). The Beijing pilot also specifies the scope of offset. In addition to the CCERs, carbon reductions from energy-saving projects and forest sinks can be used for the offset. To enforce the compliance with emissions reporting requirements and emissions caps, entities mandated but failing to submit their annual verified emissions reports will charge a fine up to Yuan 50000. Depending on the extent of noncompliance, entities are subject to fines equal to three to five times the prevailing average market prices over the past six months for each shortfall allowance. A fine of three times the average market prices is imposed if the emissions of non-complying entities exceed less than 10% of their emissions allowances, while a fine of five times the average market prices is applied if non-complying entities emit 20% more than their emissions allowances, with a fine of four times the average market prices imposed in between the two cases (BMDRC, 2014a).

3.2 Guangdong pilot carbon emissions trading

Guangdong province is second in the country after Shanghai to officially launch a pilot carbon emissions trading scheme. This pilot ETS includes 242 companies across the four major emitting sectors of power, iron and steel, petrochemical, and cement, of which 202 companies are existing emissions sources. Each company covered emits at least 20000 tons of CO_2 emissions every year (GPDRC, 2013), which are two times the specified threshold of 10000 tons of CO_2 emissions every year in the Trial Administrative Measures released in January 2014 (PGGP, 2014). All entities emitting 5000 tons of CO_2 emissions or above per year are mandated to report their carbon emissions annually (PGGP, 2014). The amount of allowances in 2013 was capped at 388 million tons of CO_2 emissions, of which 38 million tons of CO_2 allowances are reserved for new entrants and adjustments in allowances (GPDRC, 2013). Guangdong positions itself as the world's second largest ETS, in terms of the volume of allocated allowances.

The Guangdong pilot scheme takes a unique means of allocating allowances, combining grandfathering and auctioning. The covered enterprises are mandated to purchase 3% of the total amount of allocated allowances during 2013-14 through auction before they get the remaining 97% for free. The required purchase in 2015 is further increased to 10% of the total amount of allocated allowances. On grandfathering, Guangdong has taken benchmarking as the primary allocation method. Benchmarking has been applied to the majority of production processes of power, cement, and iron and steel sectors, while grandfathering is applied to petrochemical sector and the remaining part of production processes of power, cement, and iron and steel sectors (GPDRC, 2013).

As the sole pilot to mandate the covered enterprises to purchase a proportion of initial allowances, Guangdong sets the reserve price in the initial auction at Yuan 60 per ton of allowance (GPDRC, 2013). By mandating the covered enterprises to purchase the fixed quantity at the predetermined prices, this pilot would make these enterprises directly feel the cost of emissions, thus pushing them to cut their emissions. However, this fixed price approach could not reflect their abatement cost or demand, nor would it be coupled with the allowance price in the secondary market (Duan et al., 2014). Moreover, the mandatory purchasing has led to objections from some of the covered enterprises. Based on the mandated 3% purchasing of 350 million tons of allowances, 242 companies covered need to purchase 10.5 million tons of allowances for complying their 2013 caps. But from six auctions from 16 December 2013 to 5 May 2014, only 178 enterprises purchased 9.76 million tons of allowances (Tanpeifang, 2014a). This means that 64 enterprises covered have still not purchased their allowances in 2013, thus leaving all their free allowances on hold. Consequently, these enterprises are unable to engage in allowance trade and to proceed with their compliance. One of the two enterprises, which

failed to comply with the emissions caps, argued that it is unfair to purchase the allowances, given that enterprises in other parts of China do not need to pay for them. GPDRC is reported to evaluate this mandatory purchasing through auctioning (Wang, 2014).

To enforce the compliance with the emissions caps, non-complying enterprises will charge a fine of Yuan 50000, and two times their shortfall amount of allowances will be deducted from the amount to be allocated to non-complying enterprises in the following year. Moreover, the scheme also allows the use of the CCERs up to 10%, but at least 70% of that CCERs have to be generated from Guangdong (PGGP, 2014).

3.3 Shanghai pilot carbon trading scheme

Shanghai Municipal Government (SMG) officially launched the pilot carbon emissions trading scheme in Shanghai on 16 August 2012. This scheme runs from 2013 to 2015, and covers 191 industrial and non-industrial enterprises, with their direct and indirect CO_2 emissions in either 2010 or 2011 exceeding at least 20000 tons for industrial enterprises in iron and steel, petrochemical, chemical, non-ferrous metals, power, materials, textile, papermaking, rubber, and chemical fibber sectors, and 10000 tons for non-industrial enterprises in such sectors as aviation, ports, airports, railway, commerce, hotels and financial institutions, respectively (SMDRC, 2012 and 2014; SMG, 2012). All together their CO_2 emissions account for about 57% of the total carbon emissions in Shanghai (SMDRC, 2013b). In addition, enterprises emitting at least 10000 tons of CO_2 emissions per year in any year from 2010 to 2015 are required to report their emissions during this pilot period in order to be prepared for the next expanded phase.

Shanghai Municipal Development and Reform Commission (SMDRC) distributes all the emission allowances over 2013-15 for free for all the covered enterprises at one time (SMG, 2012). For industrial sectors other than power sector, commerce, hotels, large commercial and public buildings, this will be done by grandfathering, and their CO_2 emissions from 2009 to 2011 are taken as the base. For some specific homogenous sectors like electric power, aviation, ports, airports, their initial quota of emission allowances are determined based on benchmarking (SMDRC, 2013a). For coal-fired power generation, six benchmarks are established based on the type of technology (ultra-supercritical, supercritical or subcritical plants) and size of installed capacity, and are set at more efficient levels year by year, while one benchmark is set for gas-fired units regardless of their capacity size and remains unchanged over the period 2013-15. Moreover, for those sectors based on benchmarking, to mitigate output uncertainty, prior to surrendering the allowances for a given year, *ex-post* adjustments in their allowances

would be made based on the enterprises' actual production. Furthermore, the pilot takes early abatement action into consideration in allocating allowances. Regardless of the methods of allowance allocation, the covered enterprises except for power plants get allowance rewards for having taken actions for energy-saving technical transformation or energy performance contracting over the period 2006-11. The amount of allowance awards is set to be 30% of the avoided carbon emissions associated with the amount of verified energy saving, which was awarded with the payments from the central government or the Shanghai municipal government[7] (SMDRC, 2013a).

To enforce the compliance of regulated companies to surrender allowances, SMDRC can deduct the corresponding shortfall amount of allowances from their accounts and charge them a fine ranging from Yuan 50000 to Yuan 100000 (SMG, 2013). The pilot scheme also allows the use of the CCERs up to 5% of annual emissions allowances (SMDRC, 2013a).

3.4 Shenzhen pilot carbon emissions trading

The Shenzhen emissions trading scheme covers 635 local industrial enterprises from 26 sectors and 197 large public buildings.These enterprises each emitted at least 5000 tons of CO_2 emissions every year, and all together discharged over 31.73 million tons of CO_2 emissions, or 38% of the city's total carbon emissions in 2010. Adding emissions from 197 large public buildings, each of which has at least the space of 20000 square meters, this share will rise to 40%.These industrial enterprises together receive 100 million tons of carbon allowances over 2013-15. They have to cut their carbon intensity by 32% by 2015 relative to 2010 levels. This reduction requirement is much higher than both the

[7] To support energy-saving technical transformation projects, the Ministry of Finance and NDRC (2007) awarded enterprises in East China Yuan 200, and enterprises in the Central and Western part of the country Yuan 250 for every tce saved per year since August 2007. Since July 2011, such awards are increased to RMB 240 for enterprises in East China, and RMB 300 for enterprises in the Central and Western part of the country for every tce saved per year (Ministry of Finance and NDRC, 2011). China also introduces market mechanism, developing energy management company (EMC) to promote energy saving. The National Development Reform Commission and the Ministry of Finance of China award EMC Yuan 240 for every tce saved, with another compensation of no less than Yuan 60 for every tce saved from local governments (The State Council, 2010).

average reduction requirement of 21% for the city as a whole and a 25% reduction requirement for manufacturing (Lu, 2013; SMLAO, 2013; Zhao, 2013).

In the Interim Administrative Measures released by Shenzhen Municipal Government in March 2014, this threshold of coverage has been lowered to 3000 tons of CO_2 emissions for enterprises and the threshold of 10000 square meters is applied to both large public buildings and office buildings of state organs (SZMG, 2014). Thus, more enterprises and buildings are expected to be included in the future. The Measures also specify that enterprises emitting more than 1000 tons but less than 3000 tons of CO_2 emissions yearly are mandated to report their annual emissions, while the reporting requirement is for entities emitting more than 3000 tons but less than 5000 tons of CO_2 emissions yearly in the Trial Measures (SMLAO, 2013).

Allowances consist of five parts: 1) allowances for initial distribution, 2) allowances for adjustments, 3) allowances for new entrants, 4) allowances for auctioning, and 5) allowances reserved for maintaining the price stability. Annual allowances reserved for new entrants account for 2% of the total amount of annual allowances. Allowances are allocated in a combination of free distribution and paid distribution. Free distribution is for those allowances initially allocated to existing entities and those allowances reserved for new entrants and adjustments in allowances. For regulated entities in electric power, gas and water supply sectors, their initial quota of emission allowances are determined based on benchmarking, while for regulated entities in other sectors, mainly the manufacturing sector, this will be done by grandfathering, taking into consideration of their existing emissions levels and future reduction commitments relative to other entities in the same sector.

Given great uncertainties over future outputs of the manufacturing sector, the Shenzhen pilot has adopted an innovative competitive game-based allocation of allowances in one given sector (SZMG, 2014). The key game rules are defined as follows. First, the emissions cap of a given sector is set. Second, all regulated entities in one given sector are informed about historical and target intensity benchmarks of that sector. Third, each regulated entity submits its emissions allowance demand and projected output to compete with other entities in the same sector for free allowances. Fourth, historically more carbon-intensive entities are required to achieve more reductions and at the same time, entities whose existing carbon intensities are low are encouraged for large reduction. In each round of game, one entity can choose to accept allowances and exit the game provided that it is satisfied with its allocation. If not, it can choose to continue to compete for allowances in the next round of game. As the sector cap is set, allowances allocated to those satisfied entities in this round of game will be deducted and thus allowances

available for the remaining rounds will decrease as the game repeats. In the last round of finite repeated games, those entities that have yet to accept allowances can only receive allocation from the remaining allowances (Jiang et al., 2014). Paid distribution of allowances can take the form of sales at fixed prices and auctions. Moreover, the amount of allowances allocated through auctioning is at least 3% of the total amount[8], and the portion of auctioning can be gradually increased as the carbon trading market evolves.

In the Shenzhen pilot scheme, the Municipal Government also reserves some allowances and sells these allowances to the regulated entities at fixed prices for their compliance purpose wherever necessary for cost containment purposes. The allowances reserved for this purpose include those buyback that the competent department purchases from the market at the preset conditions, with the annual buyback amount capped at 10% of the total allowances in that year (SZMG, 2014). This buyback mechanism is designed to reduce market supply or increase market demand for allowances in order not to let the allowance prices below the predetermined floor level.

To enforce the compliance with the emissions caps, any shortfall amount of allowances will be deducted from the amount to be allocated to non-complying enterprises in the following year, and non-complying enterprises will charge a fine equal to three times the prevailing average market prices over the past consecutive six months for each shortfall allowance. Regulated entities can utilize CCERs for up to 10% of their annual emissions, but all have to be generated outside of Shenzhen but inside of China (SZMG, 2014).

Of the seven pilot emissions trading cities, Shenzhen ETS includes the largest number of enterprises. The city launched its first trading through China Shenzhen Emission Exchange on 18 June 2013. State oil giant PetroChina and private power generator Hanergy conducted the first two trades on the Shenzhen exchange, buying 10000 tons of CO_2 permits at the prices of Yuan 28 and Yuan 30 per ton respectively. Overall, eight deals involving 21112 tons of CO_2 quotas were traded on the first day at prices ranging from Yuan 28 to Yuan 32, about US$ 4.5-5.3, per ton of CO_2 quota. The value of traded allowances totals Yuan 610000 (Zhao, 2013). Allowances have being traded on the Shenzhen exchange, with small volume being traded for each transaction. That very much acts as the purpose of price discovery. While the prices went to the

[8] This is different from those in the Trial Measures. The latter specified that in the initial trading phase, the amount of allowances that are allocated for free accounts for at least 90% of the total amount of allowances, and that the amount of allowances allocated through auctioning cannot exceed 3% of the total amount (SMLAO, 2013).

highest level at Yuan 130.9 per ton on 17 October 2013 with only 3 tons traded, in most time they remain very stable at Yuan 60-80 per ton of allowance in the first compliance year. By the end of 30 June 2014, Shenzhen is the first pilot whose value of accumulated trade in allowances exceeded Yuan 100 million of the seven pilots, and takes the lead on this ground (Yang, 2014).

However, as the country's first carbon trading scheme in operation, Shenzhen ETS is just a baby step when you look at the total amount of the regulated emissions compared to the country's total CO_2 emissions of over 8 billion tons in 2012, but it is hailed as a landmark step for China in building nationwide carbon emissions trading scheme planned for later this decade.

3.5 Tianjin pilot carbon trading scheme

The Tianjin pilot scheme covers iron and steel, chemical, power generation and heat supply, petrochemical, and oil and gas exploration, and mandates the participation of those entities that both directly and indirectly emit 20000 tCO_2 equivalent per year or above since 2009 (TMG, 2013b). As a result, 114 enterprise are covered in this pilot scheme (TMDRC, 2013b). Entities consuming 10000 tCO_2 equivalent or above per year are mandated to report their carbon emissions annually, which need to be verified by the third party (TMDRC, 2013a). All emissions allowances for the covered entities are allocated each year for free during the pilot period running from 2013 to 2015 (TMG, 2013b).

To enforce the compliance of regulated companies to surrender allowances, they will not get preferential financing services, and will not be on the priority list of applying for national recycling economy projects, enjoying supportive national policies on energy conservation and emission reduction, and receiving budgetary investment projects within three years. However, no requirements are specified for the penalty if they fail to comply with their emissions obligations (TMG, 2013a). As discussed in Section 4.6 Compliance, this will limit the effectiveness in enforcing compliance. The Tianjin pilot scheme also allows the use of the CCERs up to 10% of annual emissions allowances (TMG, 2013a).

4. Design, implementation and enforcement issues

The market-based carbon emissions trading approach can achieve significant cost reductions in cutting carbon emissions while also allowing flexibility for reaching compliance only if it is structured effectively (e.g., Tietenberg et al., 1999; Zhang, 2000b). This section addresses a number of design, implementation and enforcement issues that,

although far from comprehensive, must be considered in order to make such a trading scheme to work reliably and effectively. These issues include carbon leakage (the issue related to which sectors are to be covered in the carbon trading pilots), potential market power of dominated players, the use of carbon offsets, price uncertainty and market stabilization, cost pass-through in the electricity sector, and enforcement and compliance.

4.1 Carbon leakage

Differences in climate abatement commitments could lead production of carbon-intensive products to move away from carbon-constrained countries to non- or less carbon constrained countries. This could in turn lead to losses of employment and economic output, in carbon-intensive sectors of these more carbon regulated countries. Since greenhouse gases are the uniformly mixed pollutants, namely, one ton of greenhouse gas emitted anywhere on earth has the same effect as one ton emitted elsewhere, simply shifting production of carbon-intensive products from the carbon-constrained countries to non- or less constrained ones can reduce the environmental effectiveness of the regulating country's efforts. This phenomenon is referred to as carbon leakage (IPCC, 2001 and 2007). It is defined as the ratio of an increase in CO_2 emissions outside the countries taking domestic climate policies to a reduction in emission within these abating countries relative to their reference levels. Zhang (2012) provides a comprehensive review of carbon leakage and the effectiveness of anti-leakage policies associated with differentiated climate abatement commitments among countries. The review clearly shows that differentiated climate abatement commitments among countries have raised great concern about carbon leakage.

Can the findings derived from the international context be directly transplanted into the domestic context of China? At first glance, carbon leakage in the domestic context is of great concern just like carbon leakage concern in the international context. But on second thought, it may be not that severe as it is initially thought. This is mainly related to the characteristics of either specific trading design of these pilot schemes or the Chinese economy as discussed below.

First, the sectors covered are hard to relocate. For example, the first trading phase in Guangdong only covers the four major emitting sectors of power, iron and steel, petrochemical, and cement (GPDRC, 2013). The enterprises in these sectors are capital-intensive, and need approval of the NDRC or are subject to national restrictions on the overall capacity given their production already exceeds demand. Thus, they are not that ease to relocate from one region to another.

Second, as discussed in Section 3, all pilots allocate all or the majority of

allowances for free, and allocations for some sectors covered are based on emissions intensities. The free allocations of allowances on the basis of emissions intensities allow emissions caps to be *ex post* adjusted with real output, thus mitigating negative economic effects. In addition, some *ex post* adjustment mechanism is built to mitigate potentially significant increase in compliance cost. For example, the Hubei pilot specifies that if the yearly verified emissions of one covered entity exceed its cap by 20%, or 200000 tCO_2, then the extra emissions will be covered by the government allowance reserve, which is capped at 10% of total amount of allowances (HPG, 2014).

Third, differing from the EU ETS, indirect emissions from electricity generation are covered in all of the seven pilot schemes,[9] and this design feature could help to reduce carbon leakage in two ways. The first way is to cut carbon leakage from the increased electricity imports if no indirect emissions are covered. For a region like Beijing, over 60% of electricity consumption is imported from other regions. If indirect emissions associated with imported electricity are not covered, then a significant amount of emissions in this region are not covered. The region would import more electricity instead of producing electricity on its own, thus leading to more carbon emissions in other regions than what would otherwise be the case. Covering indirect emissions caused from the amount of imported electricity would reduce the potential of carbon leakage. The second way is to cut downstream companies' potential shift to electricity consumption. As discussed in Section 4.5, electricity tariffs have remained controlled by the central government and still remain flat and regulated (Zhang, 2014a). As such, the increased carbon costs of power generators to comply with the carbon or energy limits cannot be passed through to the downstream energy consumers. If indirect emissions are not covered, then downstream companies could reduce their emissions by means of replacing fossil fuel consumption with electricity consumption, provided that they found this shift economically profitable.

Fourth, the prevailing findings from the pollution haven literature are that environmental regulations have a small to negligible impact on relocations (Oikonomou

[9] Feng et al. (2013) show that more than 75% of emissions associated with products consumed in Beijing-Tianjin occur in other regions. Shanghai, Tianjin, and Beijing are net importers of embodied emissions, with a proportion of imported emissions embodied in finished goods up to 62% in Tianjin. While it would be ideal to include all indirect emissions, in practice all the pilot regions only cover indirect emissions released in generating the amount of imported electricity because it is straightforward to measure the amount of electricity generation and its flows across China.

et al., 2006), not to mention that carbon cost is only a small portion of the overall costs, at least in the short term. Putting a price on carbon through carbon trading affects a firm's competitiveness by changing its relative production costs. However, relative production costs are determined not only by pollution regulation alone and pollution regulation may not be an important determinant of costs (Copeland and Taylor, 2003). Indeed, a firm' competitiveness is influenced both by 'micro' factors, such as cost structure, product quality, trademark, service and logistical networks, and by 'macro' factors, such as exchange rates, trade rules and political regime stability (Baron and ECON-Energy, 1997). The fact that why the widely believed fear of environmental relocations was not observed in the international context indicates that differences in regional pollution policy are only one of the many factors that affect the firm's competitiveness and relocation (Jaffe et al., 1995; Levinson and Taylor, 2008). The costs associated with this pollution abatement factor represents a small fraction of costs compared to other costs or barriers which still favor production in industrialized countries (Oikonomou et al., 2006): tariffs, transport costs, labor productivity, volatility in exchange rate, political risk, etc. If other factors outweigh the effects of carbon abatement policy on comparative advantage, then relocation would not occur to regions with weak carbon regulation.

Fifth, each province or region has mandatory emissions targets, and these targets are considered, at least perceived, comparable among comparable regions. In taking on emissions commitments, each province or equivalent has several rounds of bargaining with the NDRC. It would be hard for one province to make a deal with the NDRC when it finds that another province in a comparable position does not make a comparable commitment. Indeed, the bargaining process will ensure that each province takes on stringent energy-saving and pollution-cutting commitments up to its expectation. This is very different in the international context, where commitments across countries, in particular commitments by developed countries and developing countries, are widely perceived as incomparable, although such a difference is not necessarily irrational.

Sixth, in any case, it is not easy to relocate enterprises in a given region to other regions in China. There are a lot of restrictions, regardless of carbon trading. The aforementioned first point illustrates that by carbon trading design itself it is not easy to relocate enterprises in a covered region to other regions. Even without consideration of carbon trading, relocation is not easy either. Just like elsewhere in the world, local governments in China are responsible for not only providing public services, but also for promoting their local economies. However, given that the central government only accounted for less than 25% of the country's total government expenditure but received over 50% of the total government revenue in China since China adopted the tax-sharing

system in 1994[10], local governments increasingly face the burden of rapidly growing expenditures for culture and education, supporting agricultural production, social security subsidiary, urban infrastructure and urban development, etc. To enable to pay their expenditure, local governments have little choice but to focus on local development and GDP. That will in turn enable them to enlarge their tax revenue by collecting urban maintenance and development tax, contract tax, arable land occupation tax, urban land use tax, etc. Partly because of the drawback of the existing tax system in China, which separates the origin of tax from the collecting place,[11] local governments even intervene

[10] Since the tax-sharing system was adopted in China in 1994, taxes are grouped into taxes collected by the central government, taxes collected by local governments, and taxes shared between the central and local governments. All those taxes that have steady sources and broad bases and are easily collected, such as consumption tax, tariffs, vehicle purchase tax, are assigned to the central government. VAT and income tax are split between the central and local governments, with 75% of VAT and 60% of income tax going to the central government. As a result, the central government revenue increased by 200% in 1994 relative to its 1993 level. This led the share of the central government in the total government revenue to go up to 55.7% in 1994 from 22.0% in the previous year. In the meantime, the share of the central government in the total government expenditure just rose by 2%. By 2009, local governments only accounted for 47.6% of the total government revenue, but their expenditure accounted for 80.0% of the total government expenditure in China. On the one hand, to enable to pay their expenditure for culture and education, supporting agricultural production, social security subsidiary, etc, local governments have little choice but to focus on local development and GDP. On the other hand, local governments seek off-budget funds from land concession to cover a disproportional portion of the aforementioned government expenditure. Objectively speaking, this tax-sharing scheme in China plays a part in driving local governments to seek higher GDP growths and off-budget funds from land concession at the expense of the environment (Zhang, 2008, 2010 and 2011b).

[11] Based on the existing tax system in China, the origin of tax is different from the collecting place. Enterprises are mandated to pay the business taxes to the places where they are registered, not to the places where these taxes occur. Take the project of natural gas transmission from West to East China as a case. When natural gas is transmitted from the western part of China to Shanghai, 40% of the business tax revenues are in Shanghai where the enterprises are registered, and 60% of the revenues go to the central government. But more than ten provinces along this transmission line hardly receive any

mergers, acquisitions and relocations of enterprises in order to prevent losses of revenues and negative effect of economic growth, even if these enterprises often are small-sized, less efficient and highly polluting, and the regions would benefit from mergers, acquisitions and relocations in terms of improved environmental quality and sustained economic development.

4.2 Market power

There are potential dominated players that could exert the market power in a pilot trading region. Baosteel Corp. in Shanghai accounts for 20% of emissions in Shanghai. ZTE in Shenzhen is also a very large holder of carbon allowances. To avoid exerting potential market power of dominated players, China's carbon trading pilots have to deal with the issue of market power in their design and implementation just like any emissions trading schemes in other countries do (Tietenberg et al., 1999).

There are many ways to prevent market power or at least mitigate market power concerns. The governments of pilot regions could set limits to the amount of allowances that each entity can bid. For example, in a given auction under the Beijing pilot scheme, each complying entity is not allowed to bid for more than 15% of the total allowances to be auctioned, while each entity of no compliance obligations is only allowed to bid up to 5% of the total auctioned allowances (BMDRC and BMBFW, 2014). The pilots could also specify the ways to handle larger order. For example, the Shanghai pilot mandates that for any single transaction of 100000 tons of allowances or above the two sides have to be settled the deal through negotiated transactions (SMDRC, 2013b). Linkage to other pilot trading regions in China or establishing national carbon trading scheme is another venue. That will expand the carbon market and thus limit the potential market power of a given larger player in a small, fragmented market. No need to say, setting a price ceiling is very helpful in this regard.

4.3 Use of the CCERs

The NDRC allows each pilot region to use the Chinese Certified Emission Reductions that meet the requirements of China's national MRV regulation. There are some rationales behind this decision. Regions in less developed, middle and western part of the

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business revenues, although they spend a lot of money for services. With some provisional measures on the distribution of business revenues among sub-entities across provincial borders implemented since 2008, there has been some progress but this issue has not been completely settled (Wu, 2014).

country or those sectors not covered in a pilot region need technology and capital, while the pilot regions need low-cost options to cut their emissions. In the meantime, for the country as a whole, emissions need to be kept under control. Thus, the use of the CCERs can be a win-win-win option, just as the use of certified emission reductions (CERs) under the EU ETS has achieved.

Indeed, as indicated in Table 1, all pilot regimes allow to a different degree the use of the CCERs. However, the volume of CCERs available nationwide could be more than the total need in a pilot region. Moreover, if these regimes are just interested in getting cheap CCERs, there will be no strong incentives to encourage potential investors to develop those sustainable but costly projects like renewable energy projects.

This suggests the restricted use of CCERs just as the limited use of CERs under the EU ETS. Given the potential oversupply of CCERs for one pilot region, the question then is how to filter CCERs. There are two broad set of options. One set of options are to give priority to those CCERs from the pilot region itself. This allows to maximize sustainable benefits to the region. For example, the Guangdong scheme requires that at least 70% of the allowable CCERs have been generated from Guangdong (PGGP, 2014). Priority could also be given to those CCERs from those tied regions, for example, those pairing-assistance regions or regions of more bilateral cooperation to support pairing-assistance regions or facilitate more bilateral cooperation. With dense smog and haze frequently hitting in Beijing and other places in China, the need for improved environmental quality has been raised to unprecedented importance.[12] This not only requires enhanced efforts in key energy-consuming sectors, but also unprecedented, coordinated regional efforts, in particular in more developed and severely polluted regions. Along this line, priority could also be given to those CCERs from other regions whose coordinated efforts are needed to collectively achieve a regional goal set by the central government.[13]

[12] In March 2014, Chinese Premier Li Keqiang said to about 3000 delegates to China's legislature that China will "declare war against pollution as we declared war against poverty" after nearly every Chinese city monitored for pollution failed to meet state standards in 2013.

[13] For example, the Atmospheric Pollution Prevention Action Plan (The State Council, 2013) sets more stringent concentration targets for hazardous particles for more-developed areas, with Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta required to cut by 25%, 20% and 15% respectively.

Another set of options are to give priority to those projects that promote both climate and sustainable development goals. That would direct capital flows towards those projects with the high overlap possible with other social and environmental criteria. This will ensure that the CCERs help accelerate the Chinese economy in general and a pilot region in particular to move along the more sustainable paths. The pilot regimes could set a premium price for certain desirable CCERs investment. For example, the Dutch Ministry of Housing, Spatial Planning and the Environment established the CERUPT (Certified Emission Reduction Unit Procurement Tender) program to directly purchase carbon credits through tender procedures. The offering prices of CERs are differentiated according to technology types, with renewable energy projects in general assigned with a premium price (Table 2). This will broaden project types that carbon finance renders viable. Indeed, this has increased the number of renewable energy projects in the Dutch CERUPT portfolio to 75% (Zhang, 2006a,b). However, this may be an unrealistic option for the pilot regions, because the entities to purchase CCERs in the pilot regions are not the government in the CERUPT case. The more feasible option is that the pilot regions amend their administrative measures or rules governing their carbon pilot schemes. Just like the Chinese government has prioritized the areas of the CDM investment, this amendment could be done by explicitly prioritizing the areas of the CCERs investment. The priority areas for such investment projects in China are energy efficiency improvement, development and utilization of new and renewable energy, and methane recovery and utilization.

Table 2 The maximum offering prices of CERs under the Dutch CERUPT program

CDM project type	Maximum offering prices of CERs under the Dutch CERUPT program (€ per ton of CO_2 equivalent)
Renewable energy (excluding biomass)	5.5
Biomass energy (excluding waste)	4.4
Energy efficiency improvement	4.4
Fossil fuel switch and methane recovery	3.3

Sources: Zhang (2006a,b).

4.4 Market stabilization mechanism: allowance reserve and buyback versus a price floor and a price ceiling

With a wide expectation for a high, rising price in allowances, the EU ETS incorporates offsets to contain prices. However, because of generous allocations of allowances by the Member States and the economic recession, the prices of carbon allowances plunged to € 7/tCO_2 in mid-December 2011, well below the peck price of over € 30/t CO_2 in July 2008. With the further fall in the prices of allowances under the EU ETS, the price of CDM credits fell below € 1/t CO_2. But until the Commission proposed in January 2014 to establish a market stability reserve at the beginning of the next trading period in 2021 (European Commission, 2014b), there is no provision in the ETS Directive to prevent significant drops in demands for allowances and thus prices. The European Commission has recognized the impact of the growing surplus of allowances, and has proposed back-loading auction volumes towards the end of the third phase (European Commission, 2012b,c). Through an amendment to the EU ETS auctioning regulation, the European Commission is postponing the auctioning of 900 million tons of allowances from 2014-16 until 2019-2020 to allow demand to pick up (European Commission, 2014a). In addition to this simplest mechanism to set aside allowances, other proposed options to strengthen the EU ETS include tightening the greenhouse gas reduction target and the ETS cap and trajectory and undertaking reserve price auctions (Grubb, 2012; European Commission, 2014b).

Having learned from this price uncertainty under the EU ETS, the Australian and Californian emissions trading schemes have incorporated price corridor mechanisms to protect against price uncertainty.

To prevent the dramatic price fluctuation seen under the EU ETS, all pilot ETS in China have incorporated some mechanism to address supply-demand imbalance and the resulting price uncertainty. For example, in the Beijing and Shenzhen pilot schemes, the Municipal Governments reserve some allowances and auction these allowances wherever necessary for cost containment purposes. When allowances are over supplied and the prices of allowances are thus pressed down to a very low level, the government can buyback some of the allowances in surplus from the carbon market. This mechanism certainly helps stabilize the prices of allowances. But the difficulty lies in setting aside an appropriate level of allowances for this purpose, which is related to the triggering conditions that have not yet been disclosed for most of the pilots. Even if the Beijing pilot scheme has set the triggering conditions based on the average price of allowances over the ten consecutive trading days, it is unclear whether the size of reserved allowances is sufficient at a given triggering price. If the triggering price is set too low, it might be the case that the size of reserved allowances is not enough to meet the demand. If it is set too high, then it may not be able to achieve cost containment purposes.

In my view, it would be ease but effective against price uncertainty to introduce both a price ceiling and a price floor in its pilot trading scheme. Moreover, establishing a floor price will remove downside risks for investors while delivering its objective of cutting carbon emissions efficiently.

As for a price ceiling, it could be set in relation to the prevailing international prices as the proposed Australian ETS does (Jotzo, 2012). But setting a price floor is not that easy. Detailed sectoral, regional and countrywide studies on carbon abatement can provide some basis for what a level a price floor would be set at. Given that the cost of abating carbon emissions differ widely among the sectors, a price floor should be set to be higher than the lowest abatement cost projected for the trading sectors. This will encourage carbon abatement for some sectors that are relatively hard to meet their emissions targets through their own actions. It should be no less than carbon tax levels to be introduced. But it should not be higher than the highest abatement cost for the trading sectors. Otherwise there will be no trading.

While we emphasize that having a carbon price floor is very crucial at the initial stage of the ETS, whether to continue keeping that price floor needs to take many factors and circumstances into consideration. For example, at a late stage when China is going to consider to link with other ETS in the world, China needs to consider whether it is appropriate to keep its price floor, depending on which ETS China decides to link its ETS with. This has been the case for the linkage between the Australian and EU ETS. In this case, the proposed Australian carbon pricing scheme, which did not put into operation because the Abbott government banned it, would undergo significant changes in order to facilitate the linkage. As planned initially, the Australian ETS would keep its carbon pricing floor until it starts links with the EU ETS in July 2015. Afterwards, the Australian ETS would remove its carbon price floor because it is not positioned to set the price (Jotzo, 2013). The ETS of larger size, the EU ETS in this case, will determine the level of carbon price. Because the EU ETS does not have a price floor, the Australian ETS would have to drop off its price floor once the link starts. The Australian scheme, however, would continue to have a ceiling price, expected to remain in force until the full link comes into effect no later than July 2018. This ceiling price, which was earlier A$22.1 per ton above international carbon prices, will now be based on expected 2015-16 price of the European allowances (European Commission, 2012d).

4.5 Cost pass-through in the electricity sector

Power generation is the large consumer, and is included in the EU ETS and other emissions trading schemes. In the initial discussion on the coverage of sectors, the

electricity sector is widely considered to be a top candidate for inclusion in emissions trading pilots in China. Indeed, this sector has been included in all seven carbon trading pilots. The sector is also a top candidate for inclusion in a future national emissions trading scheme, because its consolidation into the big five power corporations makes implementation in the power sector easy relative to other sectors.

Given that firms treat free allowances in the same way as they would do purchased allowances, it is thus likely that firms pass through some, if not all, of the opportunity cost from holding allowances to consumers so that they can increase short-term profits (Zhang, 2012). Pass-through rates differ significantly across sectors and among countries. Empirical studies on cost pass-through and windfall profits in the Dutch and German power sectors estimate that pass-through rates range from 60-100% for wholesale power markets (Sijm et al., 2006).

A key question for China is how to address the effect of carbon costs in the electricity sector where the price of power is currently regulated by the central government (Zhang, 2014a). In recent years, with rising coal prices but without the corresponding increases in power prices, coal-fired power generators are frequently reported to suffer a loss in China. So implementing emissions trading in the power sector creates a new impetus for power pricing reforms to allow the pass-through of carbon costs in the electricity sector as a result of implementing carbon trading. While a comprehensive power pricing reform will be an ideal option, the reality in China suggests that this will not come any time soon. Therefore, until this long-awaited reform is undertaken, we have to look for other options to reflect the carbon costs in power generation.

Just like coal-fired power plants that are mandated to install desulfurization and denitrification facility receive power price premium for desulfurization and denitrification (Zhang, 2014a), the NDRC could offer power price premium for carbon abatement. In China, only the NDRC is mandated to set and change power prices. If the central government is decided to take this option, that price premium for carbon abatement would be offered nationwide to all fossil fuel-fired power plants for their carbon abatement, not only those included in the pilot carbon trading schemes. Another option is that the power regulator sets the allowable level of increase in allowance prices. This could be done by incorporating design features in emissions trading scheme that allow the central government to adjust the supply of allowances into the market. A predetermined amount of allowances are set aside and are only released into the market if prices reach an allowable certain level (Yu and Elsworth, 2012). However, implementing

this option requires a national emissions trading in place, and that national scheme incorporates the market stabilization mechanism for that purpose.

Indeed, there are already mechanisms to address demand-supply imbalance. The European Commission is back-loading auction volumes of allowances from 2014-16 towards the end of the third phase (European Commission, 2014a). These mechanisms aim to correct for drops in demands for allowances. But our proposed mechanism is for increases in allowances to regulate prices not to go beyond the allowable level.

4.6 Compliance

Compliance requires that emissions allowances that each covered entity surrenders in one given year equal its verified level of emissions in that year. For any emissions trading scheme, this involves putting effective and enforceable compliance rules into place (Tietenberg et al., 1999). To enforce the compliance of covered entities with their emissions obligations, all pilots have built a variety of public disclosure and punishment mechanisms. Some pilots include non-compliance in the credit record of non-complying enterprises and make it public (SMG, 2013). Some pilots also deprive those non-complying entities from applying for public energy saving funds for a certain period of time, and being given preferential treatment of their application for public financial support for low-carbon development, energy conservation and renewable energy projects for a certain period of time (TMG, 2013a). Depending on the extent of noncompliance, they are charged a penalty ranging from Yuan 30000 to Yuan 100000. These sticks are necessary, but not sufficient. Some pilots go further. For example, Shenzhen and Shanghai deduct shortfall allowances from the amount to be allocated to non-complying enterprises in the following year, while Guangdong and Hubei deducts two times the shortfall amount of allowances from the amount to be allocated to non-complying enterprises in the following year (HPG, 2014; PGGP, 2014; SMG, 2013; SZMG, 2014). Shenzhen and Beijing pilots charge the non-complying entities at 3-5 times the prevailing average market prices for each shortfall allowance (BMDRC, 2014a; SZMG, 2014).

All five pilots have also done a lot of extra work to supervise and urge the covered entities to comply with their emissions obligations before the compliance deadlines. For example, through workshops and on-site visits, SMDRC (2014) aimed to have a better understanding of issues and difficulties that the covered entities were confronted with in the process of allowance surrendering and sent the designated persons to provide the corresponding policy advice and technical supervision. Since March 2014, BMDRC (2014b,c) organized the training and on-site inspections to help the regulated entities to meet their obligations.

In addition to these rules and supervision and urging work, the pilots have introduced a variety of measures and policies to enhance their compliance. Several pilots have extended the compliance deadlines. For example, Guangdong extended the deadline from 20 June to 15 July 2014. The market remained open at the weekends in the final two weeks in order to help the regulated enterprises to meet their emissions caps. Tianjin adjusted twice the deadline of commitment. The deadline was first extended to 10 July, and again to 25 July 2014. Beijing extended the deadline from 15 June to 27 June 2014. Moreover, on 18 June 2014, BMDRC (2014d) publicly released a list of 257 non-complying entities, which means that over half of 490 covered entities in the Beijing pilot failed to meet their obligations before the initial deadline, and urged them to comply with their obligations before the extended deadline.

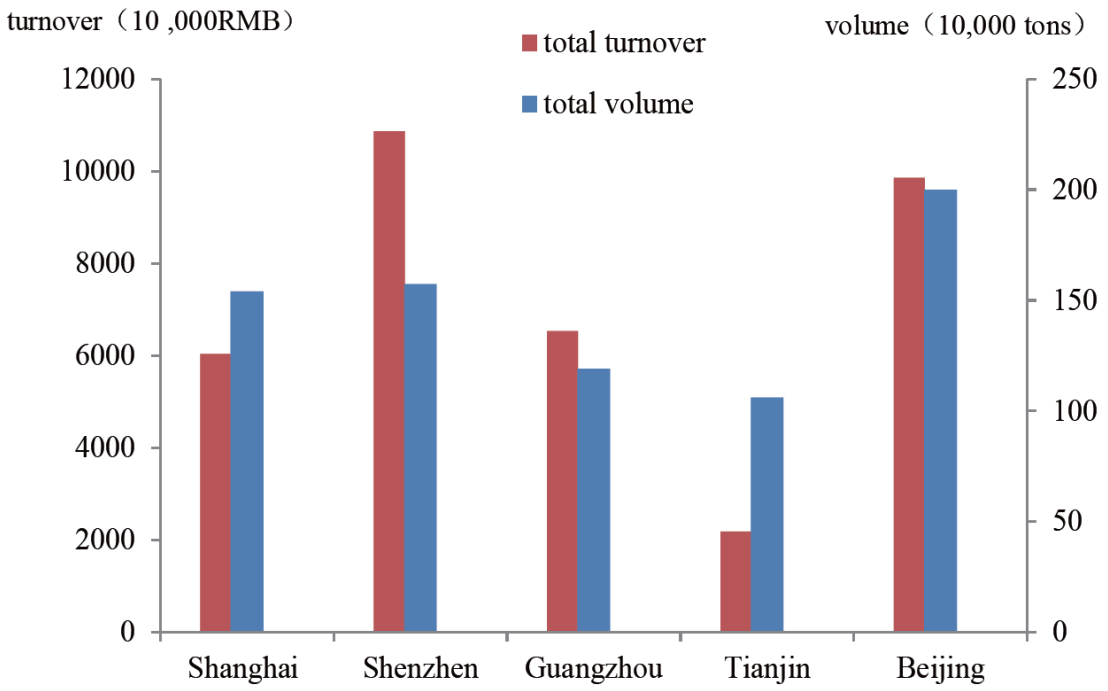
Some pilots also allow the changing in status in one compliance cycle. On 9 June 2014, GPDRC announced on its website that if companies emit less than 20000 tons of CO_2 emissions due to equipment maintenance, suspension of business or bankruptcy, they could apply to be excluded from the program. As a result, 18 enterprises covered were converted to reporting enterprises[14] (GPDRC, 2014a) and consequently are not subject to compliance obligations for 2013.

Some pilots auction additional allowances, with eligibility specified only for those enterprises of compliance gap, and the allowances received are only for compliance needs and cannot be traded on the market. The Shenzhen Emission Exchange issued the notice on allowance auction on 27 May 2014. The volume for auctioning was 200000 tons, and the reserve price was half the average price on 27 May. Only those whose actual emissions exceeded the allocated quota in 2013 are eligible for bidding. Moreover, the maximum bidding volume for each bidder could not exceed 15% of difference between its actual emissions and the given quota in 2013. The allowances acquired will be directly deposited on the bidder's compliance account for fulfilling the commitment requirement, and cannot be traded in the market (China Emissions Exchange, 2014). Similar to Shenzhen, SMDRC issued on 13 June 2014 a notice on paid distribution of 580000 tons of allowances for enterprises of shortfall allowances at the end of that trading day to comply their obligations for 2013. The auction was set on 30 June 2014, the last day of the compliance period. But unlike Shenzhen, each enterprise is allowed to purchase up to the total amount of shortfall allowances. Moreover, a reserve price is set at

[14] Guangdong pilot initially covers existing 202 companies (GPDRC, 2013), and 184 companies are mandated to comply with emissions obligations for 2013 (Wang, 2014). This suggests that 18 companies initially covered became reporting companies.

1.2 times the weighted average market price over 30 trading days prior to auctioning, but should not be lower than Yuan 46 per ton of allowance (Tanpeifang, 2014b). This reserve price is the highest hammer price ever for one single deal before the announcement of the last auction on 13 June 2014. Taking the price as the reserve price was aimed to protect the benefit of earlier allowance purchasers and encourage regular trading in allowances on the market. This strategy implies potential high prices of allowances and effectively stimulates the market on both sides of demand and supply, thus promoting allowance trading on the market or allowance transfer through agreed deals. As a result, the total accumulated volume of trade reached 584000 tons in the last two weeks before the compliance deadline, accounting for 37% of the total accumulated volume of trade (1.553 million tons of allowances) from the beginning trading date of 26 November 2013 to the last trading date of 27 June 2014. At the same time, the last auction provides the last opportunity for enterprises of shortfall allowances to meet the compliance obligations. In the end, only two enterprises purchased 7220 tons of allowances through the last auction for complying with their 2013 obligations (SMDRC, 2014). While the amount of auctioned allowances is very small compared with the aforementioned planned amount of paid distribution, the last auction is vital to the overall compliance of Shanghai.

Figure 2 shows the five carbon trading pilots' total accumulated volume and turnover of traded allowances in the first compliance year. With the incentives and mechanisms built in these pilot trading schemes and a variety of measures and policies put in place to enhance their compliance, as shown in Table 3, the first-year performance of the five pilots is generally good. Shanghai and Shenzhen met their commitments before the original deadline. Of 635 covered enterprises in the Shenzhen pilot, 631 companies completed their commitments for 2013. This corresponded to the compliance rates of 99.4% and 99.7%, respectively measured against enterprises or allowances (Q. Zhang, 2014). Shanghai achieved a compliance rate of 100%, although investment institutions and individuals were not allowed to participate in trading (SMDRC, 2014). By the end of 30 June 2014, the total accumulated volume of traded allowances in the first compliance year was 1.458 million tons of allowances for Shenzhen and 1.26 million tons of allowances for Shanghai, being close to each other. However, because the prices of allowances in the Shenzhen pilot market were much higher than that of the Shanghai pilot market, the total accumulated value of traded allowances reached Yuan 106 million for Shenzhen, 2.16 times that of Shanghai (Yuan 49 million) (Q. Zhang, 2014).



Note: Beijing's data as of 25 July 2014.

Figure 2 The five carbon trading pilots' total accumulated volume and turnover of traded allowances in the first compliance year

Source: Climate Bridge (2014).

Table 3 Five carbon trading pilots' compliance rate in the first compliance year

	Measured against enterprises (%)	Measured against allowances (%)
Beijing	97.1	Not available
Guangdong	98.9	99.97
Shanghai	100	100
Shenzhen	99.4	99.7
Tianjin	96.5	Not available

Sources: GPDRC, 2014a; SMDRC, 2014; Tanpeifang, 2014c; TMDRC, 2014; Q. Zhang, 2014.

Beijing, Guangdong and Tianjin performed well after their compliance deadlines were extended somewhat (less than one month). Guangdong achieved the compliance rates of 98.9% and 99.97%, respectively measured against enterprises or allowances (GPDRC, 2014a). Moreover, through technical innovation, 80% of the covered

enterprises are estimated to cut to a differing degree their emissions per unit of product (Li and He, 2014). This is a significant accomplishment for a big manufacturing province like Guangdong. Based on the number of enterprises covered, Beijing and Tianjin achieved the compliance rate of 97.1% and 96.5%, with twelve and four enterprises failing to compliance with their emissions caps, respectively (Tanpeifang, 2014c; TMDRC, 2014). The relatively low rate of compliance in Beijing is mainly because it faced very complicated conditions. The Beijing pilot not only covers a large number of entities, but also these entities covered are very broad in scope, ranging from large centrally own enterprises like Sinopec, multilateral corporations like Microsoft, universities like Peking University, hospitals, medias like CCTV and Xinhua News Agency, and other public service units like ministries (Zhang and Li, 2014a,b). The lowest rate of compliance in Tianjin of the five pilots subject to compliance obligations for 2013 might be associated with the fact that, unlike Shanghai and Guangdong pilots, the enterprises covered by the Tianjin pilot would not be required to pay the penalty if they failed to comply with their emissions obligations. They would only suffer from not getting preferential financing services, not being on the priority list of applying for national recycling economy projects, enjoying supportive national policies on energy conservation and emission reduction, and receiving budgetary investment projects within three years (TMG, 2013a). Overall, while these five pilots have experienced the ups and downs, their good start and performance in the first compliance year provide encouraging sign for the compliance of all the seven pilot schemes in the next year and beyond.

Emissions trading is not only a means of helping the covered entities to meet their emissions obligations, but can also help them achieve that goals at low costs. However, many enterprises view that governments may not be that serious in enforcing the compliance so that they only take advantage of emissions trading until the last minute. Some enterprises are even not familiar with the procedures and rules related to emissions trading (Li and He, 2014). In either of cases, these enterprises miss the earlier opportunities to engage in emissions trading to their advantages. As a result, they all rush trading in the last minute to fulfill their emissions obligations. While the majority of them meet with their obligations in the end, they pay higher prices than what would be otherwise the case. For example, the total accumulated volume of trade in Beijing reached 1411000 tons from 1 June 2014 to 27 June 2014, the compliance deadline. This volume is 5.4 time the total volume of traded allowances in May 2014, 19.1 time the total volume of traded allowances in April 2014, and accounts for 75.3% of the total accumulated volume of trade from the beginning trading date of 28 November 2013 to the last trading date of 27 June 2014. Not only trading rose rapidly in the last month of

the compliance circle, did the prices of allowances traded online. The allowances were traded at a price of Yuan 66.48 per ton of allowance, 17% higher than the price one day earlier and 24.29% higher than one week before (Zhang and Li, 2014a). Shenzhen and Shanghai also had the similar experience. The total volume of traded allowances in the last month accounted for 65% and 73% of the total accumulated volume of trade from the beginning trading date to the last trading date of the first-year compliance circle for Shanghai and Shenzhen, respectively. The daily volume of trade reached the highest point at 204000 tons of allowances on 23 June 2014 in Shanghai and 128500 tons of allowances on 25 June 2014 in Shenzhen, respectively (Q. Zhang, 2014).

5. Conclusions

It is becoming increasingly crucial for China to harness market forces to reduce its energy consumption and cut carbon and other conventional pollutants and genuinely transit into a low-carbon economy. To that end, China is experimenting with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities. Putting a price on carbon is considered a crucial step for such endeavor. A carbon tax or a domestic carbon trading scheme serves as a cost-effective supplement to costly administrative means on which China has mainly relied to meet its current energy saving goal. Given that the whole legislation process of amending the existing environmental law and promulgating environmental tax law to authorize the levy of environmental taxes takes time on the one hand, and that there is the pressing need to meet with the increasingly stringent energy and emissions targets in a cost-effective way on the other hand, China opts for emissions trading.

The NDRC has approved the seven pilot carbon trading schemes. The seven pilot regions are given considerable leeway to design their own schemes. These pilot trading schemes, running from 2013 to 2015, have features in common, but vary considerably in their approach to issues such as the coverage of sectors, allocation of allowances, inclusion of price floors and ceilings in trading schemes, use of offsets, and compliance. While these pilots have experienced the ups and downs, with the incentives and mechanisms built in these pilot trading schemes and a variety of measures and policies put in place to enhance their compliance, the first-year performance of the five pilots examined is generally good. Their good start and performance in the first compliance year provide encouraging sign for the compliance of all the seven pilot schemes in the next year and beyond.

Going forward, the pilot regions need to take the lessons learned in the first compliance year. Indeed, the pilot regions are amending the interim provisions whenever necessary to improve the operation of their ETS. For example, differing from the mandatory purchasing at the predetermined prices in the first compliance year, the Guangdong pilot in the second compliance year allocates paid distributions of allowances through auctioning. Moreover, the reserve price has been lowered from Yuan 60 per ton of allowance in the first compliance year, but is set to increase from Yuan 25, to Yuan 30, Yuan 35 and to Yuan 40 per ton of allowance in the four consecutive auctions for the second compliance year (GPDRC, 2014b). These changes are able to provide the covered enterprises with increased flexibility in terms of when and where to purchase the paid distributions of allowances (Wu, 2004), increase the liquidity of the market, and to better reflect their abatement cost or demand and the allowance price in the secondary market.

The pilot regions need to educate the covered entities to actively participate in emissions trading, rather than wait until the last minute. Experience in the pilot regions like Beijing, Shanghai and Shenzhen shows that many enterprises rush trading in the last minute to fulfill their emissions obligations, thus missing the earlier opportunities to engage in emissions trading to their advantages. As would be expected, while the majority of them meet with their obligations in the end, they pay higher prices than what would be otherwise the case. Therefore, efforts towards helping these entities to recognize the potential of emissions trading lowering their compliance costs, rather than just view emissions trading as a means of compliance, need to be strengthened.

The pilots could learn from each other. In the first compliance year, 12.31 million tons of emission allowances were traded in both the primary and secondary market, which yielded an overall turnover of Yuan 732 million in the Guangdong pilot. However, the primary market played the dominated role, with only 1.19 million tons of allowances traded in the secondary market and the resulting turnover of Yuan 65.32 million, which only accounted for 10% and 9% of the totals, respectively (Zhang and Wei, 2014). To increase participation and liquidity, the Guangdong pilot has learned from the Hubei pilot, which is the first Chinese pilot to allow institutional investors to bid for allowances in the primary market, and allows institutional investors to trade emission allowances. With qualified institutional investors allowed to trade allowances in the Shanghai carbon market, since September 2014 all the seven pilots have opened allowance trading to institutional investors, with the Tianjin setting the highest eligibility condition for institutional investors (SMG, 2014). Shenzhen even goes further, becoming the first Chinese carbon market to allow foreign companies to participate in emissions trading since September 2014.

Moreover, as China gains experience, China needs to allow forward trading of carbon allowances. At this stage, all pilot carbon trading takes place on government-approved exchanges, and only spot trading is allowed. Given that forward trading is necessary to determine the proper value of the carbon credits that are traded, and that companies need forward disclosure to make future investment decisions, however, such a scheme without forward price disclosure cannot be effective to timely trace market price trend and take risk prevention measures to maintain the stability of the carbon market.

Furthermore, the better than expected performance in the first year of the five pilots examined encourages other regions to develop carbon trading. Meantime, there are significant variations in the prices of allowances across the seven pilots. This raises the issue of future development of carbon trading in China. There are the two prevailing views on the development of national carbon market along a regional pathway (Zhao, 2014). One is to continue to expand existing carbon pilots in terms of geographical coverage and sectoral scope. The second is to authorize the constructions of new pilots. These two options mean that China will continue to still act in regional carbon markets, but with expanding geographical coverage and sectoral scope. Alternatively, China goes for establishing a national carbon market. There are two ways to move in this direction. One is to establish a nationwide ETS by linking those existing pilot carbon trading schemes that meet all the qualification conditions to be integrated into a national linked system. Another way is that, based on experience and lessons learned in the pilots, China establishes a national ETS, and until a full-fledged national ETS is established and works, regional ETS continues to function in parallel, but those entities covered in the existing regional carbon trading pilots will be unconditionally integrated into a nationwide ETS scheme if they meet the threshold set by a nationwide regime, which is expected to be much higher than ones set in most of the existing regional carbon trading pilots. Each of the options has its own pros and cons in China's context, and needs weighted against a variety of criteria including administrative costs. Which option better fits into China's specific situation is of highly policy-relevant issue, and deserves further investigation. But no matter which option takes in the end, it is important to ensure that all the emissions data are properly measured, reported and verified in an aim to make each unit of emissions reduction reliable and comparable across regions. This is a prerequisite to link fragmented regional carbon markets and trade allowances across regions, and thus to ensure that a nationwide carbon emissions trading scheme functions properly in China. To that end, a national ETS legislation needs to be established to authorize emission trading at the national level, providing united guidelines and methodologies on ETS design and operation and enforcement of MRV and penalties for non-compliance at the

minimum, ascribing allowances as financial assets and defining their valid duration in an aim to generate economically valuable and environmentally-credible reductions and to provide a solid basis for building a sound national ETS.

Finally, it should be pointed out that carbon trading and environmental taxes are not substitute, and China needs to impose environmental taxes to level the playing filed. As discussed in the paper, emissions trading schemes initially operate only in few regions. Even in the regions where emissions trading schemes are implemented, they do not cover all the sectors. The differing timing provides an impetus for introduction of environmental taxes to level the playing filed between the sectors covered and those sectors not covered in the regions of operating emissions trading and the regions with and without the operation of emissions trading. Environmental taxes can be imposed on those sectors that are not covered by emissions trading and are implemented in the regions that do not implement emissions trading. As such, environmental taxes will integrate regions of no emissions trading and sectors not covered by emissions trading together. The newly amended environmental law makes the imposition of environmental tax to move one step forward, but getting it into implementation still requires the Chinese legislature to promulgate environmental tax law to provide a legal basis. Moreover, in terms of timing, given that China has not levied environmental taxes yet, it is better to introduce environmental taxes first, followed by carbon taxes, not least because such a distinction will enable China to disentangle additional efforts towards carbon abatement from those broad energy-saving and pollution-cutting ones (Zhang, 2011a,b).

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