



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

Papers downloaded from AgEcon Search may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Carbon Emissions Trading in China: The Evolution from Pilots to a Nationwide Scheme

CCEP Working Paper 1503

April 2015

ZhongXiang Zhang

School of Economics, Fudan University

Abstract

The Chinese central government has approved the seven pilot carbon trading schemes. These seven pilot regions are deliberately selected to be at varying stages of development and are given considerable leeway to design their own 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 opts for emissions trading, rather than carbon or environmental taxes at least initially, discusses the key common and varying features of these carbon trading pilots and their first-year performance, draws the lessons learned, discusses the potential pathways for evolution of regional pilot carbon trading schemes into a nationwide carbon trading scheme, and raises fundamental issues that must be addressed in order to make such an emissions trading scheme to work reliably and effectively and with an increasingly expanded coverage and scope.

Keywords:

Pilot carbon trading schemes; environmental taxes; compliance; carbon offsets; energy prices; China

JEL Classification:

H23; O13; P28; Q43; Q48; Q52; Q54; Q58

Suggested Citation:

Zhang, ZhongXiang (2015), Carbon Emissions Trading in China: The Evolution from Pilots to a Nationwide Scheme, CCEP Working Paper 1503, April 2015. Crawford School of Public Policy, The Australian National University.

Address for Correspondence:

ZhongXiang Zhang
Professor & Chairman
School of Economics
Fudan University
Shanghai
China
Email: ZXZ@fudan.edu.cn

The Crawford School of Public Policy is the Australian National University's public policy school, serving and influencing Australia, Asia and the Pacific through advanced policy research, graduate and executive education, and policy impact.

[The Centre for Climate Economics & Policy](#) is an organized research unit at the Crawford School of Public Policy, The Australian National University. The working paper series is intended to facilitate academic and policy discussion, and the views expressed in working papers are those of the authors. Contact for the Centre: Dr Frank Jotzo, frank.jotzo@anu.edu.au

Carbon Emissions Trading in China: The Evolution from Pilots to a Nationwide Scheme

ZhongXiang Zhang

张中祥 复旦大学经济学院“千人计划”特聘教授

Distinguished University Professor and Chairman, School of Economics, Fudan University, Shanghai, China; Email: ZXZ@fudan.edu.cn

Abstract

The Chinese central government has approved the seven pilot carbon trading schemes. These seven pilot regions are deliberately selected to be at varying stages of development and are given considerable leeway to design their own 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 opts for emissions trading, rather than carbon or environmental taxes at least initially, discusses the key common and varying features of these carbon trading pilots and their first-year performance, draws the lessons learned, discusses the potential pathways for evolution of regional pilot carbon trading schemes into a nationwide carbon trading scheme, and raises fundamental issues that must be addressed in order to make such an emissions trading scheme to work reliably and effectively and with an increasingly expanded coverage and scope.

Keywords: Pilot carbon trading schemes; Environmental taxes; Compliance; Carbon offsets; Energy prices; China

JEL classification: H23; O13; P28; Q43; Q48; Q52; Q54; Q58

1. Introduction

China had proposed at the sixth National Environmental Protection Conference in April 2006 to transform from the over-reliance on command-and-control regulations to a comprehensive use of legal, economic, technological and necessary administrative measures to achieve energy-saving and pollution-cutting goals (Zhang, 2011b). However, China had relied mostly on administrative means to achieve its 20% energy-intensity reduction goal for 2010 (Zhang, 2010 and 2011a,b; Qi, 2011). Such administrative measures are effective but not efficient. In the end, China has had a limited success in meeting that goal. The country cannot continue to rely on costly administrative measures to honor its carbon intensity pledge in 2020 and its 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.

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

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). Aligned with China's grand experiment with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities, the National Development and Reform Commission (NDRC) in late October 2011 approved 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).

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. 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. A recent joint

Tsinghua-MIT study suggests that in the so-called continued effort scenario under which China will maintain its Copenhagen pledge momentum and achieve a carbon intensity reduction rate of approximately 3% per year from 2016 through 2050,¹ China's carbon emissions would not peak until 2040, while China's carbon emissions under the baseline scenario would not peak until 2050 (Zhang et al., 2014). This suggests that China's commitment to cap its carbon emissions around 2030 is ambitious.²

Second, all existing emissions trading schemes are operating under the given condition of a mature market economy (Han et al., 2012; Lo, 2013). 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 (Duan et al., 2014; Munnings et al., 2014; Zhang et al., 2014; Zhang, 2015b). Indeed, it would pose a daunting challenge for China 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.

¹ At the Copenhagen climate change summit, China pledged to cut its carbon intensity by 40-45% by 2020 relative to its 2005 levels. This raises the issue of whether such a pledge is ambitious or just represents business as usual. See Zhang (2011a,b) for detailed discussion on stringency and credibility issues related to China's carbon intensity commitment and their implications.

² While it is not mandated by the central government, all the pilot provinces and cities under the low-carbon city or region development program set CO₂ emissions peak in 2030 or early.15 pilot provinces and cities even aim CO₂ emissions peak in 2020 or early, with Shanghai publicly announcing its peak year in 2020, Suzhou in 2020 and Ningbo in 2015, respectively (Zhang, 2015a). 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.

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. The remaining two of the seven pilot schemes, Hubei and Chongqing, launched trading on 2 April and 19 June 2014 respectively, marking the commencement of the pilot scheme as a whole. The seven pilots are deliberately selected to be located in regions at varying stages of development. Building on Zhang (2015b), this article discusses key features and compliance of China's pilot carbon trading, the lessons learned, and the potential pathways for evolution of regional pilot carbon trading schemes into a nationwide carbon trading scheme. Section 2 discusses why China turns to market forces and chooses for emissions trading, not carbon or environmental taxes at least initially. Section 3 discusses the key common and varying features of the seven pilot carbon trading schemes. Section 4 examines the first five pilots that have to comply with their emissions obligations for the year 2013 by June 2014. Section 5 draws some lessons learned and Section 6 discusses ways to move regional pilot carbon trading schemes forward a nationwide carbon trading scheme. The article ends with raising some fundamental issues that must be addressed in order to make such an emissions trading scheme to work reliably and effectively and with an increasingly expanded coverage and scope.

2. Harnessing the market forces to genuinely transit into a low-carbon economy

To date, China has relied mostly on administrative means to achieve its set energy-saving goal for 2010. Qi (2011) shows that during the eleventh five-year plan (FYP) period, the total amount of CO₂ reduction reached 1.25 billion tCO₂e through mandatory regulations and auxiliary financial stimuli, while only 0.035 billion tCO₂e were reduced as a result of market-based instruments. In the end, China has had a limited success in meeting that goal. Learned from this lesson in the 11th FYP 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. 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, green economy during the 13th FYP.

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 FYP.

2.1 Getting the energy prices right

To have the market to play that role, getting the energy prices right is crucial because it sends clear signals to both producers and consumers of energy. While the overall trend of China's energy pricing reform since 1984 has been moving away from the pricing completely set by the central government in the centrally planned economy towards a more market-oriented pricing mechanism, the pace and scale of the reform differ across energy types (Zhang, 2014).

To date, the reform on electricity tariffs has lagged far behind, and accordingly the government still retains control over electricity tariffs. This complicates implementing the pilot carbon trading schemes in the power sectors in China. The latter 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. Thus power pricing reforms will be the key area for reform in the 13th FYP.

Natural gas prices are also the pressing area for further reform. Given coal-dominated energy mix in China, increasing a share of cleaner fuel, like natural gas, has been considered as the key option to meet the twin goal of meeting energy needs while improving environmental quality. However, natural gas price has long been set below the producers' production costs, and does not reflect the relationship between its supply and demand, or alternative fuel prices. This has not only led Chinese domestic gas producers to be reluctant to increase investments in production, but also has constrained the imports of more costly natural gas from abroad. The government has changed the existing cost-plus pricing to the "netback market value pricing" in Guangdong province and the Guangxi Zhuang Autonomous region (NDRC, 2011). Under this new pricing mechanism, pricing benchmarks are selected and are pegged to prices of alternative fuels that are formed through market forces to establish price linkage mechanism between natural gas and its alternative fuels. Gas prices at various stages will then be adjusted accordingly on this basis. The pilot schemes in Guangdong and Guangxi provide the right direction to establish a market-oriented natural gas pricing mechanism. China needs to take lessons learned from the two pilot schemes and examine what kinds of adjustments and improvements are needed regarding the choice of alternative fuels, the selection of the pricing reference point and the creation of netback market value pricing formula in order to implement the Guangdong and Guangxi pilot reform program to the entire country in the 13th FYP (Gao et al., 2013; Zhang, 2014).

2.2 Resource tax reform

Even if the energy price reform is undertaken, however, from a perspective of a whole value chain of resource extraction, production, use and disposal, energy prices still do not fully reflect the cost of production. Thus, combined with the pressing need to avoid wasteful extraction and use of resources, getting energy prices right calls for China to reform its current narrow coverage of resource taxation and to significantly increase the levied level (Zhang, 2015a). The resource tax levied on crude oil and natural gas by revenues rather than by existing extracted volume, which started in Xinjiang since 1 June 2010 and then was applied nationwide since 1 November 2011, is the first step in the right direction. China have further broadened that reform to coal, overhauling the current practice and levy on coal by revenues since 1 December 2014. This will also help to increase local government's revenues and alleviate their financial burden of local governments to incentivize them not to focus on economic growth alone (Zhang, 2010).

2.3 Imposing environmental taxes or carbon pricing

Right energy prices from a perspective of a whole energy value chain also need to include negative externalities. 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 chooses 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 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 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 the key features and compliance of these pilot carbon trading schemes and Section 4 discusses the features and compliance of these pilots. 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. As experienced in environmental taxes in other countries, such taxes will initially be levied with low rates and limited scope, but their levels will increase over time (Andersen et al., 2007; Andersen and Ekins, 2009; Grubb et al., 2014; Zhang and Baranzini, 2004; Zhang, 2011b). Moreover, environmental taxes should be shared taxes, with the majority of the revenues going to local governments. When implemented, these long-awaited environmental taxes should have the far-reaching effects on technology upgrading, industrial restructuring and sustainable development in China that has been hoped for. However, in terms of timing, given that China has not levied environmental taxes yet, it is better to introduce environmental taxes first in the 13th FYP, not least because such a distinction will enable to disentangle China's additional efforts towards carbon abatement from those broad energy-saving and pollution-cutting ones.

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. All pilots have accordingly issued administrative regulations providing a legal basis for their ETS. This section discusses the key common and varying features of the seven pilot carbon trading schemes.

3.1 Features in common

All seven 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, 2000). This requirement implicitly precludes including all gases in the pilot trading scheme. As would be expected, only CO₂ 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.³ While it would be ideal to include all indirect emissions, in practice all the pilot regions only covering indirect emissions released in generating the amount of imported electricity is simply because it is straightforward to measure the amount of electricity generation (Zhang et al., 2014). 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 Conclusions, electricity tariffs have remained controlled by the central government and still remain flat and regulated (Zhang, 2014). As such, the increased carbon costs of power generators to comply with the carbon or energy limits cannot be passed through to

³ 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.

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.

In each pilot scheme, 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. All pilots to varying degree take early abatement actions into consideration in allocating allowances to reduce the effect of whipping the fast ox. The pilot schemes also treat 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 ETS⁴ 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 or benchmarking depending on sectors. Moreover, the pilots allow the mandated entities to apply for adjustments in allowances in case a significant shortage of allowances occurs under the specific conditions.

To prevent the dramatic price fluctuation seen under the EU ETS, all carbon trading pilots 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 both municipal governments reserve some allowances and auction these allowances wherever necessary for cost containment purposes (BMDRC and BMBFW, 2014; SZMG, 2014). For example, in the Beijing pilot scheme, the municipal government sets aside up to 5% of total annual allowances for this purpose. In the Shenzhen pilot scheme, the allowances reserved for this purpose include those buyback that the competent department purchases from the market at the preset conditions, with

⁴ 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.

the annual buyback amount capped at 10% of the total allowances in that year (SZMG, 2014). 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 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.

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. For compliance purposes, 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 CO₂ 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	50% ^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). In the trial administrative measures for carbon offsets, released September 2014, BMDRC and BMBLF (2014) specifies that the regulated entities can use up to 50% of that CCERs generated outside of Beijing.

Sources: BMDRC and BMBLF, 2014; CMDRC, 2014; HPG, 2014; PGGP, 2014; SMDRC, 2013a; SZMG, 2014; TMG, 2013a.

3.2 The varying features

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 tCO₂ 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).

Ways to allocating allowances differ across pilots. In most pilots, allowances are allocated for free year by year, but in the Shanghai pilot all the emission allowances over 2013-15 are distributed for free for all the covered enterprises at one time (SMG, 2012). While all pilots allocate all or the majority of allowances for free, such allocations are based on grandfathering, benchmarking or in both. 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. Even if allowances are grandfathered on a historical basis, the treatment of early abatement actions differs among pilots in terms of time profile of historical emissions, allocation methods, and allowance reward (Duan et al., 2014). 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 Shanghai, 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 (SMDRC, 2013a).

The Guangdong and Shenzhen pilot schemes take a unique means of allocating allowances. 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). In the Guangdong pilot scheme, 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 (GPDRC, 2013). As the sole pilot to mandate the covered enterprises to purchase a proportion of initial allowances at the predetermined prices, the Guangdong pilot would make these enterprises directly feel the cost of emissions, thus pushing them to cut their emissions.

While emissions caps set for the regulated entities on the basis of emissions intensities are allowed to be *ex post* adjusted with real output, pilots have established different conditions and mechanisms for adjustments in allowances to mitigate potentially significant increase in compliance cost in case a significant shortage of allowances occurs. For example, the Hubei pilot specifies that if the yearly verified emissions of one covered entity exceed its cap by 20%, or 200000 tCO₂, then the extra emissions will be covered by the government allowance reserve, which is capped at 10% of total amount of allowances (HPG, 2014).

The carbon trading pilots have considered the issue of market power of dominated players, for example, Baosteel Corp. in Shanghai, in their design and implementation just like any emissions trading schemes in other countries do (Tietenberg et al., 1999), but their ways to prevent market power or at least mitigate market power concerns differ. Some pilot regions 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). Some pilots 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).

The triggering conditions to use the reserved allowances for cost containment purposes, which have not yet been disclosed for most of the pilots, are expected to differ across pilots. The Beijing pilot scheme has set the triggering conditions based on the average price of allowances over the ten consecutive trading days. When the average price of allowances over the ten consecutive trading days are above Yuan 150 per ton of allowance, 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 of allowance, the government can purchase some of the allowances in surplus from the carbon market (BMDRC and BMBFW, 2014).

Regimes differ regarding the origin of CCERs. Shenzhen specifies that all CCERs have to be generated inside of China but outside of the city, but Hubei requires that all have to come from inside the province (see Table 1). The use of CCERs is specified differently across pilots. For example, 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). The scope of offset also differs among pilots. For example, in the Beijing pilot, in addition to the CCERs, carbon reductions from energy-saving projects and forest sinks can be used for the offset. Moreover, priority could be given to those CCERs from Hebei province and Tianjin with whom Beijing has signed agreements on coordinated efforts towards combating climate change, ecological construction and tackling air pollution (BMDRC and BMBLF, 2014). Given that the Atmospheric Pollution Prevention Action Plan (The State Council, 2013) sets more stringent concentration targets for hazardous particles for more-developed areas like the Beijing-Tianjin-Hebei region, this should be very logical in order to enable to collectively achieve a regional goal set by the central government.

Pilots also differ when coming to compliance. While Beijing has not chosen 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 are 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). In the Shenzhen pilot, 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 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.

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). For example, in the Beijing pilot, 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). 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).

Although all carbon pilots have been in operation, some details of their design have yet to be finalized. While all pilots have issued administrative regulations providing a legal basis for their ETS, only Beijing and Shenzhen have passed the legislation through their local legislature. While all seven carbon pilots have completed their allowance allocation, the level of transparency varies across the pilots (Qian and Yu, 2015). For example, Beijing and Chongqing have not released a list of the regulated entities under their ETS. While all pilots issued their local MRV guidelines, they are released in format of differing legal effect, some in the form of local standards and others in the form of local government documents. Guangdong, Hubei and Chongqing are yet to make the relevant documents public. While the accounting methodologies in these guidelines are similar, significant differences exist in the sector coverage, the set default factors and other technical details for specific industrial processes across pilots (Duan et al., 2014; Zhang and Li, 2014c).

4. 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 enough. 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).

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. All these 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 CO₂ 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 enterprises⁵ (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 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

⁵ 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.

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.

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 2, 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).

Table 2 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.

5. Lessons learned from the carbon trading pilots

Fundamentally, the accounting of enterprises' emissions needs to follow uniform MRV standards. Given allowances ascribed as financial assets, this is even crucial to ensure each unit of emissions reduction reliable and comparable among sectors and across pilots and regions. On 15 October 2013, NDRC issued the Greenhouse Gas Emission Accounting and Reporting Guidelines for Enterprises in the Ten Sectors (GONDRC, 2013). But it is too late for the pilots to apply these national guidelines in the initial accounting of covered enterprises' historical emissions (Duan et al., 2014). Instead, all pilots issued their local MRV guidelines in the form of either local standards or local government documents. This has led to significant variations in consistency and reliability of the emissions data measured, reported and verified on the basis of their local MRV guidelines across pilots. Taking a retrospective perspective, it would be preferable to have national, uniform MRV guidelines in place before each pilot starts issuing allowances. While that would slow the whole process somewhat, that would make link fragmented regional carbon markets into a nationwide market and trade allowances

across regions much easier and effective and at the same time reduce sunk costs that each pilot invests in facilities for its own trading scheme if they are not consistent with national ones and will have to be eliminated as a national ETS starts operating.

The pilot regions are taking 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. 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. Based on an evaluation of this mandatory purchasing through auctioning in the first compliance year (Wang, 2014), Guangdong has decided that in the second compliance year paid distributions of allowances are allocated 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 shows that that have not recognized that 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. 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). In addition, the fact that the regulated entities engaged trading in the last minute could be attributed to the uncertainties over the duration of how long allowances that they hold are valid as financial assets (Jiang, 2015; Zhao, 2014). As a result of the uncertainties, they engage trading just only for compliance purposes.

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.

Another lesson that other pilots and the to-be-established national scheme could learn is Shanghai's practice to seek the support of financial institutions to increase the rate of compliance. The Shanghai pilot scheme includes non-compliance in the credit record of non-complying enterprises and make it public to financial institutions and the general public (SMG, 2013). While the penalty for non-complying entities in the Shanghai pilot is not strictest compared to peers, Shanghai achieved the 100% of compliance. Indeed, seeking the support of financial institutions to promote improved corporate environmental performance is not new in China. From 1 April 2007, China's Ministry of Environmental Protection (MEP) has worked with the People's Bank of China on a new credit-evaluation system under which companies' environmental compliance records are incorporated into the bank's credit-evaluation system. This information will serve as a reference for commercial banks' consideration of whether or not to provide loans. The bank could turn down requests for loans from firms with poor environmental records (Zhang, 2007 and 2008). In mid-July 2007, MEP announced the "green credit" policy jointly with the People's Bank of China and China Banking Regulation Commission. They work together to enforce it, with the financial bodies denying loans to firms that MEP identifies as failing to meet environmental standards. MEP later posted on its web site and notified China's central bank and top banking regulatory commission of 30 offending companies that will be barred from receiving credits (Xinhua Net, 2007). Some bank branches go further. Jiangyin Branch of the People's Bank of China in Jiangsu province issued the color-coded lending guidance, favoring those companies with superior environmental performance. For those green-rated companies, banks will enhance their lending scale and give priority to their financial needs. By contrast, the lending scale for those red-rated ones at best remains at its current level unless lending is requested for environment-improving equipments and technical transformation. Particularly strict lending conditions are attached to those black-rated companies. They cannot receive any new borrowing, and if they still fail to comply with the environmental regulations within a given period, banks will cut their borrowing and in the worst case can even ask them to return all their previous loans (Legislative Affairs Office of the State Council, 2007). Clearly, this concerted action by the central bank and MEP is expected not only to reduce the risks borne by commercial

banks, but also to encourage companies to think more about the environmental effect of their operation and self-discipline their environmental behavior. The pilot regions really need to learn from these experiences. They show another avenue to help the pilot regions and the national scheme to increase the rate of compliance.

6. Evolution into a nationwide carbon trading scheme

By June 2014, all seven carbon trading pilots started trading. These pilots together cover 1919 entities, with the total amount of allowances capped at 1.2 billion tons of CO₂ emissions (DCCNDRC, 2015). As of 1 December 2014, the all carbon trading pilots' total accumulated value of traded allowances reached Yuan 536 million, and total accumulated volume of traded allowances reached 14.4 million tons of CO₂ (Qian and Yu, 2015). The Hubei pilot takes the lead on the grounds of the total accumulated volume and value as well as the accumulated daily average of traded allowances, which reached 7 million tons of CO₂, Yuan 234 million, and 38000 tons of CO₂ as of 4 January 2015 respectively (Liao and Zhang, 2015).

The better than expected performance of the pilots since Shenzhen launched its first trading in June 2013 encourages other regions to develop carbon trading. Meantime, there are significant variations in the MRV and the prices of allowances across the seven pilots. On top of these facts, ensuring China's commitment to cap its carbon emissions around 2030 to be met adds the urgency to further develop emissions trading scheme to complement with administrative means on which China has relied mostly to achieve its increasingly stringent energy-saving and carbon intensity goals (DCCNDRC, 2015). 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.

However, NDRC has not approved any new carbon pilot since the approval of the seven pilot carbon trading schemes in late October 2011. This could be interpreted as China attempting to expand into a national carbon market based on the seven pilot's carbon markets. Such an interpretation turns out to be right. Indeed, both senior NDRC officials and the NDRC itself indicated or announced that a nationwide carbon market is to be established as early as 2016 (DCCNDRC, 2015; Jiang, 2015; Lin, 2015).

The issue then is how to establish a national carbon market. NDRC (2014b) released in December 2014 the interim measures for carbon emissions trading, which provide some legal basis for the national ETS. But more specific details still need to work out to be fully operational and to show clearer picture of the exact nature of a national market. In my view, 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.

NDRC has been preparing for launching a nationwide ETS. In January 2014, those key entities emitting 13000 tCO₂ equivalent or consuming 5000 tce or above in 2010 are required to report their carbon emissions annually (NDRC, 2014a). The reporting should be based on the accounting and reporting guidelines for the ten sectors issued by NDRC (GONDRC, 2013). In December 2014 NDRC issued guidelines for another four sectors covering oil and natural gas, petrochemical, coal, and coking (GONDRC, 2014), and released the interim measures for carbon emissions trading (NDRC, 2014b).

With all these preparation work, it seems that China has chosen for the second option. One senior NDRC official announced in February 2015 that China plans to initially include six sectors in its national ETS: power generation, metallurgy and nonferrous metals, building materials, chemicals, and aviation. The threshold for an emissions source to be covered will be set at 26000 tons of CO₂ equivalent per year (Lin, 2015). This threshold is two times that set for the aforementioned key entities required to report their carbon emissions annually (NDRC, 2014a), and is also higher than the threshold of 10000 tce for those industrial and transportation enterprises included in the 10000 Enterprises Energy Conservation Low Carbon Action Program, which covers 16078 enterprises that also include other entities consuming energy of 5000 tce in 2010 (NDRC et al., 2011; Zhang, 2015a). This implicitly suggests that the national ETS initially include about 10000 entities. Moreover, the six sectors covered in the national ETS are among the first batch of the ten sectors whose accounting methods and reporting

guidelines on greenhouse gas emissions were already issued in October 2013 (GONDRC, 2013). This would give China's carbon market estimated at three to four billion tons of CO₂ emissions (Lin, 2015), and establish China's ETS as the world's largest scheme, twice the size of the EU ETS, the current world's largest ETS. With a three-year pilot phase, such a nationwide carbon market will become fully functional after 2019 (DCCNDRC, 2015; Lin, 2015).

However, 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. The recently released interim measures for carbon emissions trading (NDRC, 2014b) moves in the right direction, but that is not enough. Not only more specific details of such interim measures need to be worked out, but more importantly the provisions governing emissions trading across regions in the form of interim measures are needed to be elevated to a level of the legal effect because dispute could become more intensive and frequent as the carbon market expands beyond the institutional jurisdiction of administrative regions.

7. Conclusions

Aligned with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities, China is experimenting with pilot carbon emissions trading schemes. 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. 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, and to strengthen efforts towards helping the regulated entities to recognize the potential of emissions trading lowering their compliance costs, rather than just view emissions trading as a means of compliance. These efforts are helpful, but not enough. Some fundamental issues must be addressed in order to make such an emissions trading scheme to work reliably and effectively and with a much expanded coverage and scope. These issues include but are not limited to price uncertainty and market stabilization, cost pass-through in the electricity sector, the launching of nationwide carbon market, and the imposition of environmental taxes.

While pilots reserve some allowances for cost containment purposes, 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, setting a price ceiling is very helpful to limit the potential market power of a given larger player in a small, fragmented market. 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.

Power generation is the large consumer, and is included in all carbon pilots and to-be-launched nationwide scheme. 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 (Sijm et al., 2006; Zhang, 2012). 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, 2014). 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, 2014), NDRC could offer power price premium for carbon abatement. In China, only 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.

China has announced to launch a nationwide carbon trading scheme in 2016. While we are hailing China's accomplishments in speeding up preparations for a national ETS, achieving smooth interconnect of carbon pilots and a national ETS will pose a daunting challenge for China. To that end, China needs to address a variety of the pressing issues including how to integrate carbon pilots into a united, nationwide carbon market, how to deal with potential surplus of unused allowances under carbon pilots as the pilot phase ends, how to deal with those sectors in pilots but not covered in a national ETS, how to ensure each unit of emissions reduction reliable and comparable among sectors and across regions, and how to deal with potential of intensive and frequent disputes as the carbon market expands beyond the jurisdiction of administrative regions, , just to mention few.

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.

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 field. 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 field 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).

Acknowledgements

An earlier version of this paper was presented at Shanghai Carbon Finance Workshop: The Role of Financial Institutions, Shanghai, 16 March 2013 and the International Symposium on Theoretical Advances and Empirical Lessons on Emission Trading Schemes, Beijing, 10-11 October 2013. Part of the paper was presented at the International Workshop on Economy of Tomorrow--Building the Good Society in Asia and Europe, Berlin, 25 November 2014 and at the invited seminars in the headquarters of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Berlin, 26 November 2014; A Special Side Event of the COP-20 to the UNFCCC, Lima, 11 December 2014; University of Groningen, The Netherlands, 27

January 2015; and Climate Economics Chair, Paris, 17 March 2015. This work is financially supported by the National Natural Science Foundation of China under grant No. 71373055. The views expressed here are those of the author and do not necessarily reflect the views of the grant provider. The author bears sole responsibility for any errors and omissions that may remain.

References

Andersen MS, Barker T, Christie E, Ekins P, FitzGerald J, Jilkova J, Junankar J, Landesmann M, Pollitt H, Salmons R, Scott S, Speck S (2007) Competitiveness effects of environmental tax reforms (COMETR). Final Report to the European Commission, DG Research and DG TAXUD, National Environmental Research Institute, University of Aarhus, Denmark. http://www2.dmu.dk/cometr/COMETR_Final_Report.pdf

Andersen MS, Ekins P (eds., 2009) *Carbon-energy taxation: lessons from Europe*. Oxford University Press, New York

Baumol WJ, Oates WE (1988) *The Theory of environmental policy*, 2nd Edition. Cambridge University Press, Cambridge

Beijing Municipal Development and Reform Commission (BMDRC) (2013a) A circular on launching pilot carbon emissions trading. 20 November. <http://www.bjpc.gov.cn/tztg/201311/t7020680.htm>

Beijing Municipal Development and Reform Commission (BMDRC) (2014a) A circular on specifying discretion of administrative punishments under carbon emissions trading. 6 May. <http://www.bjpc.gov.cn/tztg/201405/t7691323.htm>

Beijing Municipal Development and Reform Commission (BMDRC) (2014b) A circular on submissions and verification of 2014 carbon emissions report and the associated work. 6 March. <http://www.bjpc.gov.cn/tztg/201403/t7419200.htm>

Beijing Municipal Development and Reform Commission (BMDRC) (2014c) A circular on submissions and verification of 2014 carbon emissions report and the inspection of compliance status. 18 March. <http://www.bjpc.gov.cn/tztg/201404/t7527126.htm>

Beijing Municipal Development and Reform Commission (BMDRC) (2014d) A circular on urging the regulated emissions entities to comply with their obligations by the deadline. 16 June. <http://www.bjpc.gov.cn/tztg/201406/t7863548.htm>

Beijing Municipal Development and Reform Commission (BMDRC) and Beijing Municipal Bureau of Financial Work (BMBFW) (2014) A circular on administrative measures for market operation of carbon emissions trading. 10 June. <http://www.bjpc.gov.cn/tztg/201406/t7851003.htm>

Beijing Municipal Development and Reform Commission (BMDRC) and Beijing Municipal Bureau of Landscape and Forestry (BMBLF) (2014) A circular on administrative measures for carbon offsets of carbon emissions trading (trial). 1 September. <http://www.bjpc.gov.cn/tztg/201409/t8179236.htm>

Beijing Municipal Government (2014) A circular on administrative measures for carbon emissions trading in Beijing (trial). 28 May. <http://www.bjets.com.cn/article/zcfg/201407/20140700000255.shtml>

China Emissions Exchange (2014) A notice (no. 001) on auctioning under Shenzhen carbon emissions trading. 27 May. <http://www.cerx.cn/Portal/home.seam>.

Chongqing Municipal Development and Reform Commission (CMDRC) (2014) A circular on administrative measures for carbon emissions trading in Chongqing (trial). 28 May. <http://www.cqdpc.gov.cn/article-1-20505.aspx>

Department of Climate Change of National Development and Reform Commission (DCCNDRC) (2015) On the basic conditions and work plan to promote the establishment of a nationwide carbon emissions trading market. *China Economic & Trade Herald* (1): 15-16

Duan M, Pang T, Zhang X (2014), Review of carbon emissions trading pilots in China. *Energy & Environment* 25(3-4): 527-549

Ellerman AD, Convery F, Perthuis C de, Alberola E, Buchner BK, Delbosc A, Hight C, Keppler JH, Matthes FC (2010) *Pricing carbon: the European Union emissions trading scheme*. Cambridge University Press, Cambridge

Ellerman AD, Joskow PL, Montero JP, Schmalensee R, Bailey EM (2000) *Markets for clean air: the US acid rain program*. Cambridge University Press, Cambridge

European Commission (2009) Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the community (text with EEA relevance). <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:EN:PDF>

Feng K, Davis S, Sun L, Lie X, Guan D, Liu W, Liu Z, Hubacek K (2013) Outsourcing CO₂ within China. *Proceedings of the National Academy of Sciences* 110(28): 11654-11659

General Office of National Development and Reform Commission (GONDRC) (2013) A circular on the issuance of the first batch of accounting methods and reporting guidelines on greenhouse gas emissions for enterprises in the ten sectors (trial). 15 October. http://www.gov.cn/zwgk/2013-11/04/content_2520743.htm

General Office of National Development and Reform Commission (GONDRC) (2014) A circular on the issuance of the second batch of accounting methods and reporting guidelines on greenhouse gas emissions for enterprises in the ten sectors (trial). 3 December. <http://www.ccchina.gov.cn/Detail.aspx?newsId=51762&TId=70>

Grubb M, Hourcade JC, Neuhoff K (2014) *Planetary economics*. Routledge, London and New York

Guangdong Provincial Development and Reform Commission (GPDRC) (2013) A circular on the initial carbon allowance allocation and work plan of Guangdong. 25 November. http://www.gddpc.gov.cn/xxgk/tztg/201311/t20131126_230325.htm

Guangdong Provincial Development and Reform Commission (GPDRC) (2014a) Results of carbon emissions trading and compliance in Guangdong. 15 July. <http://www.cnemission.com/article/news/jysgg/201407/20140700000764.shtml>

Guangdong Provincial Development and Reform Commission (GPDRC) (2014b) A circular on the carbon allowance allocation and work plan for 2014 of Guangdong. 18 August. http://www.gddpc.gov.cn/xxgk/tztg/201408/t20140818_253453.htm

Han G, Olsson M, Hallding K, Lunsford D (2012) China's carbon emission trading: an overview of current development. Stockholm Environment Institute and FORES, Stockholm

Hubei Provincial Government (HPG) (2014) Interim administrative measures for carbon emissions trading in Hubei province. 4 April. http://gkml.hubei.gov.cn/auto5472/auto5473/201404/t20140422_497476.html

Jiang J, Ye B, Ma X (2014) The Construction of Shenzhen's carbon emission trading scheme. *Energy Policy* 75: 17-21

Jiang M (2015) Carbon trading across the Beijing-Tianjin-Hebei region had only one transaction in the first month. *Beijing Business Today*, 16 January. <http://www.bbtnews.com.cn/news/2015-01/1600000010950.shtml>

Jotzo F (2012) Australia's carbon price. *Nature Climate Change* 2: 475-476

Legislative Affairs Office of the State Council of China (2007) Work report on pilot corporate environmental performance disclosure in Jiangsu province.

June. <http://www.chinalaw.gov.cn/article/dfxx/dffzxx/jx/200706/20070600021431.shtml>

Li G, He Y (2014) Carbon trading pilot in the first year met with expectation, 98.9% of the covered enterprises in Guangdong complied with their obligations. *People's Daily*, 20 July, p. 3. http://paper.people.com.cn/rmrb/html/2014-07/20/nw.D110000renmrb_20140720_1-03.htm

Liao Z, Zhang X (2015) The accumulated turnover of allowances traded under Hubei carbon trading surpassed the mark of ten million tons of CO₂. 4 January. http://www.gov.cn/xinwen/2015-01/05/content_2800133.htm

Lin H (2015) NDRC: Nationwide carbon market is to launch in 2016. *China Economic Net*, 4 February. http://www.ce.cn/xwzx/gnsz/gdxw/201502/04/t20150204_4516588.shtml

Lo AY (2013) Carbon trading in a socialist market economy: can China make a difference. *Ecological Economics* 87: 72-74

Lu S (2013) Shenzhen: launching carbon trading and releasing new dividend. *People's Daily*, 19 June. <http://env.people.com.cn/n/2013/0618/c1010-21871352.html>

Munnings C, Morgenstern RD, Wang Z, Liu X (2014) Assessing the design of three pilot programs for carbon trading in China. RFF Discussion Paper 14-36, Resources for the Future, Washington DC

National Development and Reform Commission (2011) A circular on launching pilot carbon emissions trading. 29 October. http://www.ndrc.gov.cn/zcfb/zcfbtz/2011tz/t20120113_456506.htm

National Development and Reform Commission (2014a) A circular on launching the reporting of greenhouse gas emissions from key entities. 13 January. http://www.sdpc.gov.cn/zcfb/zcfbtz/201403/t20140314_602463.html

National Development and Reform Commission (2014b) The interim administrative measures for emissions trading. 10 December

National Development and Reform Commission (NDRC) and Eleven Other Central Government Organizations (2011) A Circular on the ten thousand enterprises energy conservation low carbon action program. NDRC Environment & Resources No. [2011]2873, Beijing, 7 December. http://www.ndrc.gov.cn/zcfb/zcfbtz/2011tz/t20111229_453569.htm

National People's Congress (2014) Amended environmental protection law. *Xinhua News*, 25 April. <http://news.sina.com.cn/c/2014-04-25/005530006573.shtml>

People's Government of Guangdong Province (PGGP) (2014) Trial Administrative measures for carbon emissions in Guangdong province. 15 January. http://zwgk.gd.gov.cn/006939748/201401/t20140117_462131.html

Qi S, Wang B, Zhang J (2014) Policy design of the Hubei ETS pilot in China. *Energy Policy* 75: 31-38

Qi Y (ed., 2011) *Annual review of low-carbon development in China 2011-2012*. Social Science Academic Press, Beijing.

Qian G, Yu S (2015) China ETS: preparation for national system speeds up. In: International Carbon Action Partnership (ICAP, ed) *Emissions trading worldwide: ICAP status report 2015*. The ICAP Secretariat, Berlin, pp. 14-15

Shanghai Municipal Development and Reform Commission (SMDRC) (2012) A circular on the list of enterprises covered by carbon emissions trading pilot in Shanghai (first batch). 29 November. http://www.shdrc.gov.cn/main?main_colid=319&top_id=312&main_artid=22019

Shanghai Municipal Development and Reform Commission (SMDRC) (2013a) A circular on the allocation and management plan for carbon emissions allowances for 2013-2015 in Shanghai. 22 November. http://www.shdrc.gov.cn/main?main_colid=319&top_id=312&main_artid=23535

Shanghai Municipal Development and Reform Commission (SMDRC) (2013b) Carbon emissions trading: economic lever promotes pollution cutting, 57% of the total carbon emissions in Shanghai are covered. 26 November http://www.shdrc.gov.cn/main?main_colid=363&top_id=316&main_artid=23574

Shanghai Municipal Development and Reform Commission (SMDRC) (2014) Shanghai completed the surrendering of carbon emissions allowances for 2013, with 100 % of compliance. 30 June. http://www.shdrc.gov.cn/second.jsp?colid=551&top_id=316&artid=24609

Shanghai Municipal Government (SMG) (2012) Implementation notice on launching pilot carbon emissions trading in Shanghai. 3 July. <http://www.shanghai.gov.cn/shanghai/node2314/node2319/node12344/u26ai32789.html>

Shanghai Municipal Government (SMG) (2013) Trial administrative measures for carbon emissions in Shanghai. 18

November. <http://www.shanghai.gov.cn/shanghai/node2314/node2319/node12344/u26ai37414.html>

Shanghai Municipal Government (SMG) (2014) Shanghai Carbon market opens to institutional investors. 6

September. <http://www.shanghai.gov.cn/shanghai/node2314/node2315/node4411/u21ai925180.html>

Shenzhen Municipal Government (SZMG) (2014) Interim administrative measures for carbon emissions trading in Shenzhen. 19

March. <http://www.chinalawedu.com/falvagui/22016/ca2014040816584072349928.shtml>

Shenzhen Municipal Legislative Affairs Office (SMLAO) (2013) Trial administrative measures for carbon emissions trading in Shenzhen (draft). 29

October. <http://fzj.sz.gov.cn:8080/cms/templates/fzb/fzbDetails.action?siteName=fzb&pageId=4443>

Sijm J, Neuhoff K, Chen Y (2006) CO₂ cost pass through and windfall profits in the power sector. *Climate Policy* 6(1): 49-72

Tanpeifang (2014a) Some enterprises were still absent from the fourth batch of allowances auctioned in Guangdong, another auctioning plan may come. 6

May. <http://www.tanpaifang.com/tanjiaoyi/2014/0506/31921.html>

Tanpeifang (2014b) Shanghai carbon trading pilot will allocate 580000 tons of allowances for 2013 with a charge for the purpose of compliance. 13

June. <http://www.tanpaifang.com/tanjiaoyi/2014/0613/33600.html>

Tanpeifang (2014c) Twelve Enterprises failing to complying with their emissions caps in Beijing will go through the enforcement process. 27

September. <http://www.tanpaifang.com/tanjiaoyisuo/2014/0927/38520.html>

The State Council (2013) Atmospheric pollution prevention action plan. 10

September. http://legal.china.com.cn/2013-09/12/content_30005965.htm

Tianjin Municipal Development and Reform Commission (TMDRC) (2013b) A circular on list of enterprises covered by carbon emissions trading pilot in Tianjin for 2013.

18 December. <http://www.tjzfxgk.gov.cn/tjep/ConInfoParticular.jsp?id=45441>

Tianjin Municipal Development and Reform Commission (TMDRC) (2014) A circular on the carbon emissions compliance of enterprises covered by carbon emissions trading pilot in Tianjin for 2013. 28

July. http://www.chinatcx.com.cn/tcxweb/pages/news/news_info.jsp?article_id=2618

Tianjin Municipal Government (TMG) (2013a) Interim Administrative measures for carbon emissions trading in Tianjin. 20 December. http://www.chinatcx.com.cn/tcxweb/pages/news/news_info.jsp?article_id=2129

Tietenberg T, Grubb M, Michaelowa A, Swift B, Zhang ZX (1999), *International rules for greenhouse gas emissions trading: defining the principles, modalities, rules and guidelines for verification, reporting and accountability*. United Nations, New York and Geneva

Wang C, Lin J, Cai W, Zhang ZX (2013) Policies and practices of low carbon city development in China. *Energy & Environment* 24(7-8): 1347-1372

Wang J (2014) Two Guangdong firms face punishments over failures in emissions program. *Caixin Net*, 7 August. <http://english.caixin.com/2014-08-08/100714692.html>

Wu WH (2004) Guangdong adjusts the work plan for allocation of carbon emissions allowances, changing from the mandatory purchasing to auctioning. *Xinhua Net*, 22 August. http://news.xinhuanet.com/energy/2014-08/22/c_126903727.htm?prolongation=1

Xinhua Net (2007) SEPA together with the People's Bank of China and the Banking Regulatory Commission restrict lending to highly energy-consuming and heavily polluting companies. 30 July. http://news.xinhuanet.com/newscenter/2007-07/30/content_6451563.htm

Yang, Y (2014) The accumulated value of Shenzhen carbon emissions trading first broke the mark of Yuan 100 million. *Economic Daily*, 5 August. http://www.chinadaily.com.cn/hqcj/xfly/2014-08-05/content_12139315.html

Yu G, Elsworth R (2012) Turning the tanker: China's changing economic imperatives and its tentative look to emissions trading. Sandbag, London

Zhang D, Karplus V, Cassisa C, Zhang X (2014) Emissions trading in China: progress and prospects. *Energy Policy* 75: 9-16

Zhang Q (2014). Shenzhen and Shanghai completed the compliance for 2013: deal gradually increasing and price rising. *21st Century Business Herald*, 7 July. <http://money.21cbh.com/2014/7-7/1NMDA2NzZfMTIyMzU1NA.html>

Zhang Q, Li S (2014a) The compliance period of the Beijing carbon market ended, but the enterprise's awareness of carbon management still needs to be strengthened.

21st Century Business Herald, 1 July. <http://money.21cbh.com/2014/7-1/xNMDA0MDRfMTIxNjMxNA.html>

Zhang Q, Li X (2014b) The compliance rate of the Beijing carbon pilot reached 97.1%, the policy concerned may go through minor adjustments. 21st Century Business Herald, 16 September. <http://jingji.21cbh.com/2014/9-16/3OMDA2NTFfMTMwNTQ3OA.html>

Zhang Q, Li X (2014c) The national administrative measures for emissions trading released, trading platform to be determined by the central government. 21st Century Business Herald, 16 December. <http://jingji.21cbh.com/2014/12-16/yNMDA2NTFfMTM1NDQyNg.html>

Zhang Q, Wei Y (2014) The compliance of the Guangdong carbon market smoothly ended, but the auctioning roles will change. 21st Century Business Herald, 21 July. <http://money.21cbh.com/2014/7-21/1NMDA0MDRfMTIzOTc1Ng.html>

Zhang X, Karplus VJ, Qi T, Zhang D, He J (2014) Carbon emissions in China: how far can new efforts bend the curve? MIT Joint Program Report No. 267, MIT Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Cambridge, MA

Zhang ZX (2000) The design and implementation of an international trading scheme for greenhouse gas emissions. *Environment and Planning C: Government and Policy* 18(3): 321-337

Zhang ZX (2007) China's reds embrace green. *Far Eastern Economic Review* 170(5): 33-37

Zhang ZX (2008), Asian Energy and Environmental Policy: Promoting Growth While Preserving the Environment, *Energy Policy*, 36, 3905–3924

Zhang ZX (2009) Climate commitments to 2050: a roadmap for China. *East-West Dialogue*, No. 4, Honolulu, Hawaii

Zhang ZX (2010a) Is it fair to treat China a Christmas tree to hang everybody's complaints? putting its own energy-saving into perspective. *Energy Economics* 32: S47-S56

Zhang ZX (2010b) China in the transition to a low-carbon economy. *Energy Policy* 38: 6638-6653

Zhang ZX (2011a) Assessing China's carbon intensity pledge for 2020: stringency and credibility issues and their implications. *Environmental Economics and Policy Studies* 13(3): 219-235

Zhang ZX (2011b), *Energy and environmental policy in china: towards a low-carbon economy*. New Horizons in Environmental Economics Series, Edward Elgar, Cheltenham, UK and Northampton, USA

Zhang ZX (2012) Competitiveness and leakage concerns and border carbon adjustments. *International Review of Environmental and Resource Economics* 6(3): 225-287

Zhang ZX (2014a) Energy prices, subsidies and resource tax reform in China. *Asia and the Pacific Policy Studies* 1(3): 439-454

Zhang ZX (2015a) Programs, prices and policies towards energy conservation and environmental quality in China. In: Shunsuke S (ed) *Handbook of Environmental Economics in Asia*. Routledge, London and New York, pp. 532-551

Zhang ZX (2015b) Crossing the river by feeling the stones: the case of carbon trading in China. *Environmental Economics and Policy Studies* 17(2): 263-297

Zhang ZX, Baranzini A (2004) What do we know about carbon taxes? an inquiry into their impacts on competitiveness and distribution of income. *Energy Policy* 32(4): 507-518

Zhao C (2014) Tradable carbon allowance derivatives enter into the development stage, but a legislation is needed to ascribe allowances as financial assets. *21st Century Business Herald*, 20 May. <http://jingji.21cbh.com/2014/5-20/yMMDA2NTFfMTE2NjkyMA.html>

Zhao R (2013) The first pilot carbon permits scheme in operation, China's pollution-cutting accelerating. *Xinhua Net*, 19 June. http://news.xinhuanet.com/fortune/2013-06/19/c_116209030.htm

Zhao XN (2012) Levying on environmental taxes during the 12th five-year plan period. *Nanfang Daily*, 31 August. http://epaper.southcn.com/nfdaily/html/2012-08/31/content_7121178.htm