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Adaptive policy innovations and the construction of emission trading schemes in China: Taking stock and looking forward

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ABSTRACT

Harnessing market instruments of climate governance, such as emission trading schemes (ETS) into an authoritarian and highly fragmented governance system like China can be challenging. It requires tremendous efforts from local states for policy experiments and innovations. This paper examines these local adaptive measures to develop pilot ETS around China. The key finding is that these local policy innovations have played an important role to kick off carbon trading activities effectively, by addressing a number of challenges such as highly imbalanced economic and political contexts, very limited emissions data and technological capacity, and low participants' awareness of ETS. The implications of such policy innovations to the construction of a nationwide ETS system are also discussed. Some of local policy innovations can be legitimised and adopted into the design of national carbon market, while others are more likely appreciated only at initial stage of market development at local level.

1. Introduction

The global governance of climate change has entered a new age since the agreement reached in Paris Climate Conference (COP21) in December 2015 has been hailed as a turning point in the struggle to achieve sustainability of human life on our planet. Yet the implementation of this agreement depends heavily on the decisive action at the national level, as it is based on 197 countries' national commitments on emissions reduction under the name of Nationally Determined Contributions (NDCs). Among these countries, China's NDC is particularly acute due to its sheer size of Greenhouse Gas (GHG) emission (over 28% of world's total in 2015), and its exemplary role among the emerging economies and developing countries to combat climate change (Mathews and Tan, 2015; State Council, 2015). Rather surprisingly, China's behaviour and attitude changed significantly at COP21, compared to its rather tenacious position previously (Conrad, 2012). Considering the country was thought of as a 'deal blocker' back in the Copenhagen climate conference in 2009 (Dimitrov, 2010), China's NDC is ambitious and prescribes comprehensive targets and measures to curb its soaring emissions at home.[1]

Among these measures, one of the key policy instruments that China claim to apply to achieve its ambitious NDC is to construct a nationwide carbon market based on the current pilot regional emission trading schemes (ETS) operated since 2013. Indeed, applying market mechanisms in promoting emission reduction and saving energy consumption has become the dominant narratives in China's climate policy arena during the last decade (Shen, 2015). According to China's 12th Five Year Plan (FYP), the country's paramount

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[1] China's INDC comprise 4 major targets, including a peak emission time (by 2030), reduction on carbon intensity (60–65% by 2005 level), share of non-fossil fuels in primary energy consumption (20% by 2030), and forest stock volume (increase by 4.5 billion cubic meters on 2005 level).

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economic development guideline issued by the central government, experiment on ETS sits on the top agenda for climate officers between 2010 and 2015. Seven regions, including two provinces and five major cities, are selected as the forerunners of ETS pilots to test the water of applying this rather innovative instrument in the Chinese contexts. Based on almost three years' experiments of piloting operations, Chinese government recently confirmed its plan to construct a nationwide ETS system by 2017.

Compared to other ETS around the world, China's efforts in constructing these domestic pilot ETS are notably efficient. The institutional infrastructures have been established within two years compared to a considerably longer preparation period for most of carbon trading systems around the globe (Jotzo and Löschel, 2014). This is mainly because the task of constructing ETS pilots are implemented in a typical top-down fashion, with tremendous support from central and provincial climate officers, who have been active in almost every aspect of designing and implementing local carbon trading institutions (Lo, 2013). There is a strong state corporatist element in driving the policy process regarding the construction of ETS pilots in China. In addition to the state officers' strong support, another reason that China could establish piloting programmes so quickly is that many existing knowledge and practices of ETS around the globe, particularly from the EU-ETS, were absorbed during the process via large number of capacity building programmes, often co-developed by international and EU organisations and experts on emission trading (Jiang et al., 2016a,b).[2] These activities significantly accelerated the policy learning process among various pilot localities so that the major building blocks of the institutional frameworks do not have to be built from the scratch.

However, besides strong government intervention and policy learning from existing ETS, this article argues that there is another, and often neglected, factor that is driving the fast institutional development of Chinese carbon market in the past few years, which is based on the adaptive capacities of government officers (particularly at the local level) to develop innovative measures and practices to adapt the ETS experiment into China's rather unique political, economic, and industrial contexts. Previous studies already illustrated that integrating market instruments of climate governance into an authoritarian and highly fragmented governance system like China may face a number of challenges (Kong and Freeman, 2013; Lo, 2013; Zhang et al., 2014), yet how these challenges are being dealt with through continuous policy innovation and adaptation are rarely examined. This article would like to fill this gap by examining the adaptive measures and practices during China's experimentation on ETS pilots, and understand their implications for the nationwide ETS. The article will be divided into four sections. We will first presents a conceptual framework to understand the role of local adaptive policy innovations in the Chinese context. Section 3 presents the major policy development during China's ETS experiment since its inception. Section 4 presents a detailed analysis of the innovative measures and practices noted among seven ETS pilots, and the main purposes and features of these institutional designs. The next section explores the relevance of these innovative measures to the construction of national ETS, by explaining why some of these adaptive measures may or may not be adopted in the national system. The article concludes with a discussion regarding the role of adaptive policy innovation in China's climate governance domain.

2. Adaptive policy innovation: review of the literature

This section provides a conceptual framework of adaptive policy innovation based on two strands of studies focusing on local government innovations and experiments in the Western countries and in China's reform era. The efforts of linking these literature is not only because they seldom speak to each other previously, but also because ETS is a policy instrument that imported into China from Western liberal market economies. It is essentially an important part of dissemination or diffusion process of market instruments and neo-liberal ideology of climate governance at the global level (Newell and Paterson, 2010). Among the studies of local policy innovation in Western localities, innovations are often defined as new ideas, practices or processes (Rogers, 1995; Mulgan and Albury, 2003), in which 'novelty' is usually the essential element of these actions (Altschuler and Zegans, 1997). In the governance and public services domain, innovation often include new relationships between the regulators or regulated, and between service providers and users (Hartley, 2005). It is noted that innovations in public sectors must involve new power configurations of key stakeholders apart from new institutional or technological development (Greenhalgh et al., 2004). Therefore, the evaluation of local policy innovation should include people, process and technology dimensions (Orange et al., 2013).

One major difference between private and public innovation is that good innovative practices initiated by private entities are often restricted from sharing with other organisations due to competitive purposes, while public entities usually encourage widespread policy diffusion and policy learning among localities and even nations (Hartley, 2005; Moore, 1995). In this regard, diffusion or dissemination of policy innovation plays a crucial part regarding how innovative practices are adapted to different context and cultures, as the special features of 'receiving' localities to recognizing and importing innovations from elsewhere and embed them locally (Hartley, 2005).

However, such adaptive process for imported local policy innovation is not rare in China. Local policy experiments have a long tradition (Heilmann, 2008a) and became particularly important during China's marketisation reform out of its previous Leninist governance system (Goldstein, 1995; Heilmann, 2008b; Huang, 2013; Husain, 2015). Although China remains as an authoritarian and highly centralised state where local governments have to obey the central government, there are ample space for local innovation as the details of implementing and managing marketising reforms are often set by the local frontline offices (Husain, 2015). In addition, due to the political, ideological and institutional barriers in advancing reforms, and uncertain outcomes of the experiments, central government often handpicked localities to develop various innovative policy instruments or measures, and to evaluate the

[2] By March 2017, there are seven capacity building centres being established across China, working with the flagship initiatives such as China-EU Carbon Trading Programmes and a wide range of foreign government, international organisations and multinational corporations.

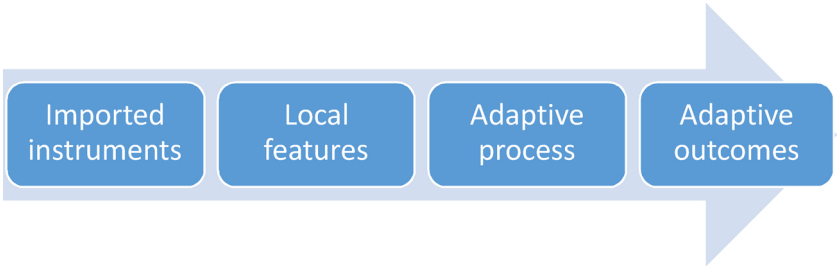

Fig. 1. Adaptive local policy innovations:.

feasibility to promote these innovations the at national level. Such centrally controlled innovation system had almost become standard process for Chinese economic reforms. In this regard, local policy experiment is not only allowed, but also encouraged and even required by the central government.

In this regard, studies on Chinese local policy experiments also finds that most of these local innovations are not transformative but rather incremental. In addition, they often lack originality and novelty as the majority of these innovations are learnt from other localities or overseas experiences, which does not aim for structural breakthrough of the existing system (Chen and Huang, 2010) but second-best institutional arrangement only to fix specific challenges in the given locality. Such 'adaptive' innovations, though may not be codified into national policies, could generate accumulative impact on more systematic institutional change via continuous propagation in other localities faced with similar challenges (Huang, 2013).

Based on the review of the existing literature on local policy innovations, four key conceptual pillars emerged to understand the adaptive policy practices at the local level (Fig. 1).

First, adaptive innovation often emerge when policy instruments were imported from outside the locality, either voluntarily (as often seen in Western localities) or enforced by the central government (as often seen in China). In this regard, innovation happens during the internalisation process of adopting an exogenous product. Second, the introduction of new policy instruments would face various challenges due to the special features of the receiving locality. The challenges can be political (such as the existing interests groups that against the reform), economic (such as lack of economic capacities or incentives among the stakeholders) and institutional (such as the lacking regulations or rising frictions with the existing ones). Third, changes needs to be made either on some aspects of the policy instruments, or the existing local management system, or both, which is known as the adaptive process. Lastly, a new adaptive political economy and institutional arrangement has been achieved so that the new policy instrument can be operated within the locality. We argue that the key is to understand adaptive process and outcome as a two-way process, that the imported instruments is simultaneously shaping and shaped by local environments. Such framework would help us to analyse how ETS has been introduced into Chinese context and what has been changed via local innovations both on the instrument and its governance system.

3. An overview of the policy framework in China's carbon market

The concept of emission trading is not new to Chinese regulators and business. The country started several experiments on sulphur dioxide (SO2) emission trading pilots as early as 1990s, yet most of these pilots have largely failed due to the extremely low level of market activity (Shin, 2013; Tao and Mah, 2009). These unsuccessful experience, however, have not thwarted Chinese regulators' appetite of embracing market instruments to contain the country's soaring pollutant emissions and environmental crisis result from rapid industrialisation in the past few decades (Lo and Howes, 2015). This is largely because the ideology that markets would outperform government in allocating resources efficiently has been gaining prominence throughout the decades of marketisation reforms since early 1980s. Being a country that once wrecked and paralyzed by the central planning system, a prevailing faith in market instruments is only understandable.[3] In this sense, ETS pilots for GHG is not only a significant instrument to be developed for curbing soring emissions, but an integral part of a broader political efforts to facilitate a paradigm shift in order to achieve the so called new 'ecological civilisation' (Geall and Ely, 2015).

Consequently, there is a comprehensive and multi tired policy framework that has been developed around the experiment of ETS (see Table 1.), which largely includes three sets of documents. First, market instruments and emission trading of GHG was mentioned in some important domestic and diplomatic policy documents issued by the top political institutions at the central level, such as the State Council, the National People's Congress, or via bilateral joint statements (see Table 1). These documents mainly serve as political announcements that exhibit the ambition and sincerity of Chinese leadership and set the tone, overall targets and timeframe for developing the market based policy instrument. Such announcements could also be interpreted as the official launch of the central 'command' to establish the carbon market. From these documents it is also clear that the determination for Chinese top leaders to carry on ETS experiment grows only gradually throughout the years. For example, the State Council and 12th Five Year Plan in 2010

[3] In late 2013, an important guideline policy was adopted at the close of the Third Plenary Session of the 18th COC's (Communist Party China) Central Committee. Within this policy, The Decision on Major Issues Concerning Comprehensively Deepening Reforms, it stated clearly that markets are to play the determinant role in allocating the resources.

Table 1
Policy framework for ETS pilots between 2010 and 2016.

	File name	Issued by	Date	Main content
Top Policy Announcement	Resolutions on Accelerating the Development of New Industries with Strategic Values	State Council	2010.10.18	Establish the emission trading system for major pollutants and GHG emissions
	The 12th Five Year Plan for National Economic and Social Development	Central Committee of CPC	2010.10	Establishing enforceable targets for reducing energy and carbon intensity; gradually establish emission trading markets
	Keynote Report during the Opening Ceremony of the 18th CPC National Congress	National Congress	2012.11	Progressing the Preparation of Piloting ETS Programmes
	The Resolutions on Key Issues for Comprehensively Deepening the Reforms	Central Committee of CPC	2013.11	Specifically Requiring for the Promotion of ETS System
	U.S.-China Joint Presidential Statement on Climate Change	Ministry of Foreign Affairs	2015.9	Announcement of establishing a nationwide ETS in 2017, covering steel, electricity, chemical, construction material, pulp and paper, and nonferrous metal metallurgy industries
	The Comprehensive Plan of Institutions Reforms for Ecological Civilisation	State Council	2015.9	Deepening piloting experiment on ETS and preparing for the nationwide ETS.
Central Deployment Policies	Notification of the Commencement of the ETS Pilots	NDRC	2011.10	Approving seven pilots ETS to start their operation in 2013
	Temporary Measures on Regulating Voluntary Emission Trading for Greenhouse Gases	NDRC	2012.6	Comprehensive measures on carbon offset programme (CCER)
		NDRC	2012	Seven trading platforms were registered
	Guidelines for Validation and Certification of Voluntary Emission Trading Projects	NDRC	2012.10	Regulations on accrediting validators, and setting rules for their working procedures and reporting format
	Temporary Measures on Regulating Carbon Emission Trading Scheme	NDRC	2014.12	These measures specifically set out the direction, institutional arrangement, and basic architecture of the nationwide ETS
	Notifications on Strengthening the Preparations for Starting up the Nationwide ETS	NDRC	2016.1	Announced 8 industries to be included in the nationwide ETS, requiring to carry out MRV for these sectors historical emissions, and asking capped enterprises to supply addition emissions data and report

discussed merely the needs to consider constructing ETS for both GHG and other pollutants. In 2012, in the final report of18th Party Congress, the then Chinese president Hu Jintao required to progress on the establishment of ETS pilots for GHG emissions in specific. In 2015, current president Xi Jinping announced officially in the Sino-US joint statement on climate change that the national ETS will be kicked off in 2017, covering high emission sectors such as steel, electricity, chemical industry, construction, paper and pulp, and metallurgy industry.

Although top political paper shows a growing commitment of political leaders, they usually do not contain specific implementation methods and routes for ETS experiment, which is often the task for the sectoral regulators. The responsible government agency for the construction of ETS is the National Development and Reform Commission (NDRC), and more specifically its Climate Change Department. Since 2011, there are a number of umbrella measures and guidelines regarding the institutional design of the ETS (Table 1) were issued. Firstly, seven localities were selected to establish a pilot ETS (NDRC, 2011), including five cities (Beijing, Shanghai, Tianjin, Chongqing and Shenzhen) and two provinces (Hubei and Guangdong), covering around 18% of the country's total population, 27% of the national GDP in 2010 and 20% of national GHG emissions (Lo, 2013; Munnings et al., 2016). NDRC also announced detailed rules and measures for the carbon offset activities with the ETS pilots, known as Chinese Certified Emission Reductions (CCER), and its validation and verification procedures (NDRC, 2012a,2012b). Between 2013 and 2015, NDRC announced several methodology guidelines for measuring and reporting GHG in 24 major emission industries and require all the major polluting entities to compile annual emission reports validated by certified independent validators (NDRC, 2014a). In 2014, NDRC made its first regulatory attempts for setting up the institutional frameworks in constructing the national ETS (NDRC, 2014b), by clarifying some basic principles and main policy objectives in designing the national trading system. It also requires local government and their climate offices to be actively involved in the preparation works towards a nationwide ETS and make sure its successful launch (NDRC, 2015,2016).

From the above description of the major policy evolution at the central level, mainly by the NDRC as the guardian authority of ETS, it can be noted that the central regulator set out the basic institutional outline and guiding principles for local ETS pilots, regarding the pilot locations, the measuring and reporting system, and the carbon offset activities, etc. The detailed the operational plans and rules, however, are not included in these regulations. This is understandable because the purpose of pilots is to find out the most appropriate measures to govern ETS from below, such as issues of how the cap and the allocation strategy are set, or who and how to verify and validate emissions for each industry and each trading transaction, and how to establish and operate trading platforms or exchanges, to name but a few. As a result, provincial governments are given considerable flexibility and autonomy in designing specific institutional arrangements to deal with these challenges to kick off and operate their ETS pilots. It is also expected that the creative institutional designs in various ETS pilots, and the possible problems and achievements emerged from these experiments, can be used as valuable lessons for the later construction of nationwide ETS (Qi et al., 2014).

One of the distinctive features of the ETS pilots is that these seven localities present notable variants in terms of their economic structure and developmental stage as they span across China's eastern, central, and western areas. Some of these localities, such as Hubei and Guangdong, have an economy that dominated by the heavy industries, while others, such as Beijing and Shanghai, have a strong service sector. Consequently, their carbon intensity, energy consumption, and emission trajectory are considerably different. In addition, the governance tradition and political culture are also highly contrasted, where coastal localities have a relatively more liberal and marketised governing style as being the forerunner of the economic reforms, while inner localities like Hubei and Chongqing are more inclined to the traditional 'command and control' system.

Despite these notable variants, the pilot localities face similar challenges to feed ETS pilots into the local contexts. First, the awareness of the urgency regarding climate change and GHG emission reduction is usually low among both local regulators and business leaders (Qi et al., 2008). Beside climate officers and a handful of provincial governors, few would put climate change issue at top of their agenda. In addition, since 2013 the growth of Chinese economy has slowed down, and many local enterprises face tremendous pressure due to the market uncertainty and turbulence, often known as the 'new normal' in Chinese policy narratives.[4] Policy tools to address carbon emissions, even in the name of a market instrument, was introduced in a particularly unwelcomed time for their potential negative effect on the already struggling local economy and industrial corporates. Second, the hybrid nature of China's economy means that some high polluting industries are not fully marketised, with state-owned monopolies dominate the market and are generally more responsive to the political pressures other than the carbon price signals, addition to the fact that energy prices are heavily controlled by the regulators.

Lastly, the legal framework and database for emission trading are insufficient, which threatens the credibility of many crucial institutional aspects, ranging from the cap calculation, the allowance distributions methods, to the punishment enforcement for any non-compliance entities. Legislation and data are the fundamental prerequisites of a functional ETS, which are lacking at the initial stages of ETS pilots in China. It is noted that all these issues and challenges had to be carefully considered by the local climate regulators when designing the institutions for pilot ETS in China, and their responses to these challenges have led to various adaptive policy innovations that often rarely seen in most of the ETS in mature market economies, as illustrated in the following section.

4. Adaptive policy innovations in China's ETS experiment

The architecture of ETS comprise several key institutional building blocks, including the regulatory institutions (policy makers,

[4] The 'new normal' concept can be understood as an official departure of the previous development strategy that often focus solely on GDP growth, and overlooked many structural imbalances and environmental or social impacts.

trading platforms and validators), boundaries of capped industries or activities, methodology to quantifying the allowances, the allocation system for the allowances, and the offset mechanisms. In this section, the innovative measures in these key elements are analysed.

4.1. The regulatory frameworks: who governs?

The experimental nature of the ETS pilots at local level means there is no specific legal framework or legislation established from the central level at current stage. The legal status of emission trading depends on local legislature process. Among 7 pilots, only Beijing and Shenzhen's legislature entity, the local People's Congress passed formal legislations for their ETS pilots (Beijing Municipal People's Congress, 2014; Shenzhen Municipal People's Congress, 2012). The other 5 pilots instead passed government orders and measures, which have a much weaker legal status and enforceability. In terms of the governing body, the local NDRC branches are assumed as the direct regulators of the ETS pilots. However, most these branches do not have a dedicated climate change unit, with only Guangzhou as the exception as a Climate Change Division was established in 2013 to specifically facilitate and supervise the implementation of ETS pilots.

All 7 pilot ETS localities established emission trading exchanges as the trading platforms, yet the ownership structure of these exchanges are highly different. Some of them are sponsored mainly by the government funding while others are largely private institutions. As for the validators, most of validators' work are paid by the local governments, who are also responsible to allocate validators to carry out the MRV activities in different capped corporates. But Shenzhen, and lately Beijing since 2015, allow the capped corporates to choose the validators and pay for their works as they see fit.

The variant regulatory arrangement and actor configurations presented here indicate highly adaptive nature of the localities to create institutions.[5] First, the experimental nature of the pilots indicates the contingency of these institutions as they may no longer be needed at the end of the experiment, particularly some of the exchanges. Therefore, many localities have a cautious supportive attitude towards ETS pilots (Huang, 2013), and largely refrain from injecting significant political or economic resources to set up ETS institutions, such as a formal (and often enduring) legislature process or government sponsored exchanges. However, in order to encourage the corporates to get involved in the emission trading and lower their costs for participation, many localities also sponsored many MRV activities at the initial stage. Such arrangement also helps to prevent corporates to collude with the validators during the validation process, which may threaten the credibility of the whole system. In general, most of these institutional arrangements are designed by the localities that aim to kick off the pilots in a most cost-effective manner, and to attract corporates to participate in the schemes given their low awareness of this instrument.

4.2. The coverage of ETS pilots: who and what are governed?

Like most of the ETS around the world, only CO2 emissions out of 6 types of GHGs are included in Chinese ETS pilots as the emission data on others GHGs are largely unavailable. One of the distinctive features of Chinese pilot ETS, however, is the inclusion of indirect emissions. Although such requirement may lead to double accounting of some of the emissions, and therefore often excluded in most of the ETS elsewhere, China's practice is based on the fact that electricity price is controlled by the central government, and the higher cost of electricity production due to the carbon pricing cannot be transferred to the corporate energy consumers (Teng et al., 2014). The inclusion of indirect emissions would press industrial energy consumers to share the burden with the energy suppliers in a carbon constraint scenario and promote technology upgrade and emission reductions. This is an adaptive innovation to address the challenge of applying ETS in a non-marketised electricity market.

All the pilots are allowed to select industries and enterprises to be included in the ETS, and consequently the selection is highly compatible with the specific economic structures of different pilot localities. Factors such as the emission volume, reduction potentials, corporate size, and availability of the emission data are often considered as the basis for the selection. Among 7 pilots ETS localities, Hubei, Chongqing, Guangdong, and Tianjin are traditionally the bases for heavy industries, while Beijing, Shanghai and Shenzhen have a dominant service sector. The localities with higher proportion of heavy industries often have a less number of enterprises to be included in the ETS, yet their total emission volumes are much larger than the localities dominated by service sectors. This is because individual corporate's emissions in the heavy industries are often much higher than those in the service sectors. In addition, localities with strong service sectors also include buildings, transportation, and other service industries into the ETS, indicating that these highly urbanised localities are paying more attention to the saving of energy consumption, and emissions reduction from non-industrial activities. Shenzhen even include public transportation sector into the ETS to encourage the use of hybrid or electricity vehicles (Jiang et al., 2016a,b).

Among these ETS pilots, the emission entities are not individual industrial facilities but corporates. This is because all the energy consumption statistics are collected and compiled at corporate level, and there is very little emission data regarding industrial facilities such as factories or power plants. Adopting corporate data as the basis for the emission accounting system for ETS pilots is the most convenient option. Yet such approach has presented considerable challenges to define the emission boundary of each corporate due the complex nature of their organisational structure. Some localities, such as Beijing, Shanghai and Guangdong therefore chose to take a hybrid approach and require newly built facilities to be included ETS accounted separately from their affiliated corporates (Wu et al., 2014). The mixture of project and corporate carbon accounting system is another adaptive policy

[5] We take a narrow definition of 'institutions' in this paper that refers to only formal governmental agencies and regulations.

innovation in the context of relatively underdeveloped emission data infrastructure in China.

4.3. Setting the allowance cap in a fast growing economy

China as a developing country do not have a legally binding emission cap under current global climate regime, and its latest commitment at Paris Agreement is to peak the emissions by 2030 and try to meet this target sooner than later, which means that at least at the early stages of the ETS experiment there will be no absolute and quantified emission reduction target as the anchor for setting the emission cap (Zhang, 2015a). However, China have a specific target of reducing carbon intensity (the amount carbon emissions needed for each unit of GDP) by 40–45% of 2005 level by 2020,[6] which can be used as the starting point to calculate the emission cap for ETS pilots. Yet setting intensity based cap can be highly challenging because it relates to the estimation of economic growth, which is hard to predict particularly given the relatively fast growing speed of China's economy and increasingly uncertain prospect of China's economy since the 2008 financial crises. Fortunately, China has a comprehensive economic forecasting and planning system with specific growth targets being carefully complied and announced each year by the central and local government. These annual economic targets can be applied as important references for setting the baseline for modelling the emission allowance system. In reality, most of the ETS localities worked out their emission caps based on the both economic growth and carbon intensity targets. They use historical emission data in given industries to work out the percentage of total emissions within that locality. Hence the total allowance amount for these industries.

Such approach to determines the cap requires certain degree of flexibility due to the various uncertainty associated with economic and market performance. In addition, ETS in China has to allow certain spaces for new industrial activities to be added into the existing trading system as a developing country and growing economy. Consequently, extra allowances were created in most of the pilots for the potential expansion of industrial capacity. These additional allowances are often controlled by the regulators, namely the local NDRC offices, and only used to cover newly constructed facilities or to intervene the market in case the carbon price has become too volatile. In some localities, local regulators are also given the autonomy to take back surplus allowances from the corporates, if the original allocation seems to be too generous due to the miscalculation or estimation. All these adjustment measures are designed to deal with the potential errors that may arise from an intensity based capping scheme.

4.4. Allowance distribution and allocation

The ETS localities adopted various approaches to allocate the allowances among the capped enterprises. Some localities adopted a very interactive approach between the regulators and capped corporates. This is based on the understanding that most of these corporates have a very limited knowledge of ETS and trading principles, and weak dataset for their emissions. Therefore, enhancing awareness and data quality has become requisite condition for allowance allocation. Some localities like Shenzhen allow corporates to participate in the discussion of ideal plan for the allowance allocation. Other localities, such as Chongqing, has adopted a laissez faire attitude to allow corporates to report their own emissions and apply for the allowances accordingly. The local government only control the overall quantity of the allowances. Such approach is based on the logic that only enterprises understand their own operations and emission scenarios, therefore there is no need for the government to intervene to design the specific allocation plan as long as the overall cap and reduction target is set. However, such approach has rendered tremendous autonomy for the corporates, and powerful and large enterprises with better political connection and influence may take the advantage to claim more allowances than they should have, leading to a significant moral hazard in the market, and huge pressure for oversupply of the allowances eventually.

Most of the localities adopted free allocation approach for their allowances. The only exception is Guangdong, where a small percentage of allowances were distributed via auctioning. Although auctioning is often believed as preferred method for allowance allocation, many Chinese regulators worried that such approach may be deterred by most of the corporates (and even local provincial leaders) since additional financial burden would be incurred by purchasing allowances. The free allocation approach is largely based on the historical records of corporate emissions in the past few years, or normally known as the Grandfathering. This is arguably the most convenient and cost-effective method for most of the pilot localities but with significant setbacks. It overlooks the previous emission reduction efforts prior to the ETS experiment, and putting corporates that already invested in low-carbon technologies in a disadvantaged position. Grandfathering methods therefore presents a negative incentive as high emission and low energy efficient corporates may be allocated with generous allowance. Such approach would discourage the corporates to pursue further emission reduction options, since significant reduction of emissions may lead to significant reduction of allowances too. Most of the localities designed measures to address this bias, such as awarding extra allowances for previous emission reduction efforts, or adjust the accounting system to take factors like industrial average carbon intensity, or corporates' technological stages compared to the industry average, into the equation. Such adjustments aim to rebalance the incentives within an allocation system that is based essentially on historical data.

Contrasted to the grandfathering method for allowance allocation, sectoral benchmark method can stimulate the application of low-carbon technology and upgrade among capped enterprises by setting the business as usual (BAU) scenarios for each industrial activity and products covered by ETS, so that the companies that are performing above average will be awarded with relatively more allowances while those below the average would have less (Jiang et al., 2016a,b). However, it is difficult to apply benchmark

[6] Since 2015 this target has been raised to 60–65% reduction of 2005 level by 2030 as formally announced in China's NDC to the UNFCCC.

approach comprehensively in China's ETS pilots at current stage due to the lack of data to work out BAU scenario in most of the industries and their specific activities. Consequently, baseline approach is only applied in only a handful of industries such as electricity generation, airlines, and buildings, where the activities in these sectors are highly standardised and emission data are relatively sufficient to work out the business as-usual (BAU) scenario.

The uncertainties associated with grandfathering approach also spark off a number of policy innovations to deal with the situations when the pre-allocated allowances are significantly deviated from the corporates' actual emissions. Some pilots allow the regulators to adjust the allowances in accordance with corporates' actual expansion or reduction of production capacity. Another innovative measure is to adopt a rotating historical benchmark that annually update the measurement intervals for historical emission data. In this way, the historical data becomes increasingly accurate to reflect the real emission scenarios in the latest years.

4.5. Offset mechanism

China used to be the largest suppliers of carbon offset credits under Kyoto Protocols' flexible instruments, known as clean development mechanism (CDM), delivering over 60 percent of total Certified Emission Reduction (CER) of CDM. Since 2012, the market gradually dried out as the Phase 1 of Kyoto Protocol has come to an end. However, Chinese stakeholders accumulated tremendous knowledge and expertise regarding carbon offset during these years (Lo and Cong, 2017). Since China started to experiment its own ETS, the offset mechanism, known as CCER (China Certified Emission Reduction) system, is included in of these pilot programmes, but with notable differences compared to the CDM era.

First, in order to avoid the over-supply crises that once haunted China's CDM market,[7] most of the pilots adopted a cautious attitude towards offset mechanism, allowing only 5–10% of the allowances being offset with CCER credits. Second, protectionism is obvious, as most of the localities requires the majority of offset credits being generated from local enterprises. Such requirement is based on the rationale to encourage more local un-capped enterprises to participate in the carbon trading and help achieving low-carbon transition. Lastly, most pilot ETS reject large hydro and industrial gases projects (HFC, PFC, N2O, SF6) for the CCER activities for their dubious additionality and environmental impacts, which once generated tremendous scepticism in Chinese CDM projects. Rather, agricultural and reforestation projects are encouraged in current ETS pilots. For example, the local content requirement does not apply to these projects types according in Shenzhen pilot.

One distinctive feature in China is the very unbalanced developmental stages among various provinces. Most of the large cities included in the ETS pilots such as Beijing and Shenzhen, are most urbanised and developed areas with higher emissions and abatement cost. Therefore, these localities have been creative in seeking strategic alliances among relatively underdeveloped regions for directional offset arrangement. Beijing cooperate with its neighbouring provinces as part of the regional efforts to alleviate severe local air pollution problems, while Shenzhen established strategic cooperation with inner Western provinces, such as Yunnan, Gansu, Ningxia, and Inner Mongolian provinces. These collaborative arrangements for offset activities has laid a foundation for the future institutional design of national offset mechanism between 'developed' and 'developing' provinces. Currently, there are over 200 CCER activities registered within seven ETS pilots, compared to the total number of over 2000 CCER activities around the country, indicating the vast potential of regional offset opportunities within the country.

4.6. Non-compliance penalties

The penalties faced by non-compliance corporates are rather symbolic among all the ETS pilots. Some localities such as Hubei and Tianjin did not set out any specific penalty measures for non-compliance activities under current regulation. This is mainly because most of the ETS pilots are regulated by government policies instead of formal legislation, and consequently have limited enforcement power apart from trivial administrative fines. In addition, many local regulators are reluctant to design harsh penalty at the initial stage in the fear that such penalties would further discourage corporates to participate in the ETS (Zhang, 2015b). However, some localities designed innovative non-monetary penalties to increase the non-compliance cost of the corporates, such as substantial cut for other government subsidies or no further award of public service contracts for the non-compliant corporates. Such measures can be effective under Chinese context as government support and contracts are crucial for the survival of many corporates. Some localities also expose the non-compliance corporates to the public. Large state owned enterprises (SOEs) and non-profit entities are often highly sensitive about their public image than the minor fines. For example, ETS regulator in Beijing broadcasted the full lists of the non-compliant entities since 2014. On the lists there are some well-known public and private entities such as the Palace Museum, State Grid, Municipal Public Security Bureau, People's Daily, and Beijing Obstetrics and Gynaecology Hospital (BMCDR, 2016), which attracted tremendous public and media attention for their non-compliant behaviour, which may force these entities to oblige to their emissions commitments in a much sincerer manner.

5. Adaptive policy innovations: implications for a nationwide ETS

The preceding section presents major policy innovations that can be noted during the experiment of seven ETS pilots since 2013 in China. In general, these innovative measures are designed to adapt to different challenges, namely China's hybrid market system and

[7] Between 2005 and 2011, over 3100 CDM projects are approved by Chinese government, with only 500 actually generated offset credits. There was a massive over-supply issue in China's CDM market during that period, which sparked off tremendous scepticism regarding the authenticity and additionality of these credits

fast developing economy, significant variance among localities, and shortage of data, capacity and awareness among the stakeholders. This section discusses the multiple implications of these adaptive policy innovations to the construction of nationwide ETS.

At the outset, policy innovations were grown out of the mainstream ETS practices in the mature market economies to address the hybrid nature of market and planned economy in China. The inclusion of indirect emissions in China's ETS pilots and adaptive method to quantify the emission cap, as explained in the preceding sections, are typical example of these adaptive measures. China's heavy regulation on electricity price and top-down economic planning system plays an important role to make these measures feasible if not perfect. These adaptive measures provide precious experience on how to make market instrument work in a hybrid political and economic system. Therefore, some of them can be expected to be integral part of the future design of the nationwide ETS.

The second type of adaptive measures are mainly designed to address the specific local challenges. The current design of each pilots ETS reflect the highly contrasted economic structure, carbon intensity, and per capita emissions among various localities. The coverage of the capped sectors and their allocation methods are largely different, as more developed localities usually have a stronger service sector and therefore prefer including activities such as transportation and buildings in the ETS pilots. While underdeveloped localities with dominant heavy industries would prefer major industrial activities being covered by the ETS. How to coordinate these contrasts to make sure both developed and developing provinces can be equally involved in the nationwide ETS seems to be a huge challenge for central ETS regulators. It is necessary to reconsider the axiom of 'common but differentiated responsibilities' in the Chinese contexts.

The tremendous variants among localities also raise the question of inter-locality competition and cooperation under the nationwide ETS. Emission trading needs to consider the fairness between underdeveloped localities and highly advanced cities like Shanghai or Shenzhen, as the former needs more space for development, and lack technology and human capacity for low-carbon transition. These localities can be more suitable to join the ETS by supplying offset credits. The current regional cooperation on carbon offset initiated by some ETS localities, as explained in the previous sections, can be a good model to link various localities and design a more equal and balanced national offset mechanism as integral part of nationwide ETS.

Lastly, the majority of the innovative policies presented in the preceding sections are mainly due to the lack of emission data, institutions, capacity and awareness among stakeholders at the initial stages of ETS experiment. These can be the temporary measures since most of these problems will be gradually resolved. However, how and when to exit these temporary measures needs to be carefully considered by the ETS regulators. For example, the grandfathering approach for allowance allocation would be ideally replaced by a more justifiable benchmark approach gradually once proper methodology and data are in place among the key industries, or with formal legislation the nationwide ETS is expected to design a more stringent penalty, MRV, allowance auctioning system. Yet these policy changes need to be based on accurate understanding of the quality of data and actual level of awareness among the capped corporates in order to avoid market turbulence. Many of the temporary innovative measures presented in the preceding sections can become obsolete yet they need a proper strategy to be replaced.

6. Conclusion

According to the Chinese officer's announcement at Paris climate conference, the nationwide ETS can be expected as early as 2017, which includes 31 provincial municipals (out of 34 in total), 7 major industries plus the aviation sector, covering 4 billion tons of CO2 equivalent (around 50% of China's total emission), making it the world's largest ETS. It is believed that this political ambitious plan is faced with tremendous challenges to be materialised (Liu et al., 2015). based on the experience and practical knowledge that have been accumulated in the pilot stage. In this paper, it is argued that various adaptive policy innovations are developed by pilot localities in order to contextualise the operation of ETS into the local political and economic reality. These adaptive measures have played an important role to kick of carbon trading activities effectively in a hybrid market system, among highly contrasted localities, and with limited emissions data and capacity, and low participants' awareness of ETS. However, while some of these measures are expected be integrated into the construction of nationwide ETS, others are likely to be gradually phased out as the carbon market becomes increasingly legitimised and matured.

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