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*Title page

Designing and Implementing Pollutant Emissions Trading Systems in China: A Twelve-Year Reflection

Weili Ye[1], Lingxuan Liu*[2], Bing Zhang[3]

Abstract:

Over the past few decades, the pollutant emissions trading policies in China have undergone significant innovation and exploration. It is considered as a market-based approach that became integrated with command-and-control mechanisms such as total emissions control or pollution permits. This study is the first to provide systematic, reflective thinking that tracks the regional initiatives of pollutant emissions trading systems in China. In this article, we divided China's emissions trading practices into three stages and conducted a comparative qualitative analysis of the country's eleven provincial emissions trading pilots. We found that provincial pilots are highly diverse and complex regarding the pollutants that can be traded, the industrial sectors involved, the design of trading administration and processes, and the implementation of trading practices such as allowance, pricing and platforms. We also identified four main challenges: legislation setup, monitoring and verification, administrative interference, and the technical quantification of pollutant hotspots. We conclude the article by providing policy implications so that emissions trading policies can be integrated with the newly developed pollution permitting system.

Key words: Emissions trading; China; Environmental governance; Environmental management

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COVER LETTER

Re: Manuscript JEMA-D-19-00901

Dear Editor,

After a substantial language proof, we would like to submit the enclosed manuscript which we hope to be re-considered for publication in a special issue on "on Changing Environmental Governance System in China: Theory and Practices", in Journal of Environmental Management. Attached please find the revised manuscript.

Best Regards.

Your Sincerely,

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18/01/2020

***Response to Reviewers**

Response to reviewers' comments:

Reviewer #3: I believe the paper is acceptable for publication, however it needs to be professionally edited before publication. I noted that my previous concerns about this had been noted by the authors but I didn't see evidence of any changes from the previous revisions. Further, the additions made by the authors (Revision 2) contained some clear grammatical errors (for example page 20 - "What we have learnt about PETS shall offer practical insights as it becomes part of a new mechanism of co-ordinate regional development, which lay more emphasis on cross-regional tradings and ecological compensation among local governments. But more debates is required from both academic and practitioners for the institutional designing of emission permit system and its secondary market." and also "Last but not least, we recommend a few direction for future environmental management and policy studies in this area.")

These need to be addressed.

Thank you for the valuable advice you offered in all the previous reviewing rounds. This time again we have hired professional proof-reading service to substantially revise the language of the manuscript.

Reviewer #5: I suggest to accept it for publication after the language checking.

Thank you for the valuable advice you offered in all the previous reviewing rounds. We have hired professional proof-reading service to substantially revise the language of the manuscript.

***Highlights (for review)**

Click here to view linked References

Highlights

- Pollutants emission trading systems in China have been shaped at regional level instead of central.
- 11 provincial pilots of PETS have high diversity and complexity thanks to socio-economic variey.
- PETS faces challenges such as legislation setup, monitoring, and administrative interference.

Designing and Implementing Pollutant Emissions Trading Systems in China:
A Twelve-Year Reflection

Abstract:

Over the past few decades, the pollutant emissions trading policies in China have undergone significant innovation and exploration. It is considered as a market-based approach that became integrated with command-and-control mechanisms such as total emissions control or pollution permits. This study is the first to provide systematic, reflective thinking that tracks the regional initiatives of pollutant emissions trading systems in China. In this article, we divided China's emissions trading practices into three stages and conducted a comparative qualitative analysis of the country's eleven provincial emissions trading pilots. We found that provincial pilots are highly diverse and complex regarding the pollutants that can be traded, the industrial sectors involved, the design of trading administration and processes, and the implementation of trading practices such as allowance, pricing and platforms. We also identified four main challenges: legislation setup, monitoring and verification, administrative interference, and the technical quantification of pollutant hotspots. We conclude the article by providing policy implications so that emissions trading policies can be integrated with the newly developed pollution permitting system.

Key words: Emissions trading; China; Environmental governance; Environmental management

1 Introduction

The economic incentive approach enables more flexibility and efficiency in environmental management. Emissions trading has been recognized as one of the most effective environmental policies in Western countries (Stavins 1995, FØRSUND and NÆVDAL 1997). In the United States, for example, the report on emissions trading policies issued by the Regan Government summarized the practices of banking, bubbles, offsets, and tradable credit (Schwarze and Zapfel 2000). These practices were integrated into an emissions trading system at the state level, which formalized the market mechanisms to monitor and reduce pollution. The EU Emission Trading System (EU-EST) covers approximately 11,000 power stations and manufacturing plants in the 28 EU Member States, as well as aviation activities in these countries (Boemare and Quirion 2002). In total, roughly 45% of total EU greenhouse gas emissions are regulated by the EU-ETS[1].

China has been piloting pollutant emissions trading systems (PETSs) since the 1980s. Despite the complexities and ambiguities of policy design and implementation, PETS initiatives keep evolving with ongoing challenges of environmental pollution and have become one of the fundamental environmental policies in China for point-source environmental management (Jiang et al. 2016, Guo 2018). Thus, such initiatives are significantly different from carbon (CO_2) emissions trading systems in China (Jotzo and Löschel, 2014, Zhang et al., 2014) since the latter are usually not considered part of China's fundamental climate mitigation strategies. Most previous studies about PETSs in China apply environmental economics analyses (Cao and Ikeda 2005, Zhang et al. 2010) to reveal the efficiency of a single emissions trading scheme at the enterprise level, regardless of the regulatory nature of a single pollutant, i.e., CO_2 is not considered a "pollutant" in China at central or local levels. This is probably why the outcomes of PETSs are diverse (Ji et al. 2017, Dickson and Mackenzie 2018, Xian et al. 2019). Researchers have also pointed out that the maneuverability of the

[11] https://ec.europa.eu/clima/policies/ets_en

current emissions trading policy, conflicts between different environmental policies, and administrative interference are considered as the main barriers to the success of the SO_2 emissions trading programs in China (Wang et al. 2002, Dudek et al. 2004, Dudek et al. 2007). Dudek et al. suggest that the clarity of policies is necessary for China's PETS implementation, such as the certainty regarding the spatial and temporal scope of trading, formulations on monitoring, data transparency, well-integrated policy systems and a sufficiently severe penalty (Dudek et al. 2007, Lo et al. 2018). Jarvis and Xu recommend providing autonomous decision-making power to enterprises, a phased-in program with a scientifically based emissions cap, a view of allowances as property rights and so on as part of a successful trading system in China (Jarvis and Xu 2006). However, so far there have not been any studies or reflections on PETSs in China that can provide a systematic review at the regional initiatives level.

In this article, we argue that the shaping of regional initiatives has played a critical part in the trajectory of China's PETSs. Our argument is supported through a comparative qualitative approach to analyze a unique longitudinal dataset on the evolution and institutional arrangement of China's PETSs. We aim to provide a critical and holistic review that elaborates on the features and challenges of China's PETSs, sheds light on the fundamental reasons for those features and challenges, and offers insight in support of future environmental management policy design in China.

2 Unfolding China's pollutant emissions trading practices

2.1 Research context

Like many other environmental policies, PETSs in China were imported from western countries. Over a long period of piloting, exploration and innovation, they are among the very few imported policies that have a robust Chinese context in terms of institutional design and governance regimes. The first emissions trading practices in China were applied in 1987 among enterprises in Minhang District in Shanghai. *The Interim Measures for Water Pollutant Permits Management* published

in 1988 by the State Environmental Protection Agency (SEPA[2]) made a vague statement that "the allowance of total emission control on water pollutants can be traded among the emitting units locally." Since then, there have been three stages, as listed in Table 1, in the design, implementation and improvement of emissions trading policies in China at both central and local levels.

The first stage involved preliminary experimentation. At this stage, there was little central guidance or regulation on emissions trading activities. Such experimentation was conducted where local governments coordinated between enterprises and matched their trading interests. There were no regulatory or scientific methods for pricing, and there was no allocation of initial pollution permits. However, the experimentation did provide initial knowledge and lessons for the next stage (Zhang and Wang 2002, Chang and Wang 2010).

The second stage began with typical central-local interaction and exploration. The central government, including the Ministry of Finance, Ministry of Environmental Protection, and National Development and Reform Committee, worked together to authorize and formalize the local pilot program of emissions trading. To develop a national pilot program, local governments needed to establish provincial policies and regulatory guidance on emissions trading activities, such as the initial allocation (Ye et al. 2014, Feng et al. 2015), pricing (Zhang et al. 2016, Guo et al. 2018), bidding (Wang and Wang 2016), measurement, and verification. During this stage, the main feature of all eleven pilot programs was integration between PETSs and the regional total emissions control policy. The latter holds all provincial governments accountable for reducing environmental pollutants such as COD and SO_2 (Zhang et al. 2014). Trading happened either between the government and one point-source facility or between two point-source facilities. Such integration was expected to improve the efficiency of pollution reduction so that clean technologies could benefit from high emissions standards. The implementation of local pilots, however, was highly varied (Xue et al. 2014), which we describe in the next section of this paper.

The third stage was initiated in 2014 with the publication of Document #38 titled *Guiding Opinions on Further Implementing the Paid-Use of Emissions Permits*

[2] The SEPA evolved into the Ministry of Environmental Protection in 2008 and the Ministry of Ecology and Environment in 2018.

and Emissions Trading. The document transformed various local explorations of emissions trading systems into central regulatory guidance and offered a clear paradigm for the technological specifics of initial allocation, pricing, bidding, measurement and verification (Wang et al. 2014). Not only have the eleven pioneer provinces begun to improve provincial emissions trading systems based on guidance from this document, but new regions have also voluntarily begun to design their PETSs based on their understanding of Document #38.

Since 2017, the evolution of emissions trading policy has entered a state of uncertainty and reflection. Reforms to the Ministry of Environmental Protection (following its restructuring into the Ministry of Ecology and Environment in 2018) have led to an institutional redesigning of Total Emissions Control policy and the Pollution Permitting policy, and the design and implementation of PETS have been under the significant influence of these two parallel policies. Explicitly, the national policy document of 2016 on *Implementation of Pollution Permits* states that "*the amount of pollutant abatement in the pollution permit system can be used to trade*", but it does not link this "permit trading" scheme to any existing emissions trading policies. With such ambiguity and complexity, there is no more local political interest in developing or innovating the PETSs to the next level; because central understanding is not clear, bold voluntary action at the local level comes with great risks.

Table 1 The Evolution of China's Emissions Trading Practices

Stage	Year	Milestone events and/or policy documents
Experimentation	1980s-2006	1. On March 20th, 1988, SEPA published The Interim Measures for Water Pollutant Permits Management, which mentioned that the allowance of water pollutants could be traded locally. 2. In 1994, six cities implemented air pollutant emissions trading under administrative guidance. 3. In 2001, the District of Xiuzhou in the city of Jiaxing, Zhejiang Province, published interim measures on water pollutant emissions trading and began to pilot a program. 4. In 2002, Shanxi Province, based on the outcomes of #2, designed the work plan for a city-level emissions trading scheme on SO_2. 5. In 2006, the city of Jiaxing in Zhejiang Province initiated a city-wide emissions trading program.
Exploration	2007-	

	2013	1. From 2007-2011, the central government authorized eleven provinces and municipalities as PETS pilot regions. These regions have issued local measures for managing and implementing PETSs. 2. In 2011, the state council issued the work program of the 12th Five-Year Plan (FYP) on energy saving and emissions reduction. Article 44 of the program encourages the design of PETSs and the establishment of an emissions trading market. 3. Also in 2011, the state council published Opinions on Improving Key Actions on Environmental Protection, which also encourages the implementation of local emissions trading pilots. 4. Until 2013, under the guidance of central government signals, pilot regions have issued over 50 policy documents and over 70 technical documents for the management of emissions trading programs.
Institutionalization	2014-2016	1. In 2014, the State Council issued what was later referred to as "Document #38", Guiding Opinions on Further Implementing the Paid-Use of Emission Permits and Emission Trading. Since then, Document #38 has served as the main source of policy guidance on local PETSs. 2. Some provinces other than the eleven pioneering provinces of Stage 2 began to implement PETSs based on Document #38 voluntarily. 3. In 2015, the Ministry of Finance issued Interim Measures of Purchasing and Selling Pollution Permits. 4. In 2015, the State Council issued the action plan for the prevention of water pollution, which emphasized the further exploration of local PETSs and potential financial instruments to facilitate emissions trading. 5. In 2015, the central government document titled The General Plan on the Institutional Reform of Ecological Civilization also formalized the emissions trading policies as an essential instrument. 6. The revised Air Pollution Prevention Law became effective on January 2016. Article 21 mentions that the country would promote the emissions trading of key air pollutants. 7. In March of 2016, The 13th FYP clearly notes the establishment of the paid-use of emissions permits and country-wide emissions trading schemes.

2.2 Research setting

The challenges of PETSs in reality are imminent. Questions have been raised on whether such policies have come to an end, and if so, what will become of the legacy of the pollution permit system. Critical reflections and reviews of PETSs at the regional level are needed from policy design to implementation. The following sections examine the eleven pioneering provinces (marked in red in Figure 1) and present a comparative qualitative analysis that systematically reviews the diverse

provincial PETSs that were developed and evolved in Stage 2 (prior to Document #38) and Stage 3 (after Document #38). We have chosen to study these eleven provinces as part of a multi-case study because they served as pilots authorized by the central government and almost all starting from 2007[3]. We first collected qualitative data for this study based on in-depth stakeholder workshops and focus group discussions held during 2008-2016. In total, we conducted 32 semi-structured interviews and 17 focus groups with 890 government representatives, officers from relevant governmental agencies, industry representatives, and experts through focus group workshops. For confidentiality reasons, the specific departments and regions that the interviewed stakeholders are affiliated with are not listed in Table 2.

The empirical cases and interview contents were then transcribed and categorized for coding. An open-coding method was used to analyze the data (Yin, 2009). This process involved reviewing key narratives exhibited by the transcripts, including repeating keywords and insights from the interviews and focus groups, and matching those narratives with elemental concepts and constructs of China's multilevel environmental governance framework. We then used the secondary data to triangulate our coding, during which we collected policy documents and reports from all eleven provinces and municipalities. We in turn reviewed a wide range of action plans, interim measures and guiding opinions of PETSs at the provincial or municipal levels, including over 120 policy or technical documents, in turn identifying the specific pathways of local PETSs.

Table 2 Interviews and focus groups held from 2008-2018

Type	Time	Stakeholder	People interviewed
interviews	2009.4	local government	4
	2009.10	national government	1
	2009.12	local government, experts	5
	2012.12	experts	3
	2013.4	experts	3
	2013.6	experts	5
	2013.7	national government	3
	2014.2	local government	12
	2014.5	local government, industry	14

[3] The city of Qingdao was excluded from our study because it started programs later than the other eleven provinces; the city thus skipped Stage 2.

Type	Time	Stakeholder	People interviewed
interviews	2009.4	local government	4
		representatives	
	2015.6	industry representatives	3
	2015.9	experts	4
	2015.12	local government, experts	7
	2016.4	experts	10
	2016.5	local government	11
	2016.5	industry representatives, experts	21
	2016.10	local government	3
	2017.1	local government	5
	2017.4	national government	2
	2017.5	local government, industry representatives	10
	2017.6	local government, experts	4
	2017.6	national government	2
	2017.6	industry representatives	6
	2017.7	officers from relevant governmental agencies	1
	2017.7	local government	34
	2017.11-2018.12	local government	10
	2018.1	local government	7
	2018.4	experts	8
	2018.5	local government, experts	4
	2018.4-2018.6	industry representatives	76
	2018.7	local government	6
	2018.9	local government	5
	2018.10	local government	33
	total		**322**
focus groups	2011.7	national government, experts	5
	2012.4	officials from relevant governmental agencies, industry representatives, experts	68
	2012.8	national and local government, experts	43
	2012.11	local government, industry representatives	5
	2013.6	local government	11
	2015.1	national and local government	34
	2015.9	local government, experts	147
	2015.12	national and local government, officials from relevant governmental agencies	13
	2016.4	local government, industry representatives	20
	2016.5	local government	20
	2016.5	local government, officials from relevant governmental agencies, experts	51
	2016.11	local government	30

Type	Time	Stakeholder	People interviewed
interviews	2009.4	local government	4
	2017.5	national and local government, experts	17
	2017.6	national and local government	31
	2017.11	experts	7
	2017.11	local government, experts	39
	2017.12	local government, experts	27
	Total		**568**

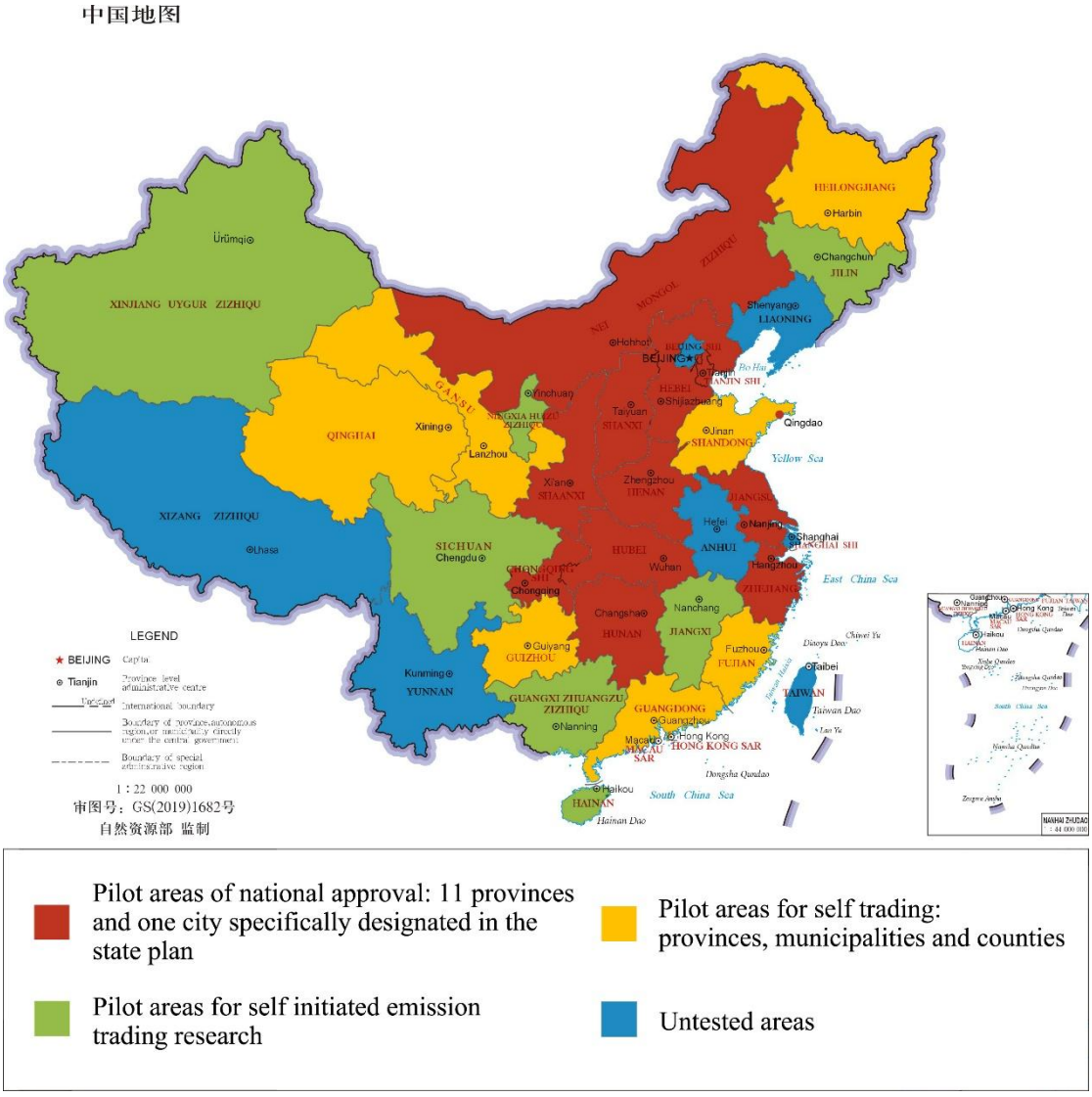

Figure 1 China's Emission Trading Practices at a Glance

3 Regional comparison of PETSs

3.1 The scope of PETSs in China

The following three aspects are examined to describe the scope of local PETSs: 1) What kinds of pollutants can be traded? 2) Which industries are eligible to trade, and what kinds of industrial projects are eligible to trade? 3) Can trading happen across different administrative regions (e.g., cities or counties) within the same province? These aspects are critical because they are relevant to the regulatory nature of specific pollutants and industries, i.e., the level of integration between PETSs and a regional total emissions control policy. Table 2 provides a detailed comparison of the eleven cases explored in our study. Although all eleven pilot regions allow for the trading of COD and SO_2, some areas permit the trading of specific industrial pollutants such as total phosphorus (TP) or even heavy metals (Wang 2018). The requirement to reduce NOx and NH_3-N was also introduced with the 12^{th} FYP (2010-2015) and was soon integrated into the objectives of PETS pilots. Meanwhile, many pilot regions focus on the allowance acquisition of newly built or authorized industrial projects, i.e., to enable a new project, an enterprise must purchase emissions allowances from other enterprises so that the regional limit of emissions control will not exceed the planned target (Wu et al. 2019). This implies that in these regions, “the right to pollute” should be promised to existing companies and projects, or the local economy might be disrupted. Emissions trading between existing industrial projects is not a priority for many pilot regions, as this may lead to more complexity of implementation. Many pilot regions also allow trading to happen across different administrative regions at city or county levels to mobilize trading allowance and enable a large industrial project in a specific area (Zhang et al. 2019). In general, the scope of local PETSs reflects the practical local demand to have certain flexibility to develop industries and economies within a given political regime where environmental capacity is stringently regulated by the central government (Chang et al. 2016, Zhou et al. 2016).

Table 2 The scope of China's Emission Trading Pilots

Province	**Pollutants**	**Regions and industries**	**Trading across administrative regions** (cities and counties within the province)
Jiangsu	COD, NH_3-N, TP, SO_2, NO_x	All manufacturing industries	No
Zhejiang	COD, NH_3-N, SO_2, NO_x	All manufacturing industries	Yes
Hubei	COD, NH_3-N, SO_2, NO_x	Newly built industrial projects and facilities across the province authorized by the city government or above	Yes
Hunan	COD, NH_3-N, SO_2, NO_x, Pb, Cd, As	All manufacturing industries	Yes
Inner Mongolia	COD, NH_3-N, SO_2, NO_x	Paid use of emissions permits for existing enterprises. Emissions trading for all newly built industrial projects and facilities across the province	Yes
Shanxi	COD, NH_3-N, SO_2, NO_x, Industrial dust	All manufacturing industries involved in total emissions control	Yes
Chongqing	COD, NH_3-N, SO_2, NO_x and Industrial solid waste	All manufacturing industries	Yes
Shaanxi	COD, NH_3-N, SO_2, NO_x	Newly built industrial projects and facilities across the province	Yes
Hebei	COD, NH_3-N, SO_2, NO_x	Air pollutants from the electricity industry Water pollutants from the coastal area	Yes
Tianjin	COD, SO_2	Six vital industrial sectors and 79 state-control point sources	Yes
Henan	COD, NH_3-N, SO_2, NO_x	Four cities serving as pilots, but with each city focusing on one category of pollutants	No

3.2 The design of PETS administration

Although all eleven pilot regions were approved by the central government in 2007, administrative mechanisms of PETSs in each region have been designed in various ways. The managerial entities of each PETS pilot, for example, are listed in Table 3. Each province/city differs considerably on the nature of PETS managerial

entities, reflecting a high level of institutional flexibility in responsibilities of PETS management.

Table 3 Managerial entities of PETS pilots

Province		Nature of the managerial entity
Jiangsu	Provincial	Governmental unit
	Jiangyin	Public institution - for-profit
	Changzhou	Public institution - for-profit
Zhejiang	Provincial	Public institution - non-profit
	Jiaxing	State-owned enterprise
	Shaoxing	Government unit
	Hangzhou	State-owned enterprise
Hubei		Private company
		Public institution - for-profit
Hunan		Government unit
Inner Mongolia		Public institution - non-profit
Shanxi		Public institution - for-profit
Chongqing		Public institution - non-profit
		Private company
Shaanxi		Government unit
Hebei		Public institution - non-profit
		Private company
Tianjin		Private company
Henan		Government unit

Whether public or private, the administration of PETSs at the local level is usually executed independent of local environmental protection bureaus. The latter are considered as overseers and observers rather than enforcers. Our interviews suggest that such independence in managerial entities is essential to PETSs being effectively operational, e.g., *"…it saves tons of time and human and financial resource to start a company as a trading platform. Instead, if people need to be hired in the public service system and a budget needs to be acquired and authorized through a top-down approach, we are not able to do that within 12 months* (quote from an interviewee)." In regions that have established managerial entities in both the public and private sectors (e.g., Jiangsu, Zhejiang, Hubei, Chongqing, and Hebei) we also find that such independence helps *"establish public and business recognition of PETSs and that this is a commercial enterprise rather than a government campaign that comes and goes – participating companies might believe that governmental campaigns could be cancelled or revised anytime (quote from a focus group)."* We

believe that such designing of managerial independence is innovative and uncommon in China's environmental policy and management.

To understand the local diversity of PETS design, we used over 120 copies of policy documents from the eleven pilot regions to triangulate with our coding results. Table 4 provides a summary of our mapping efforts. When a specific policy issue is missing in one case region, this means that the region is not prepared for such policy design or has chosen not to cover this topic in its pilot. Our analysis shows that most of the pilot regions have a mature understanding of the institutional setup for PETSs and have established a systematic policy-making approach to PETS design and implementation.

It is also interesting to observe that local authorities have been able to align PETSs with other environmental management tools (the bottom section of Table 4). A few provinces have merged PETS policies with environmental impact assessment (EIA) and regional total emissions control whereby the emissions allowances of industrial projects must be acquired during EIA approval and the degree of emissions allowance allocated to this project cannot lead to a leakage of the regional total emissions control scheme (Wang et al. 2016). In doing so, these provinces have managed to institutionalize PETSs as an integrated part of local environmental management.

Table 4 Mapping the policy documents of PETS pilots

PETS policy content	Jiangsu	Zhejiang				Hubei	Hunan	Inner Mongolia	Shanxi	Chongqing	Shaanxi	Hebei	Tianjin	Henan
		p	j	s	h									
Administrative														
PETS pilot guidance and action plans	√	√	√	√	√		√		√	√	√	√	√	√
Regulation of trading management	√	√	√	√	√	√	√	√	√		√	√		√
Roles of departments	□	□	□	□	□	□	√	□	□		□	□		
Management of Emissions Trading Center		□					√	□	□	√		□	□	
Procedure for emissions trading practices	□	√	□	□	□	√	√	√	□		□	□	□	
Economic														
Pricing standards on initial emissions allowance	√	√	□	□		√	√	√	√	√	√	√	√	√
Management of	√	√	□	√			√	√	√	√	√	√	√	√

emissions trading funds														
Initial emissions allowance testing	√	√	√	□	□		√	√	√	√	√	√	√	
Verification of eligibility	□	√	□	□	□	□	√	□	□	√	□	√		√
Storage of emissions allowance	□	□	□				√	□	√		□	√		
Rules on online bidding						√			√	√	√	√	√	√
Measurement and verification of emissions levels	√	√	□		□		□	□	□	√	√		□	√
Alignment with other environmental management tools														
Regional pollution control prerequisites		√				√			√		√		□	√
Use of emissions allowance as a bank loan		√	□	√			√	√			√		√	√
Standardized application and confirmation issued for trading purposes	□	□	□	□	□	√	□	□	□	√	□	□	□	√

Note：”√” refers to a specific policy document for this topic or issue, while “□” implies that the topic was covered in another policy document that is more general or overarching.

3.3 Implementation: allowance, pricing and platforms

Theoretically, the allowance of emissions trading has three sources: reservation, initial allocation (Khezr and Mackenzie 2018), and secondary trading (Park et al. 2012, Jotzo and Löschel 2014, Xiang et al. 2016). The policy encourages a secondary trading market where the abatement of pollutants caused by applying clean technologies can be traded so that those who have applied new technologies to industrial projects can benefit financially. However, many enterprises are reluctant to sell the allowance achieved via technological advancement, as they view such allowances as precious resources *(quote from a focus group)*. In the eleven pilot cases studied, most secondary trading allowance had come from emissions transferred from facilities that are bankrupt, relocated or shut down.

Table 5 Sources of emissions trading allowance

Province	**Legitimate sources that can be traded**			
	Reservation	Clean technology abatement	Industrial restructuring	Bankrupt, relocated or shut-down enterprises
Jiangsu	√	√	√	√
Zhejiang			√	√
Hubei			√	
Hunan		√	√	√

Inner Mongolia		√	√	√
Shanxi	Not specified			
Chongqing		√		√
Shaanxi	Not specified			
Hebei	√	√	√	√
Tianjin	Not specified			
Henan	√			√

The pricing of emissions trading is guided by the provincial governments of pilot regions (Table 3). The price differences shown in Table 3 reflect the cost of pollution abatement and the effective period of emissions rights, which is determined by the status of regional economic development and environmental capacity. In the beginning stage of an emissions trading pilot program, prices are usually lower than expected to attract more enterprises to participate. There was a significant price rise over the 12th FYP (2010-2015) due to mounting pressures to archive pollution reduction goals. Actual prices set during trading are usually higher than the guiding price shown in Table 6.

Table 6 The pricing of China's EPT pilots

(Unit: RMB per ton per year. Prices last updated in August 2018)

Regions	COD	NH_3-N	SO_2	NO_x	Permit effective for:
Jiangsu	4 500	11 000	2 240	2 240	1 year
Zhejiang	4 000	4 000	1 000	1 000	1 year
Hubei	1 758	2 800	798	800	1 year
Hunan	20 000	40 000	15 000	25 000	1 year
Inner Mongolia	1 000	3 000	500	500	1 year
Shanxi	29 000	30 000	18 000	19 000	Indefinitely
Chongqing	1 360	2 400	900	1 200	1 year
Shaanxi	12 000	12 000	6 000	6 000	Not specified
Hebei	4 000	8 000	5 000	6 000	1 year
Tianjin	5 000	No data	5 000	No data	Indefinitely
Henan	4 500	9 000	4 900	5 000	5 years

Based on the various managerial entities mentioned in Session 3.2, by the end of 2017, each pilot region has also developed an online emissions trading platform (Table 7) (Ye et al. 2014).

Table 7 The online platforms of China's EPT pilots

Province	Readiness	Functions

		Database	Application, monitoring & verification	Online bidding
Jiangsu	Operating	√	√	
Zhejiang	Operating	√		
Hubei	Established	√		
Hunan	Established	√		
Inner Mongolia	Operating	√	√	√
Shanxi	Operating	√	√	√
Chongqing	Established	√		
Shaanxi	In preparation			√
Hebei	Established		√	√
Tianjin	Established			√
Henan	In preparation		√	

4 Discussion

In general, our interviews and analysis show that PETSs at the local level in China have had a good start. The pilot regions have established broad recognition among businesses and society of the value of environmental resources and have been cultivating governance capacities (e.g., data collection and tracking, exceptional management, etc.) for managing point-source pollution. They have also made significant progress in establishing a primary market of trading and in designing proper policies, mechanisms and online platforms that support trading (Da et al. 2014). However, our research also reveals four typical ongoing problems facing PETSs in China.

4.1 Institutional setup and legislation

The rule-making progress of PETS design is supposed to be executed through a regulatory approach. However, as policies in experimentation and exploration, there has been no legislative context, whether at the national or provincial level, for emissions trading activities. Among all recent revisions made to national environmental laws, only the *Air Pollution Prevention Law* mentions emissions trading. Most national environmental regulations such as the *Environmental Protection Law* or *Water Pollution Prevention Law* have not even established a definition for “emissions rights”, which creates challenges when legal disputes occur.

In China, provincial laws cannot usually be approved if similar national laws are not in place. Our research illustrates how the current diversity of PETS design and implementation can be attributed to an absence of national institutional arrangements. Such deficiency leads to institutional complexity and ambiguity in emissions trading activities when, for example, a Chinese company conducts business across various provinces of China.

4.2 Monitoring and verification

The capacity for local governments to monitor and verify the actual pollutant emissions of every participant is a crucial prerequisite of effective emissions trading. As one of our interviewees mentioned, *"Without measurement, there will be no management."* Currently, an online real-time monitoring system for pollutant emissions has not been widely established in China. For those who have created such a platform, the legitimacy and accuracy of monitoring data have been questioned. The standard measurement of emissions permits has also not been outlined. Moreover, most of the studied provinces still mainly rely on the use of secondary data rather than monitoring data (e.g., environmental impact assessments, emissions permits, sewage charges, and even self-reported data) to estimate pollutant emissions. Later, such estimations are frequently used as evidence in calculating the emitted pollutants of a participating company during trading. Among the studied PETS pilot regions, it is common practice to apply the grandfathering principle when determining the initial allowance of emissions rights (Kong et al. 2019), i.e., actual emissions data for the past three years are used for calculations. Such practices, although necessary during PETS implementation, have created misunderstanding of the difference between "emissions rights" and "actual emissions" for enterprises.

4.3 Administrative interference

During the *Exploration* stage (2007-2013), despite there being some incentivizing mechanisms (e.g., low initial allowance pricing), most of the participating enterprises were recruited under administrative orders. Through the rule-making progression of PETS pilots, local governments have enjoyed numerous advantages over participating enterprises in being able to select trading partners,

determine the pricing of emissions rights, or decide who has the privilege to buy back. Some governments have been using this advantage to manipulate trading activities based on local protectionism to, for example, forbid a specific trading activity that would lead to the underdevelopment of industrial projects in a given county area. In some regions, such as Guizhou Province before 2016, the emissions trading policy was even considered “an extra instrument to generate governmental income based on the paid use of emissions permits”, which could harm the effectiveness of PETSs.

4.4 Technical challenges for pollution hotspots

The geographic heterogeneity of pollutants has brought challenges upon PETSs in China. For example, intense emissions of air pollutants such as SO_2 can lead to the formation of a regional hotspot of poor air quality or acid rain (Krupnick et al. 1983) even thorough secondary market prices for SO_2 per ton do not vary across regions. The heterogeneity of water pollutants is not only geographic but also industrial. For example, 1) the same pollutants discharged upstream of a river should ideally be priced differently than pollutants discharged downstream, and 2) the same amount of COD discharged from different industries (e.g., manufacturing vs. agriculture) should be priced separately because associated economic or technical costs of reduction are different. None of the trading schemes used in the pilot regions have implemented different pricing mechanisms, although several provinces, such as Zhejiang, Jiangsu and Henan, are considering exploring differences in pricing. Thus, to enable efficient trading activities between upstream and downstream areas, across lake basin areas, or among different industries, a scientific evaluation must be deployed on pricing ratios for each of the scenarios mentioned above.

5 Conclusion

In this article we applied longitudinal, qualitative studies to observe the development of eleven PETS pilots in China. Our observations and analysis reveal that ambiguous policy design will bring instability and greater risks for policy

development and that necessary policy integration will help promote the development of PETSs and other similar policies. We also found that an appropriate degree of flexibility can stimulate autonomy and enthusiasm among local governments in implementing environmental policies. Thus, we conclude our paper with the following perspectives that environmental policy-makers should keep in mind:

First, we found that the initial pricing of emissions trading activities relies on the use of a command-and-control approach, which fundamentally diverges from trading activities in western countries. This form of initial pricing leads to the reality that the price cannot reflect the real value of emissions rights, i.e., the economic cost of environmental remedies to pollution per unit or the environmental capacity of a region regarding the given pollutants. Nevertheless, “emissions rights” have become valuable environmental resources for many industries and companies, without which they cannot invest in and operate new projects. Such an institutional arrangement has helped establish public and business awareness about the actual value of environmental resources (Xu et al. 2015), which should be carried on in future policy designs of similar efforts.

Second, we argue in this article that it is critical to institutionalize emissions trading activities, or any other environmental management methods, through legislation. The emissions rights of an enterprise need to be incorporated as a factor of everyday investment and production rather than a purchased privilege granted by local authorities. Emissions trading legislation is also essential to ensuring the legitimacy of emissions trading activities and to provide a legal safeguard for enterprises that support fair competition.

Third, we argue that it is vital to establish accurate and timely information and data management when implementing emissions trading activities. China needs to keep enhancing local capacities for monitoring, including the use of proper facilities and equipment, human resources and routine operation protocols, so that the infrastructure of emissions trading can support PETSs among various regions. We also recommend a broader and in-depth application of information and communications technology (ICT) that would facilitate the easier registration and participation of enterprises and improve the real-time tracking of pollutant emissions,

trading application, and trade verification and auditing so that managerial entities of PETSs can effectively observe and manage regional environmental quality.

As a major limitation of our research, our perspective is retrospective and we have not yet sufficiently covered discussion of future PETS development. Since 2017 China has faced a high degree of uncertainty in PETS policies and pilots. The overarching institutional arrangement following the “paid-use of emissions permits” is under development. What we have learned about PETSs will offer practical insight, as they become part of a new mechanism for coordinating regional development that places more emphasis on cross-regional collaboration and ecological compensation among local governments. However, more input from academics and practitioners is needed for the institutional design of the permit system and its secondary market.

Finally, we propose the following directions for future environmental management and policy studies in this area.

1) A flexible finance instrument could be introduced to PETSs to enable and recruit more participants. In regions with limited environmental capacity, emissions rights have high value in the market and can form a challenging barrier to entry for businesses and for small and medium-sized enterprises in particular (Wen et al. 2018). Academics should explore ways to apply finance instruments under PETSs to encourage businesses to purchase their emissions rights through bank loans or to use existing emissions rights as a mortgage to acquire bank loans.
2) The role of local authorities. We argued that local governments need to transform themselves into overseers, observers and auditors. There shall be minimal administrative interference in trading activities. We call for specific case studies wherein local governments are restricted from trading by executive order and charging fees and can only make an allowance buy-back from the market as ordinary traders. We also suggest that a third party consultancy service for emissions trading be applied to offer professional services for enterprises to assist with their participation in PETSs and help them benefit from these programs.

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***Declaration of Interest Statement**

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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Methodology; Formal analysis; Investigation; Resources; Data Curation; Writing - Original Draft; Visualization

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Validation; Resources; Supervision