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Views & Comments

Performance Assessment and Outlook of China's Emission-Trading Scheme

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1. Overview

China overtook the US as the world's top emitter in 2007, and produced 1.5 times the emissions of the US by 2013 [1]. At present, China's emissions make up over a quarter of the global total. China is expected to produce three times the emissions of the US by 2030 [2]. Indeed, China's role and efforts in CO_2 reductions matter greatly for the peaking of global emissions, even without further emission leakages to less-developed regions or countries. China recently announced the launch of a nation-wide emission-trading scheme (ETS) starting in 2017 [3] in order to help deliver its emission peak by 2030. A number of climate policies in China are ongoing, and require a full performance review, effective coordination, and appropriate implementation of planning and monitoring measures along with any newly added mechanisms. This paper utilizes the latest energy and emission data to explore the impact of emission trading as a policy driver toward absolute emission and emission intensity changes in China and in its seven provinces or municipalities.

2. China's efforts toward carbon emission control

China has initiated an ambitious plan to fight climate change, having already undertaken emission controls under the central commanding administration. A number of policies have been established over the past two decades. In the *National Scheme on Climate Change* published in June 2007 [4], the National Development and Reform Commission (NDRC) promised to make efforts to control greenhouse gas (GHG) emissions and produce a 20% reduction in per GDP energy consumption by 2010. The NDRC also issued mandatory environmental targets to be implemented through the national Five-Year Plan. In the 11th Five-Year Plan (2006–2010), China issued targets for a 20% reduction in energy consumption per unit of GDP (referred to as the Emission Intensity (EI) policy) [5,6]. In the 12th Five-Year Plan (2011–2015), China introduced a market-based domestic ETS; the mechanism underlying this trading system has now been established in seven pilot markets (referred to as the ETS policy) [7–9]. In 2014, the Chinese government issued more policies to control climate change and committed to more responsibility. In September 2014, the NDRC published the *National Scheme on Climate Change (2014–2020)* and stated its intention to reduce CO_2 emissions per GDP by 40%–45% by 2020 compared with that in the year 2005 [10]. China announced that it will peak its CO_2 emissions by 2030 under the *US-China Joint Announcement on Climate Change* [11], released during the Beijing Asia-Pacific Economic Cooperation (APEC) meeting in November 2014. However, there is still no quantitative limit associated with this pledge. In December, the *Lima Call for Climate Action* advocated that China, as the world's largest emitter, pledge CO_2 reductions alongside other wealthy countries. Recently, China announced the launch of a nation-wide ETS that will start in 2017, based on the current pilot scheme that is running in seven provinces or municipalities.

3. Policy-effectiveness evaluation of the ETS pilot provinces or municipalities

The introduced emission control mechanisms are successful in terms of improving emission intensities across Chinese regions; however, they have a limited effect on slowing down emission growth for the nation as a whole and for most of its provinces or municipalities. Figs. 1 and 2 show changes in annual CO_2 intensity (indicated in the diagram as "CI" and given in tonnes of CO_2 emitted per ¥10 000 CNY of the GDP) and annual CO_2 emissions (in million tonnes (Mt)) in China, in its six pilot ETS provinces or municipalities (Beijing, Shanghai, Tianjin, Guangdong, Hubei, Chongqing), and in Liaoning Province (an active carbon-exchange market) from 1997 to 2012, respectively. In Figs. 1 and 2, "EI" refers to 20% energy intensity improvement between 2005 and 2010 (rectified in 2007); "pilot ETS" refers to China's pilot ETS in seven provinces from 2011 to 2015.

Fig. 1(a) illustrates the performance of current key emission control measures that have been implemented within China. China's CO_2 intensity has experienced a rapid decrease from 3.09 t per ¥10 000 CNY (constant price at the 2007 level) in 1997 to a low point of 2.29 t per ¥10 000 CNY in 2002. After China joined the World Trade Organization (WTO), China's CO_2 intensity climbed to a peak in 2005; this peak was largely driven by the production of emission-intensive export products and capital formation [12,13]. After this point, efficiency gains were accelerated. China's EI policy helped it to achieve a 28.5% reduction in CO_2 intensity in 2013 compared with 2005, which was equivalent to a reduction of more than 2500 Mt CO_2 emissions (i.e., 10% of the global total in 2010). China's

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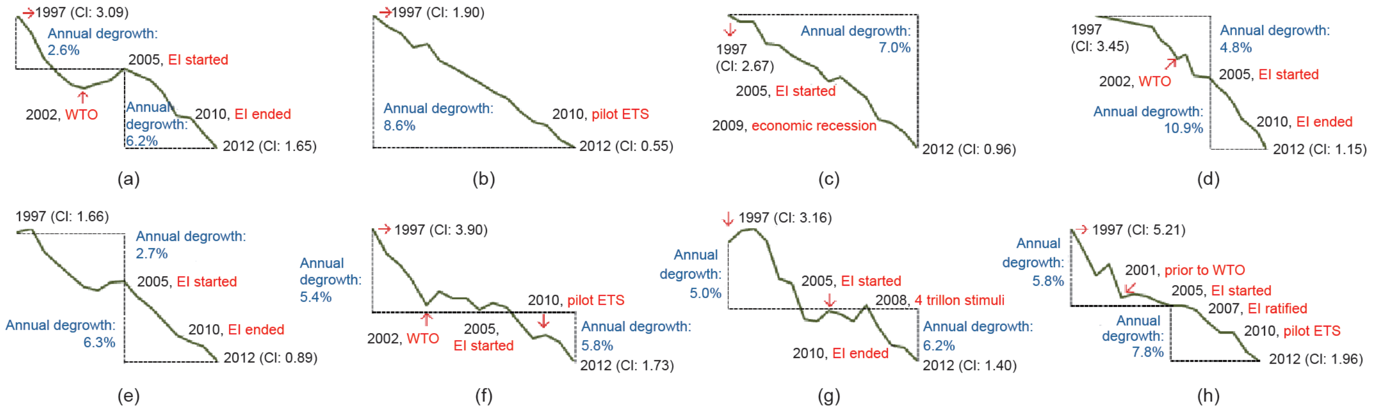

Fig. 1. CO_2 intensity changes. (a) China; (b) Beijing; (c) Shanghai; (d) Tianjin; (e) Guangdong; (f) Hubei; (g) Chongqing; (h) Liaoning. Blue text gives the rates of the changes in indicated periods (represented using dashed lines). Red text describes relevant energy or economic policy implementations.

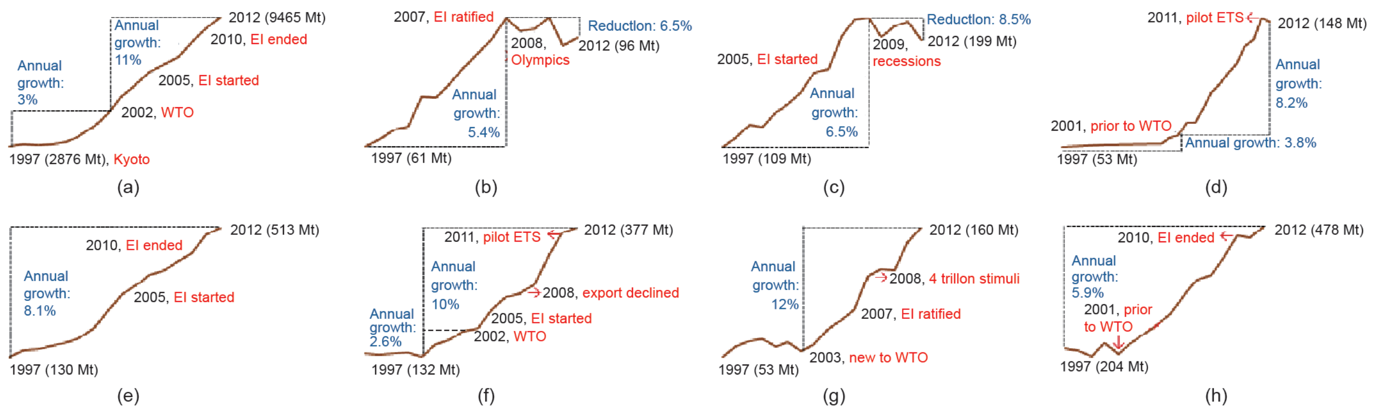

Fig. 2. CO_2 emission changes. (a) China; (b) Beijing; (c) Shanghai; (d) Tianjin; (e) Guangdong; (f) Hubei; (g) Chongqing; (h) Liaoning. Blue text gives the rates of the changes in indicated periods (represented using dashed lines). Red text describes relevant energy or economic policy implementations.

manufacturing provinces or municipalities, as shown in Fig. 1(d)–(h), experienced changes that were similar to the change in the national average. China's pilot ETS was a trigger for a further decline in intensity for all the seven provinces or municipalities starting in 2010.

Energy and emission control measures do not have a strong impact on extra efficiency gain in wealthy regions such as Beijing and Shanghai, where intensities improved at the rates of 8.6% and 7.0% annually from 1997 to 2012, respectively [14]. Beijing and Shanghai are the most developed municipalities in China. The tertiary industry is their pillar industry, counting for 76.9% and 62.2% of the GDP in 2013, respectively. These values are significantly higher than the national level of 46.1% [15]. Due to their mature and stabilized economic structure, these two cities did not have an obvious increase in CO_2 intensity after China joined the WTO in 2002. Rather, their CO_2 intensities continued to decline at a steady speed due to technology improvements and production or municipalities structure shifts.

Economic policies are the key drivers in China's emissions growth. From 1997 to 2002, Chinese emissions grew from 2876 Mt to 3587 Mt, with an annual growth of 3% (Fig. 2(a)). Since China entered the WTO, this annual growth has accelerated to 11%, with China's total emissions reaching 9465 Mt in 2012. Similar trends can be seen in almost all the manufacturing provinces or municipalities. For example, two manufacturing regions, Tianjin and Hubei, increased their emissions by 3.8% and 2.6% annually prior to WTO, respectively. Between 2002 and 2012, this annual growth accelerated to 8.2% and 10%, respectively.

The EI policy has no significant influence on slowing the rise of CO_2 emissions, at a national, municipal or provincial level [16]. Rises in emissions did temporarily slow down in 2005 due to the EI policy. Soon afterwards, however, the emissions growth rate rebounded (in 2007). However, CO_2 growth has decelerated in all pilot ETS implementing provinces or municipalities since 2010. For example, Tianjin achieved net emission reductions in 2012 when compared with the previous year, although these were less than 3%. Other manufacturing provinces or municipalities such as Guangdong and Hubei slowed their emission growth to 2%–3% during 2010–2012. Although Liaoning is not an official emission-trading region, its emission growth decelerated to 2.5% during 2010–2012, compared with its rate of 5.9% during 1997–2010. Such emission growth decelerations or reductions are mainly driven by economic growth slowdown. The pilot ETS plays a minor role in emission mitigation because the total emission-trading quotas are small, usually less than 1% of the total emissions in any implementing province or municipality.

The most developed municipalities, Beijing and Shanghai, have already achieved emission reductions since 2007. Their emissions decreased by 6.5% and 8.5% in 2012 as compared with 2007 levels, respectively. These reductions mainly result from China's anti-air pollution efforts, rather than from the pilot ETS. Beijing reduced its coal consumption by half during 2007–2012, and will achieve zero coal consumption by 2017, as a means of achieving the goal of an annual $PM_{2.5}$ concentration $\leq 60\ \mu g\cdot m^{-3}$.

4. Outlook for the nation-wide ETS

China needs a new design for its nation-wide ETS. The pilot cap-and-trade scheme that is currently being completed in seven Chinese provinces or municipalities has two major issues. Firstly, it still follows a similar emission quota distribution mechanism as the European Union (EU) ETS, which mainly relies on free allocation. The government uses very strong interventions to control quota availability and flows, whereas the market plays a minor role. Secondly, the current pilot scheme does not allow for cross-provincial or cross-municipal emission cap trading. In fact, each participating province or municipality sets its own cap and decides which sectors/factories it will cover. For example, transport is included only in Shanghai's ETS. Each province or municipality also determines how compliance will be measured. For example, Hubei Province targets enterprises that consume more than 60 000 t coal-equivalent per year, a threshold that is six times greater than that of Guangdong [2].

New and full-scale national emission trading should fully adopt the "auctioning" quota allocation mechanism. Although the auction price can be as low as "free" and a price-capping system can be set, this mechanism creates a competitive market for users who need the emission quota, and provides funds for implementing low-carbon alternatives. The government should provide a supporting, regulating, and monitoring service for the carbon market in China. Measureable and transparent emission data will form the baseline for emission targets. In addition, such a scheme should cover all emission sectors, rather than the several major industries that are addressed in the current pilot ETS. On the other hand, a full national-scale cap and trade should give sufficient consideration to regional inequalities. Economically advanced regions (e.g., Beijing, Shanghai, and perhaps other coastal provinces or municipalities) can have an absolute emission reduction cap, while interior manufacturing provinces or municipalities may be entitled to strict annual emission growth caps that allow economic transition, and regions in the west that are lagging behind may be granted a more generous emission cap that is, however, accompanied by very clear and verifiable efficiency-gain targets. In other words, the Chinese cap-and-trade scheme should be parallel to the efficiency improvement target that is currently being implemented. China's anti-air pollution efforts create co-benefits for CO_2 emission controls. China's State Council has authorized a ¥1.75 trillion CNY ($277 billion USD) investment package to implement the newly designed *Air Pollution Prevention and Control Action Plan* over the five-year period 2012–2017. However, air pollution control and climate change mitigation are coordinated by different departments in the State Council and are implemented by their regional representative offices. The design and implementation of air pollution policies are managed by the Ministry of Environmental Protection, while climate change policies are managed by the NDRC. Strong cross-departmental coordination is key to avoiding repetitive investments and the double counting of achievements.

5. Method and data

We calculated the production-based CO_2 emissions of China's provinces or municipalities based on apparent territory scope, as developed from administrative territory scope. This approach has been improved and utilized in several previous studies [1,17–21].

According to the Intergovernmental Panel on Climate Change (IPCC), administrative territory emissions occur within administered territories and offshore areas over which the region has jurisdiction [22]. This includes emissions produced by different economic sectors and residences within the region's boundary [23,24]. In the IPCC's administrative territory scope method, CO_2 emissions from secondary fossil fuel combustion are counted toward the corresponding secondary fossil fuels. Secondary fossil fuels are produced from primary fossil fuels through a transformation process. Therefore, to avoid double counting, the input usage of the primary fossil fuel should be excluded when calculating the primary fossil fuel CO_2 emissions [25]. Taking cleaned and washed coal as an example, the transformation process of coal washing consumes raw coal and produces cleaned and washed coal. Based on the IPCC administrative territory scope method, the CO_2 emitted from the raw coal consumed in the coal washing process should be excluded from the raw coal emissions. When the produced cleaned and washed coal is burned, the CO_2 emitted will be counted toward the emissions of the cleaned and washed coal. Based on the apparent territory scope approach, however, we do not include the secondary fossil fuels. Here, all of the CO_2 emissions induced during the use of the cleaned and washed coal are counted as input emissions of raw coal (Table 1).

In this study, we estimate fossil fuel-related CO_2 emissions by energy types and the total CO_2 emissions based on the IPCC national GHG inventory guidelines [22]. See Eq. (1) and Eq. (2) below:

$$CE_i = AD_i \times EF_i \tag{1}$$

$$CE = \sum_i CE_i \tag{2}$$

where, CE_i represents CO_2 emissions from 18 different fossil fuel types; AD_i represents the fossil fuels combusted within the provincial or municipal boundary measured in physical units; and EF_i represents the emission factors for the relevant fossil fuels.

These emission factors were collected from our previous research on China's fossil fuel quality [1]. By adding together the emissions from different energy types, we obtain the total CO_2 emissions for one province or municipality (Eq. (2)). We then scale down the emissions of each province or municipality by the national total emissions in order to fill the gap between aggregated emissions from the national, municipal or provincial emissions. Detailed emission inventory accounting approaches are developed in our previous research [18,25]. The constructed CO_2 emission inventories for China and its seven provinces or municipalities are consistent in terms of format and statistical approaches. All inventories have emission accounts for 18 types of fossil fuel by 47 socioeconomic sectors.

Table 1
IPCC administrative territory scope versus apparent territory scope.

Fossil fuel types	IPCC administrative territory scope	Apparent territory scope
Raw coal	CO_2 emissions from final energy consumption + CO_2 emissions from energy consumption of "thermal power" and "heating supply"	CO_2 emissions from final consumption + inputs of all possible transformations
Coal-related fossil fuels (such as cleaned coal, coke)		N/A
Crude oil		CO_2 emissions from final consumption + inputs of all possible transformations
Oil-related fossil fuels (such as gasoline and kerosene)		N/A
Natural gas		CO_2 emissions from final consumption + inputs of all possible transformations
Gas-related fossil fuels (such as liquid natural gas)		N/A

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