Region division of China's carbon market based on the provincial/municipal carbon intensity

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Abstract

The difference of carbon trading prices among Emission Trading Scheme pilots may hinder the unified carbon market that China's government plans to establish in 2017. To achieve this goal, this study develops a regional carbon market mode based on the similarity of thirty provinces/municipalities' carbon intensity by the aid of Logarithmic Mean Divisia Index, Autoregressive, and Dynamic Time Warping models. According to the dynamic clustering result, we divide these provinces/municipalities into three sub-markets that are the Western, Eastern, and Central Markets. Furthermore, we propose the carbon emission modes corresponding to each sub-market, namely, the energy-dependence mode (Western Market), sustainable-economy mode (Eastern Market), and industrial-upgrading mode (Central Market). Briefly, we suggest that the unified market should be firstly divided into some sub-markets. Finally, we propose some critical routes as well as corresponding managerial implications for establishing such unified market.

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1. Introduction

To achieve the national emission goal that is to reduce the greenhouse gas (GHG) emission by 40%–45% in 2020 compared with 2005, the China's National Development and Reform Commission (NDRC) established seven Emission Trading Scheme (ETS) pilots covering Beijing, Tianjin, Shanghai, Chongqing, Hubei Province, Guangdong Province, and Shenzhen. These pilots were expected to provide valuable experience for establishing the nationwide carbon market (Jotzo and Loschel, 2014; Wang et al., 2016; Hu et al., 2017). At present, China’s ETS pilots are facing some problems (e.g. lack of domestic demand and social investment) that blur the prospect of united carbon market (Lo, 2016). According to prior studies, we expect that the linkage of ETS pilots will help to reduce the carbon emission cost, enhance the market liquidity, and motivate the cooperation among regions on climate issues, which can well explain why the unified market should be established (Ibikunle et al., 2016; Ranson and Stavins, 2016). We argue that the most effective scheme is to establish some regional carbon sub-markets, and then extend them to the nationwide market by linking each sub-market. Thus the following issues need to be addressed: how to coordinate the difference of each sub-market, how to formulate unified criteria for dividing sub-markets, and how to integrate each ETS pilot? Thus this study aims to design regional carbon sub-markets based on provincial/municipal carbon intensity with an expectation that the sub-market division will be an optimal approach for establishing the unified carbon market in China.

The contributions of this study are as follows. First, we design a regional carbon market mode that can provide the evidence for establishing the nationwide carbon market. Given that the unified market will affect regional economies in various ways, we divide sub-markets based on the provincial/municipal carbon intensity that is an indicator reflects the quality of regional economy. Second, because of some indicators’ temporal lag effect, we introduce the Dynamic Time Warping (DTW) model to accurately show the radiation function (hub-and-spoke type) of China’s economic system. Third, for linking each sub-market, we further discuss how to optimize the sub-market layout, enhance the sub-market liquidity, and expand the coverage of carbon traders.

We expect that the unified carbon market will help to improve China’s environmental quality, thus the effect of ETS pilots should be fully understood. Specifically, these pilots are composed of three service-led municipalities (Beijing, Shanghai, and Shenzhen) and
four manufacturing-led provinces/municipalities (Tianjin, Chongqing, Hubei, and Guangdong). According to the level of pilots’ economy, China’s government formulated the decreasing rates of their carbon intensity in the 12th Five-Year Plan (2011–2015) as follows: Beijing (18%), Tianjin (19%), Shanghai (19%), Chongqing (17%), Hubei (21%), Guangdong (19.5%), and Shenzhen (17%) (Meng et al., 2012). Integrating prior studies (Guo et al., 2012; Jiang et al., 2014; Qi et al., 2014; Wu et al., 2014), we summarize the design principle of each ETS pilot as Table 1.

Given different economic levels and market demands, Beijing, Tianjin, Chongqing, Hubei, and Shenzhen allocate the carbon quota every year, while Shanghai and Guangdong usually develop the one-off allocation in a certain period. Also, if participants (including domestic and foreign organizations as well as individuals that meet admittance criteria) do not obey the prescribed quota, corresponding pilots would be punished by local governments, and participants’ reputation as well as obtained investment from governments would also suffer the loss. Overall, although the offset mechanism of each pilot is similar, obvious differences still exist in their operations (Zhang et al., 2014).

We believe that ETS pilots’ operation can provide experience for the unified market, while some obstacles would also hinder such unification. For instance, the large-scale carbon trading cost and various trading prices among pilots always trigger the weak market vitality and liquidity (Wang et al., 2014; Zhao et al., 2016). Integrating prior studies on the cross-regional carbon market, such as Australia and EU, Switzerland and EU, US and EU, Australia and New Zealand, and California and Quebec (Sterk and Kruger, 2009; Du et al., 2015; Ranson and Stavins, 2016; Venmans, 2016), we summarize three linkage schemes widely discussed. The first scheme is to link each pilot to a regional carbon market, and then extend to the whole country. To achieve it, Zhang et al. (2014) suggested linking all China’s ETS pilots and extending them into an inter-provincial trade. Also, Dai and Masui (2012) and Zhou et al. (2013) suggested that the total cost of China’s carbon emission would be noticeably reduced by the aid of interprovincial ETS linkage, although such linkage may trigger the uneven allocation of carbon emission among regions (Liu et al., 2013; Lo and Cong, 2017). Furthermore, Pang et al. (2014) proposed that establishing the regional carbon market by the linkage of each pilot has been preliminarily designed in China, while such linkage still faces some obstacles, such as the lack of timely policy guidance. The second scheme is to incorporate each pilot into its nearest province/municipality and then establish some regional sub-markets, such as the markets located in Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta. After that, these markets will be integrated into a nationwide one. From the national view, some uncertainties regarding the impact of nationwide carbon market on regional economy still exist (Cui et al., 2014; Jiang et al., 2015; Fan et al., 2016). Specifically, although we expect that regional carbon markets will push forward some industries’ growth, the higher initial trading cost may play the opposite effect. From the regional view,

<table>
<thead>
<tr>
<th>Region</th>
<th>Industry/firm distribution</th>
<th>Admittance criterion</th>
<th>Quota allocation</th>
<th>Trading subject</th>
<th>Offset mechanism</th>
<th>Restriction measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>12 industries (electric power, petrochemicals, cement, etc) with 490 firms.</td>
<td>CO₂ emission&gt;10000 t/a</td>
<td>Allocation criteria in 2013 refer to emissions of 2011 and 2012; allocation criteria in 2015 refer to emissions of 2013 and 2014.</td>
<td>All firms (registered capital&gt;3 million CNY).</td>
<td>No more than 5% of emissions.</td>
<td>For emissions not be liquidated, participants would be subject to a fine of 3–5 times of the average carbon price.</td>
</tr>
<tr>
<td>Tianjin</td>
<td>5 industries (steel, chemical, electric power, etc) with 109 firms.</td>
<td>CO₂ emission&gt;20000 t/a (from 2009 to 2012).</td>
<td>Incremental baseline principal (allocating quotas every year).</td>
<td>All types of organizations and individuals with no less than 0.3 million CNY assets.</td>
<td>No more than 5% of quotas.</td>
<td>Participants not complete the emission verification would not obtain the governmental investment for new projects.</td>
</tr>
<tr>
<td>Shanghai</td>
<td>17 industries (electric power, transportation, chemical, etc) with 191 firms.</td>
<td>Manufacturing CO₂ emission&gt;20000 t/a (from 2009 to 2012).</td>
<td>Quotas in 2013–2015 refer to emissions of 2009–2011.</td>
<td>Firms incorporated in the mandatory quota, other organizations, and individuals.</td>
<td>No more than 5% of quotas.</td>
<td>Participants refusing to complete the quota would be subject to a fine of 50–100 thousand CNY, also without the governmental investment for new projects.</td>
</tr>
<tr>
<td>Chongqing</td>
<td>7 industries (electrolytic aluminum, ferroalloy, calcium carbide, etc) with 242 firms.</td>
<td>Participants’ declaration under the governmental supervision.</td>
<td>Based on emissions from 2008 to 2012, the emission decreases 4.13% year by year from 2013 to 2015.</td>
<td>Firms incorporated in the mandatory quota (registered capital&gt;1 million CNY) and individuals with no less than 0.1 million CNY assets.</td>
<td>No more than 5% of quotas.</td>
<td>Undetermined.</td>
</tr>
<tr>
<td>Hubei</td>
<td>12 industries (electric power, steel, chemical, etc) with 138 firms.</td>
<td>Standard coal consumption&gt;60000 t/a (from 2010 to 2011).</td>
<td>Storage: 80% for quota, 20% for auction; new increment: 15% of quota reserved by the government (allocating quotas every year).</td>
<td>Firms incorporated in the mandatory quota, other organizations, and individuals.</td>
<td>No more than 5% of quotas.</td>
<td>Participants refusing to complete the quota would be deducted the uncompleted parts in the next allocation.</td>
</tr>
<tr>
<td>Guangdong</td>
<td>6 industries (electric power, cement, steel, petrochemical) with 184 firms.</td>
<td>CO₂ emission&gt;20000 t/a</td>
<td>Based on emissions from 2008 to 2012.</td>
<td>Firms incorporated in the mandatory quota, (only for their first year), other organizations, and individuals.</td>
<td>No more than 10% of emissions.</td>
<td>Participants refusing to complete the quota would be deducted the uncompleted parts in the next allocation with a fine of 50 thousand CNY.</td>
</tr>
<tr>
<td>Shenzhen</td>
<td>26 industries (electric power, heat, public building, etc) with 832 firms.</td>
<td>Manufacturing CO₂ emission&gt;5000 t/a; public building area&gt;2000 m²; governmental building area&gt;10000 m².</td>
<td>Baseline principal (allocating quotas every year; determining sub-industries’ quotas by the auction).</td>
<td>Firms incorporated in the mandatory quota, other organizations, and individuals.</td>
<td>No more than 10% of quotas.</td>
<td>For emissions not be liquidated, participants would be subject to a fine of 3 times of the average carbon price.</td>
</tr>
</tbody>
</table>

Note: (1) We only list the top 3 industries with the largest number of firms except Guangdong; (2) CCER means the Chinese Certified Emission Reduction.
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