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主　論　文　の　要　旨

論文題目	Emission Trading Scheme in China: Investigating the National Market and Exploring International Links (中国の排出量取引制度ー国内全国市場の検証と海外市場との連携の可能性)
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論　文　内　容　の　要　旨

China, the world's largest emitter, established eight pilot carbon markets in Beijing, Shanghai, Tianjin, Chongqing, Shenzhen, Guangdong, Hubei, and Fujian since 2013. Through a video conference call on 19 December 2017, China launched its national Emission Trading Scheme (ETS) with a cap of approximately 3,300 Mt/year covering around 1,700 companies in the power sector (ICAP, 2018), which is now the world's largest emission trading market. A three-phase roadmap has been adopted as announced by the National Development and Reform Commission (NDRC, 2017). Phase one is on the development of market infrastructures (roughly one year); phase two foresees simulation trading (roughly another year); and phase three will be the deepening and expanding phase with allowances spot trading for compliance purposes (roughly starting from 2020). Currently, pilot markets are still operating under the regulation of regional government. The national market is still in an emerging period with lots of uncertainties.

To summarize the lessons that CHN-ETS can learn from the existed ETS, all features of ETS design were reviewed in Chapter 2, as well as the development of different existed emission trading schemes worldwide. The uncertainties in the CHN-ETS development first, in general, would be the potential large increases in the cost of consumers, especially domestic and international household consumers. In Chapter 3, a projected ETS in China is modeled to examine its impacts on the Food-Energy-Water (FEW) nexus containing Japan and China. The changes in network availability, system resilience, and robustness of the nexus system after the introduction of a projected ETS are also examined.

Regarding the basic ETS market design features, interregional carbon leakages may occur and needs to be adjusted in the regional caps and initial allowance allocation. In Chapter 4, an integrated approach of ETS cap designing is proposed to address the unique issues of ETS development in China, such as the interregional carbon leakages caused by a coverage of ETS only

on pilot regions, an emission reduction goal in the form of intensity instead of absolute amount, and other uncertainties in the asymmetry of information among firms, regional ETS regulators, and national ETS regulators.

Moreover, considering the unique problems in ETSs in China, in the electricity supply sector which is highly regulated in pricing, how the total ETS cost is conveyed from covered producers to final consumers remains unknown. In Chapter 5, a cost transmission mechanism is modeled in a projected emission trading scheme with a coverage of the electricity supply sectors in all regions in China. The modeling considers the specific issue in electricity supply industry that the additional abatement costs caused by the projected ETS cannot be automatically conveyed between producers and consumers within the electricity supply sector due to the highly regulated electricity pricing. The increase in household consumption is also investigated.

Regarding the governance ETS market design features, too many offsets or a possible linking may place risks to cap ruining, leading to a loss of constraints on entities to reduce their total emissions. In Chapter 6, the ETS governance features (specially allowance offsets, price intervention, ETS linking, and how such governance approaches works) were discussed, as well as the development of ETS governance in different existed emission trading schemes worldwide.

Moreover, the achievement of other policy goals, such as to promote overcapacity elimination in the cement sector, may need the implementation of ETS and be involved in the ETS design period before the implementation. In Chapter 7, an LCA-RCOT model (Life Cycle Assessment and Rectangular Choices of Technologies) is established to illustrate five alternative choices of production technologies in the cement industry in China, as well as to reveal the impact of a projected ETS on the production technology upgrading. The modeling considers the specific issue of the cement industry in China that suffering from a rising marginal cost of the overcapacity elimination.

The main findings and the policy recommendations based on the main findings are listed as follows:

i) The estimation of total ETS cost should consider the burden on the covered producers in each region, and more importantly, consider the burden on consumers.

Evidence from the electricity supply sectors in China shows that rises in household consumption would occur after the introduction of a projected ETS, especially in the net emission importer regions. Such rises would be brought by the emissions embodied in other sectors rather than the ETS covering the sector. Under the current average market price, only 25.7% of the total ETS will be conveyed to household consumers. The rises in household consumption can be regarded as bearable.

ii) Initial allowances allocation can be adjusted based on the consumption-based emissions as one solution to the interregional carbon leakages. However, the scope of ETS should cover all regions in one country.

In the same projected ETS, if ETS only covers pilot regions instead of all regions in China, non-pilot regions may receive additional costs (0.27%-0.58% of the regional GDP) brought by the interregional leakages from ETS pilot regions. In the national market covering all regions in China, even under a scenario with high average market price up to 200yuan/ton, the total ETS cost to the regional economy can be regarded as bearable (with the largest regional rise less than 0.17%), especially regarding household consumers (with the largest regional rise less than 0.07%). However, the issue of interregional may be ignored.

iii) ETS regulators should be prudent if an adjustment in initial allowances and price intervention are planned to be implemented simultaneously, as once the initial allocation is fixed, the total ETS cost for each region will be largely influenced by any price changes.

In the same projected ETS, if the regional caps are adjusted by consumption-based emissions in the national market, the adjustment work as a solution to the issue of interregional carbon leakages. More importantly, such adjustment would not ruin the national cap, place a heavy burden to the local economic growth in all regions, or increase the regional disparities to a large extent. However, the solution only works in the current level of the average market price. Distortion may occur if the market price (32 yuan/ton) is further increased to the level of its guidance price (200 yuan/ton). The shares of total ETS cost in total output in all regions would be extremely high, ranging from -24.65% (Inner Mongolia) to 19.25% (Chongqing).

Policy recommendations on the governance features of ETS market design are listed as follows:

iv) As a climate policy instrument, ETS can promote the achievement of technology upgrading, overcapacity elimination, waste coprocessing, and the like.

Evidence from the cement sector in China shows that, given a factor constraint of emission allowances, the optimal technology combination may shift to fewer shaft kilns and more dry kilns under all scenarios. In the long run, the climate policy instrument, ETS, may promote the upgrading of production technology by decomposing the total emission mitigation costs to the factor inputs of each cement producer.

v) ETS linking (especially linked with another ETS with higher average market price), even with a limited share of linking, the cost of local entities may increase, and the original cap may shrink. Such linking may promote technology upgrading to reduce CO_2 emissions. In a reverse way, a local offset mechanism may raise the cap, but promote the implementation of waste co-processing technologies.

vi) From the perspective of factor inputs, given alternative production technologies, the real factor price of emission allowances can be revealed as the sum of market prices and scarcity rents (additional costs).

In the same projected ETS, the real factor price of emission allowances in the cement sector would be $22.216, although such price only exists in a perfect state where all producers adopt the lowest-cost production technology. A higher market price may drive the narrowing of the gap between the factor cost, especially the performance in CO_2 emissions that requires the input of emission allowances, of all production technologies in the cement industry, at the same time, eliminate the entities with a higher emission intensity thus further promote the overall technology upgrading, as entities with a lower emission intensity earns more scarcity rents.

Regarding the contribution of the empirical analysis, i) modeling projected emission trading schemes in the target sectors considering the unique features in China, as well as ii) providing policy comments in terms of the processes in market design, are essential to the current development of the national ETS in China and have not been thoroughly discussed in the previous literature. Regarding the contribution of methodology, an LCA-RCOT model (Life-Cycle-Assessment-Rectangular-Choices-Of-Technologies model) can be considered as an innovation to Input-Output analysis.