

A SIMULATION MODEL FOR REGIONAL EMISSION TRADE MARKET

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EXTENDED ABSTRACT

To effectively control air pollution and promote green production/service, China has established regional emission trade markets (RETM) at several “trial cities”. These systems operate under the conditions of “Cap and Trade”: Participating companies are restricted in total greenhouse-gas-emission through initial allocation of emission quotes (EQ); but allowed to purchase EQ (i.e. commercialized permits for emitting certain pollutant) to satisfy additional needs via a market system. Alternatively they can conduct self-purification (SP) to reduce emission level to satisfy their needs and sell the surplus (e.g. in the form of certified-emission-quotes) to gain revenue via the market. There are various risks associated with these decisions, e.g. fluctuation of market EQ price and cost of making green improvement (SP). The companies’ decisions are individually made (i.e. decentralized) and together they influence the market’s overall behavior significantly. The interaction between many decision makers and overall market performance is quite complex and the performance is also highly influenced by policy design (e.g. by government agencies who create, run and regulate the market).

The complexity of modeling a RETM system comes in several aspects. First of all, as a trade market for special goods such as emission quotes (i.e. commercialized permit for emission of CO₂E pollutant), it must perform a number of functions to ensure the control and operation of the market, e.g. emission allowance allocation, transaction regulation, compliance/monitor-report-verification (MRV), etc. These functions are usually designed by policy makers (governmental agencies) and involved with complicated logics and inconsistencies. Together these functions form a “macro-structure” that influences and restricts the behavior of market participants which are individual or decentralized decision entities (i.e. participating companies as the buyers and sellers of EQ). Modeling and implementation of these functions involve substantial amount of work from most concrete to most abstract level. Secondly the enterprises operate significantly different under the conditions of Cap and Trade. In addition to traditional production resources (e.g. labor, equipment and raw materials), companies must consider the acquisition and disposition of environmental resource (e.g. emission quote (EQ)), and balance between production economy and CO₂E reduction. Operation managers face greater challenge in resource planning decisions. In addition to traditional resource, they now have to plan and acquire enough emission allowance to meet their production/service emission needs. They must choose from purchasing EQ (through a market), or reducing emission level via **self-purification (SP)**, or carrying over surplus emission quote to satisfy the required emission for the planning period. Self-purification (SP) is defined as a process conducted autonomously by a generating company to reduce its total emission of CO₂E through the improvement of product design and/or processing methods or technologies. Previous studies have revealed following characteristics in this decision-making process: (1) market price of EQ follows a random fluctuation; (2) the abatement cost of performing SP to reduce emission level increases as the accumulated reduction

increases, i.e. the more reduced, the more difficult to reduce; and (3) there exist trade-offs between decision alternatives that may lead to significant cost-saving. Finally, although the behavior of individual decision entities may be predicted (given the logic and risk distribution), their collective impact on the overall performance of the system (RETM), or the “emerging behavior” of the participants as a whole, is very difficult to predict due to great uncertainties. This has raised important issues for policy-design and evaluation of such complex systems. It is a great challenge to build a model that adequately represents and effectively simulates the dynamics of a RETM to allow policy maker or system designer to effectively and efficiently conduct related experiments using the model to analyze the system’s performance under various combinations of system conditions (e.g. regulation/transaction policies) and risk profiles, and compare different policies and mitigation strategies in terms of the collective response by all participating companies.

While the related literature seems abundant, there is clearly a lack of research to address the problem from a system perspective of policy design and evaluation for regional emission trade market under C&T conditions: How to build a robust model that adequately represents and effectively simulates the composition and dynamics of a RETM to allow system designer/policy maker to analyze the overall performance of the market system? and in particular evaluate the effectiveness and efficiencies of the functions/mechanisms or the policies designed for implementation, control and management of a RETM? This research applies multi-agents modeling paradigm to develop a simulation model for conducting experimental studies on RETM system. The study focuses on the participating companies’ decisions in planning environmental resource via interactions with a regional emission trade market under the risk conditions associated with the decisions, and evaluate the collective impacts of the decentralized actions (by individual autonomous decision makers) on the system’s performance.

The work of the study is organized and reported as follows. We first propose a conceptual model that captures essential characteristics of a RETM to satisfy both system design and agent design requirements. The emphasis is given to the integrated design of agents’ and system’s logic to fulfill the complicated functions of a RETM via effective (and efficient interactions). The issue of policy design is also discussed. We then present the implementation of the model via ANYLOGIC© platform. Intensive programming (coding) was required and challenges are discussed in a brief and constructive way. Then the experimental results of testing a baseline simulation model is presented where the experiments were designed mainly for verifying the functionality of the proposed model, and discuss their managerial implication. Finally we conclude the study and discuss the challenges of modeling and validation. It is noted that due to the limit of space, the descriptions presented in the poster are unavoidably too abstract to satisfy readers’ interest. More detailed information will be available in a full journal paper that is under the development.

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