Technological Forecasting & Social Change 79 (2012) 429–435

Contents lists available at SciVerse ScienceDirect

Technological Forecasting & Social Change

Asymmetric Nash equilibrium in emission rights auctions

Congjun Rao [a,b,*], Yong Zhao [c], Chuanfeng Li [d]

[a] School of Management, Huazhong University of Science and Technology, Wuhan 430074, PR China
[b] College of Mathematics and computer Science, Huanggang Normal University, Huanggang 438000, PR China
[c] Institute of Systems Engineering, Huazhong University of Science and Technology, Wuhan 430074, PR China
[d] Department of Computer and Information Engineering, Luoyang Institute of Science and Technology, Luoyang, 471003, PR China

ARTICLE INFO

Article history:
Received 22 March 2011
Received in revised form 23 July 2011
Accepted 13 August 2011
Available online 6 September 2011

Keywords:
Emission rights auctions
Uniform price auction
Asymmetric Nash equilibrium

ABSTRACT

This paper studies the problems of emission rights auctions, and presents a uniform price auction mechanism based on three assumptions, i.e., all buyers are asymmetric, every buyer submits a nonincreasing continuous demand function, and every buyer's valuation to per unit of the emission rights is common value information. It focuses on solving the asymmetric Nash equilibrium for this auction mechanism. It concludes that there exist multiple Nash equilibria in our auction mechanism, but the arbitrary low equilibrium prices cannot emerge. We also give several suggestions on how to induce the auction to a desired ideal equilibrium state in mechanism design of emission rights auctions.

© 2011 Elsevier Inc. All rights reserved.

1. Introduction

Since the 1980s and 1990s, a series of studies drew global attention to the poor environmental quality and high levels of pollution associated with rapid industry-led growth. Many governments began to pay increased attention to environmental concerns, and they have taken various measures to mitigate environmental problems [1,2], where Tradable Emission Rights Systems (TERS) is one of the efficient measures.

With the development of auction market of the emission rights, spectrum and treasury, multi-object auctions become one of the most active research areas in auction theory in recent years, where divisible goods auctions have attracted increasing attention [3–6]. Many countries use multi-object auctions to sell their emission rights. Usually, there are two kinds of price formats that are commonly used in emission rights markets, i.e., the discriminatory format and the uniform-price format. For example, the US EPA just uses the standard sealed-bid auction with the discriminatory price to allocate SO_2 emission rights. In the actual studies and applications, the uniform price or discriminatory price is a focus of controversy in the studies of auction methods for allocating the emission rights. Cason and Plott [7] pointed out that the discriminatory auction will lead to great deviation of price signals and reduce the efficiency of emissions trading markets, but the uniform price auction can provide more accurate price information. Svendsen and Christensen [8] also analyzed the disadvantages in the discriminatory price auction of SO_2 emission rights, and they conclude that the uniform price auction may provide better price signals. Cramton and Kerr [9] studied the carbon permit auction, and show that the standard ascending-clock auction will provide credible prices, which is better than the uniform price auction. It indicates that the choice between discriminatory format and the uniform-price format remains an unsettled issue. Betz [10] also proposed an ascending clock auction mechanism based on the policy frame work and theoretical as well as experimental findings in the literature, and this auction mechanism is later applied by the Australian government. Cason [11] reviews specific experimental applications that address design issues for permit auction rules, permit expiration dates and banking, liability rules, and regulatory enforcement. Goeree et al. [12] experimentally study auctions versus grandfathering in the initial assignment of pollution permits that can be traded in a secondary

* Corresponding author at: School of Management, Huazhong University of Science and Technology, Wuhan 430074, PR China. Tel.: +86 02785543630; fax: +86 0713 8621649.
E-mail address: cjrao@163.com (C. Rao).

0040-1625/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.techfore.2011.08.012

spot market. However, these research findings are attached with certain conditions and certain limitations. If these conditions or limitations are unsatisfied, then the corresponding conclusions need to be reconsidered. For example, most auction methods of allocating the emission rights are presented by the means of indivisible goods auctions, or the uniform price auctions with special conditions (such as secret reserve price). The auction methods which aim at the emission rights with the characteristics of homogeneousness and divisibility are not sufficient and in-depth.

Emission rights, such as COD, SO2 and NH3-N, may be classed as homogeneous divisible goods (homogeneous divisible goods means one unit good can be divided into many smaller units. For example, stocks, treasury bills and spectrum besides emission rights, are all divisible goods), so we can design a uniform price auction of divisible goods mechanism to allocate the emission rights. The uniform price auction mechanism is widely used in financial and commodity markets to sell identical securities or goods to multiple buyers. Wilson [13] was the first to consider uniform price auctions of divisible goods. He showed that there exists an equilibrium in which the asset is sold for half of its value in several settings. Klemperer [14] generalized this result by showing that any low price can be supported in equilibrium. Based on the results given by Wilson and Klemperer, Back and Zender [15] demonstrated how such a uniform-price auction can yield sensible results, consider the strategic difference between unit-demand and divisible goods auctions, and compare uniform-price and discriminatory auctions. This research has motivated further theoretical analysis of the divisible goods auction. Recently, Kremer and Nyborg [16] used a model of fixed supply divisible-good auctions, to study the effect of different rationing rules on the set of equilibrium prices. Wang and Zender [17] studied the divisible good simultaneous auctions, he pointed out that when the buyers' information is symmetric, the strategic aspects of bidding imply that there always exist equilibrium of a uniform-price auction with lower expected income than provided by a discriminatory auction. However, when buyers are risk averse, there may exist equilibrium of the uniform-price auction that provides higher expected income than a discriminatory auction. Damianov et al. [18,19] compared the uniform price and the discriminatory auction in a setting of supply uncertainty. They concluded that in every symmetric mixed strategy equilibrium, buyers submit higher bids in the uniform price auction than in the discriminatory auction. Furthermore, Genc [20] compared results for discriminatory auctions to results for uniform-price auctions when suppliers have capacity constraints. He has a pretty good understanding of what equilibrium results look like for the uniform price auctions. But an unresolved problem is what happens when a discriminative auction is run and suppliers have capacity constraints. They showed that payments made to the suppliers in the unique equilibrium of the discriminatory auction can be less than the payments in the uniform-price auction, depending on which uniform-price auction equilibrium is selected.

Aiming at maximizing the profit for the seller and eliminating the low price equilibrium in the emission rights auctions, this paper presents a uniform price auction mechanism with uncertain supply and asymmetric buyers. In this auction mechanism, the seller allows strategic buyers and non-strategic buyers to participate in an auction simultaneously. Then the seller strategically rations emission rights to the strategic buyers after having observed the bids. We solve the asymmetric Nash equilibria for this auction mechanism, and give some related strategies and suggestions to the seller on how to design a better emission rights auction mechanism, and how to induce the auction to a desired ideal equilibrium state.

The rest of this paper is organized as follows. Section 2 gives some assumptions and definitions, and presents an emission rights auction mechanism. Section 3 solves pure strategy asymmetric Nash equilibria for this auction mechanism, and gives some suggestions and improved strategies on how to implement this emission rights auction mechanism. Section 4 concludes this paper.

2. The auction mechanism

To begin, we give some important assumptions and definitions to describe the emission rights auction design problem which this paper will consider.

It is supposed that there is one risk neutral seller want to sell θ units of emission rights (e.g. COD) by using a uniform price auction. The seller faces two kinds of buyers to participate in the tender. One kind is formed by $n(n>2)$ risk-neutral, rational, competitive, and strategic buyers (which is named strategic buyers hereinafter), and another kind is formed by a small number of noncompetitive and non-strategic buyers (which is named non-strategic buyers hereinafter). Suppose that the maximum total supply quantity of emission rights the non-strategic buyers can get is θ', where $0 < \theta' \leq \theta$.

The maximum amount which all non-strategic buyers would be willing to pay for the per unit emission rights is p_0. p_0 is a reserve price only known by the seller and all non-strategic buyers. However, all strategic buyers do not know the real value of p_0 and treat it as a draw from a cumulative distribution $F(p_0)$. $F(p_0)$ is defined on a support $\Omega=(0,v]$ and with a density function $f(p_0)$. The per unit value of emission rights to each strategic buyer is v and is common knowledge.

Moreover, we suppose that all strategic buyers are asymmetric, and each buyer is assumed to choose a demand function $s_i(p)$, $i=1,2,\cdots,n$, from the set S, which is defined as the set of non-decreasing, piece-wise continuously differentiable with respect to price. Let $S(p)=\sum_{i=1}^{n} s_i(p)$ be the aggregate demand function at price p, and $S_{-i}(p)=\sum_{j=1, j\neq i}^{n} s_j(p)$ be the aggregate demand function of all strategic buyers but buyer i. $S(p)$ and $S_{-i}(p)$ are also non-decreasing, piece-wise continuously differentiable.

To improve the seller's decision-making environment and increase the effectiveness of emission rights auction, we suppose that the seller strategically rations the strategic buyers after having observed the demand functions, namely, $\sum_{i=1}^{n} q_i=\lambda\theta$, where q_i denotes the emission rights quantity awarded to the buyer i. λ is called supply coefficient, and $\lambda \in [0,1]$.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
✓ امکان دانلود نسخه ترجمه شده مقالات
✓ پذیرش سفارش ترجمه تخصصی
✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
✓ دانلود فوری مقاله پس از پرداخت آنلاین
✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات