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Ecological Economics 53 (2005) 47–58

ECOLOGICAL ECONOMICS

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METHODS

Testing the theory of emissions trading: Experimental evidence on alternative mechanisms for global carbon trading

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Received 7 September 2002; received in revised form 9 August 2004; accepted 6 December 2004
Available online 9 February 2005

Abstract

Simulation models and theory prove that emission trading converges to market equilibrium. This paper sets out to test these results using experimental economics. Three experiments are conducted for the six largest carbon emitting industrialized regions. Two experiments use auctions, the first a single bid auction and the second a Walrasian auction. The third relies on bilateral, sequential trading. The paper finds that, in line with the standard theory, both auctions and bilateral, sequential trading capture a significant part (88% to 99%) of the potential cost savings of emission trading. As expected from trade theory, all experiments show that the market price converges (although not fully) to the market equilibrium price. In contrast to the theory, the results also suggest that not every country might gain from trading. In both the bilateral trading experiment and the Walrasian auction, one country actually is worse off with trade. In particular bilateral, sequential trading leads to a distribution of gains significantly different from the competitive market outcome. This is due to speculative behavior, imperfect foresight and market power.

Keywords: Emissions trading; Experiment; Efficiency; Distribution; Carbon dioxide

JEL classification: Q2; C9; K3

1. Introduction

There is general agreement among environmental economists that emission trading is well suited to restrict the emissions of a uniformly dispersed pollutant such as CO_2 emissions (Tietenberg, 1985; Klaassen, 1996). The idea that international emission trading between parties creates flexibility, thus allowing lower total abatement costs, has been the basis for incorporating emissions trading in the Kyoto protocol. Numerous publications have calculated the expected cost savings of international

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0921-8009/$ - see front matter © 2005 Published by Elsevier B.V.
doi:10.1016/j.ecolecon.2004.12.017

carbon trading, taking into account different market structures and restrictions on trade (see Yamin et al. (2000) for a survey). The common characteristic of these simulation studies is that they use a static framework and assume market equilibrium will be realized.

Assuming well-behaved emission abatement cost functions, initial grandfathering of emission permits and price taking behavior of trading parties, the proof that market equilibrium exists is relatively straightforward (Montgomery, 1972). However, it leaves the question unanswered whether starting from disequilibrium, and in a context where bilateral trades are made sequentially at changing non-equilibrium prices, the market indeed converges to an equilibrium. Recently Ermoliev et al. (2000) tackled this problem and proved that sequential bilateral trading of emissions converges to a cost minimizing emissions market equilibrium. The trading scheme only requires that sources bilaterally state their demand price (as buyers) and supply price (as sellers) and agree on price and quantity in bilateral negotiations and contracts. This reflects the behavior in existing markets, where brokers serve the important function of bringing together the relevant information.

If emission reductions are implemented immediately by sources after each round of trade, they are tied up into sunk cost. These sources may not be willing to participate in subsequent rounds of trades, which may require reversing earlier decisions on emission levels. If so, the final result will not be cost-efficient. Therefore, the dynamic market model, as specified by Ermoliev et al. (2000) assumes reversibility before irreversible real decisions are taken, by separating the price formation stage from the actual implementation stage. This problem of irreversibility can be overcome by leasing permits for a limited period rather than auctioning them in perpetuity.

An alternative to a decentralised search for the cost-effective vector of emissions is a Walrasian auction of emission permits (Ermoliev et al., 2000). Such an auction also results in minimizing total emission control cost. The auction consists of two stages: a search stage, in which the auctioneer searches for the equilibrium price; and a second stage, in which transactions are made at the market equilibrium prices. The search stage is opened by the auctioneer who announces the permit price. Each participant then knows the price to pay for an extra unit of emission reduction or to receive for each additional unit of emission reduction. If the price is higher than the participant's current marginal cost, he will decide to reduce his emissions below his initial emissions level and sell permits. He will inform the auctioneer how many emission permits he wants to sell. On the other hand when the emission price is below the marginal cost of emission reduction, the source has an incentive to increase its planned emissions; it will state its demand for emission permits. The auctioneer then calculates market demand and revises the price upwards when demand exceeds supply and downwards when supply exceeds demand. It should be noted that sources have to state only the number of permits they are willing to sell or to buy at the price proposed by the auctioneer. Only the auctioneer has knowledge of demand and supply for permits. The procedure converges to an equilibrium with cost-efficient emissions.

The above theoretical contributions to the dynamics of emission markets may be logically correct, that does not mean they are also true. The real world can differ from what theory predicts. The purpose of this article is to test the theory using the methods of experimental economics and apply these to international carbon trading under the Kyoto Protocol. Although our experiments deal with market adjustments over a series of iterations, we do not explicitly analyze banking or borrowing (in contrast to, e.g. Rubin (1996) and Stevens and Rose, 2002). Neither do we discuss anything other than the emission reduction commitments for the first compliance period of the Kyoto Protocol (2008–2012).

Analyzing proposed policies in which critical institutional design issues confront policy makers is an obvious task for experimental methods (Smith, 1994; Issac and Holt, 1999). Experimental methods have been used to examine policy proposals ranging from electricity rate design to scheduling cargo regimes on the space shuttle (Banks et al., 1989). Following Montgomery's (1972) seminal theoretical work on emissions trading, experiments on mechanisms for trading emissions permits