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ELSEVIER Journal of Economic Dynamics & Control 32 (2008) 1830–1856
JOURNAL OF Economic Dynamics & Control
www.elsevier.com/locate/jedc

A two-level dynamic game of carbon emission trading between Russia, China, and Annex B countries

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Received 8 October 2002; accepted 6 July 2007
Available online 24 July 2007

Abstract

This paper proposes a computable dynamic game model of the strategic competition between Russia and developing countries (DCs), mainly represented by China, on the international market of emission permits created by the Kyoto Protocol. The model uses a formulation of (i) a demand function for permits from Annex B countries and (ii) marginal abatement costs (MAC) in Russia and China provided by two detailed models. GEMINI-E3 is a computable general equilibrium model that provides the data to estimate Annex B demand for permits and MACs in Russia. POLES is a partial equilibrium model that is used to obtain MAC curves for China. The competitive scenario is compared with a monopoly situation where only Russia is allowed to play strategically. The impact of allowing DCs to intervene on the international emission trading market is thus assessed.

JEL classification: C73; D58; H41; Q25

Keywords: Dynamic games; Cournot–Nash equilibrium; Computable general equilibrium modeling; Climate change; Kyoto Protocol; Emission trading; Russia; China

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0165-1889/$ - see front matter
doi:10.1016/j.jedc.2007.07.001

1. Introduction

The aim of this paper is to propose a computable economic model of the strategic interactions between Russia and developing countries (DCs), in particular China, in international markets for carbon emission permits created by the Kyoto Protocol (UNFCCC, 1997). This model provides an assessment of the impact of this competition on the pricing of emission permits. We assume that some DCs will participate in future climate negotiations of the Kyoto Protocol and be able to sell emission permits on the international market. We also assume that the rest of the world will behave as a passive set of players integrating the emission permits in their production decisions according to the rules of a time-stepped[1] competitive economic equilibrium. A particular feature of the Kyoto Protocol is the large quantity of emission rights granted to Russia, since they were based on historic levels. Due to the collapse of the traditional industrial sectors in Russia, these emission rights – also called '*hot air*' – are now available at no cost. The agreement allows Russia to bank these emission rights and optimize over time their sale on the international market. This feature gives a dynamic structure to this oligopolistic competition for selling emission permits to other countries. We formalize it as a dynamic multistage game for which we compute an open-loop Nash equilibrium solution (Başar and Olsderh, 1989; de Zeeuw and van der Ploeg, 1991; Dockner et al., 2000). Differential game models have already been used successfully in environmental economics as e.g. in the fishery games[2] and more recently to analyze the acid rain game (Maler and de Zeeuw, 1998). In the Kyoto Protocol context Loschel and Zhang (2002) have analyzed the interactions between Eastern Europe and Russia as a static Cournot model of duopoly, where the two regions simultaneously set their quantity supplied to the permits market by 2010.

The model we propose also includes transaction costs. The transaction cost approach to the theory of the firm was first introduced by Coase (1937) in his seminal paper 'The Nature of the Firm'. Transaction costs refer to the cost of providing for some good or service through the market rather than from within the firm.[3] Several authors have commented on the potential importance of transaction costs in tradable permits markets (Hahn and Hester, 1989; Stavins, 1995).[4] Stavins (1995) identifies three potential sources of transaction costs in tradable

[1]This means that the equilibrium is not dynamic and the investment strategies are fixed.

[2]See Kaitala (1986), Hamalainen et al. (1986) and Benchekroun and Long (2002) as a brief sample of the large literature on the topic.

[3]In 'The Problem of Social Cost', Coase (1998) explains that 'in order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on. More succinctly, transaction costs consist of ex ante and ex post costs. In the market the ex ante costs include the expense of searching for a trading partner, specifying the product(s) to be traded and negotiating the price and contract. The ex post transaction costs are incurred after the contract has been signed but before the entire transaction has been completed. These include late delivery, non-delivery or non-payment and problems of quality control'.

[4]See also the U.S. experience on SO_2 allowance trading (Joskow et al., 1998) and RECLAIM Trading Credits for NO_x and SO_x (Dudek and Wiener, 1996).