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Emission trading and international competition: The impact of labor market rigidity on technology adoption and output

Alejandro Caparrós [a,*], Jean-Christophe Péreau [b], Tarik Tazdaït [c]

[a] Consejo Superior de Investigaciones Científicas (CSIC), Institute for Public Goods and Policies (IPP), Albasanz 26, 28037 Madrid, Spain
[b] University Montesquieu-Bordeaux IV, GREThA (UMR CNRS 5113), Avenue Léon Duguit, 33608 Pessac Cedex, France
[c] CIRED — CNRS — EHESS — Ecole des Ponts ParisTech Jardin Tropical, 45 bis av de la belle Gabrielle, 94736 Nogent sur Marne Cedex, France

HIGHLIGHTS

- ► Emission trading reduces production and improves abatement technologies.
- ► Policy makers see the first outcome as negative and the second as positive.
- ► This paper studies the impact of market rigidity on these two outcomes.
- ► It shows conditions to avoid the first outcome and maintain or enhance the second.

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ABSTRACT

Emission trading systems have been proposed in different regions to reduce polluting emissions and are in use in the European Union for carbon dioxide emissions. One of the objectives of these systems is to encourage firms to adopt advanced abatement technologies. However, permits also create an incentive to reduce output, which may be seen as negative by policy makers. We analyze the impact of a rigid labour market on these two outcomes, showing the conditions necessary to avoid reductions in production while keeping the incentives to improve abatement technologies. The analysis is done for oligopolistic firms engaged in international rivalry.

1. Introduction

The European Union has an emission trading system (EU ETS) that has gradually increased the sectors covered.[1] Right from the beginning, one of the objectives of this carbon dioxide emission trading system has been to create an incentive to adopt advanced abatement technologies: "This Directive will encourage the use of more energy-efficient technologies" (OJ, 2003).[2] Extensive literature has investigated the convenience of a permits system to reach this objective (Montero, 2002; Requate and Unold, 2003, see Jaffe et al., 2003 for a survey). However, an emission trading system may have an additional impact: creating incentives to reduce production (Gielen and Moriguchi, 2002). We analyze this impact, which is generally seen as negative, studying the conditions under which this impact can be reduced while keeping the benefit of encouraging advanced abatement technologies. There are at least two reasons that explain government's interest in maintaining production levels: (i) the preoccupation about unemployment (very strong in Europe), as lower production implies in our model lower employment in the domestic country and (ii) the interest in not reducing Gross Domestic Product (GDP), as GDP growth is a key indicator in the public debate (as long as price effects do not offset the negative impact of reduced production).

As we are interested in analyzing this issue in an international setting, we build on the model developed by Spencer and Brander (1983) to study R&D incentives and international rivalry. Thus, we assume duopolistic competition in a third market between a

* Corresponding author. Tel.: +34 916022536; fax: +34 916022971.
E-mail addresses: alejandro.caparros@csic.es (A. Caparrós), jean-christophe.pereau@u-bordeaux4.fr (J.-C. Péreau), tazdait@centre-cired.fr (T. Tazdaït).

[1] The EU ETS covers installations performing specified activities. Since the start it has covered, above certain capacity thresholds, power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Since January 2012, aviation is also included in the EU ETS. From 2013, the scope of the EU ETS will be extended to also include other sectors and greenhouse gases. CO_2 emissions from petrochemicals, ammonia and aluminium will be included, as will N_2O emissions from the production of nitric, adipic and glycolic acid production and perfluorocarbons from the aluminium sector. The capture, transport and geological storage of all greenhouse gas emissions will also be covered. As for greenhouse gases, it currently only covers carbon dioxide emissions, with the exception of the Netherlands, which has opted in emissions from nitrous oxide (available at ec.europa.eu).

[2] See also European Commission (2005).

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domestic and a foreign firm.[3] The assumption of imperfect competition is well suited for most of the sectors affected by the EU ETS (Antweiler and Trefler, 2002). We further assume that the domestic country or region (e.g. the European Union) establishes an emission trading system, while the foreign country (e.g. the United States) does not.[4] This implies that the firm producing in the domestic country has to pay the permit price $\beta > 0$ when its emissions exceed a limit E of permits grandfathered (we assume throughout the paper that the ETS has a binding cap and that the equilibrium permit price is strictly positive). Conversely, when the emissions of the firm producing in the domestic country are lower than this limit E, the firm can sell permits at the price β. As the EU ETS is mainly focused on energy intensive sectors, we assume that the inputs in the firm's production function are energy, technology (capital) and labor.

We also analyze the impact of a second big difference between the conditions under which an American (foreign country) and at least some European (domestic country) firms produce: the rigidity of their labor markets. On average, European countries have much stronger employment protection regulations than the US, although there are marked differences between countries within Europe (Southern European countries have the strongest provisions, followed by the Central European countries, the Nordic countries and finally Ireland and the UK, which are the least restrictive in Europe; see OECD, 1999). Bartelsman et al. (2004) provide evidence from firm-level data that these cross-country differences in employment protection influence firms' behavior (they show that young expanding European firms grow more slowly than their US counterparts). In contrast, in a theoretical analysis, Kessing (2006) found that firms facing employment protection will defend their market position more fiercely, resulting in a larger average market position.

We do not study possible revenue-recycling effects or the impact of distortionary taxes, as has been done in most of the literature that has linked environmental policy (mainly taxes) and labor markets (Bovenberg and Goulder, 1996; Parry et al., 1999). On the contrary, we link environmental policy and labor policy and analyze the impacts on output and technology adoption decisions of the former (we focus on energy saving technologies, for an analysis of the relationship between labor-saving technology and labor market rigidity see Lommerund and Straume, 2012).

There is a vast literature that studies strategic international environmental policy in an international competition framework (Conrad, 1993; Barrett, 1994; Rauscher, 1994; Ulph, 1996, amongst others). These models show that environmental policy, in the form of taxes, emission standards or R&D subsidies, can favor domestic firms and be therefore used by governments strategically. Our approach extends these analyses by taking into account the impact of labor market rigidity, although we do not analyze the strategic behavior of the government but exclusively the optimal reaction of the firms to a situation where both, environmental and labor policy is considered.

The analysis entails a sequential decision. In a first stage firms choose technology, while production and sales occur in a second stage. As this implies a two-stage game with complete information, the equilibrium concept to be used is the Subgame Perfect Equilibrium (SPE) proposed by Selten (1965, 1975), and we solve the game by backward induction. Instead of adding a third stage to analyze the strategic behavior of the government as in the papers mentioned in the previous paragraph, we simply suppose that the government is not interested in emission reductions obtained through reductions in output (due to undesired impacts on employment and growth), while it is interested in emission reductions induced by technological changes. Since we show below the conditions under which setting up an emission trading system (or increasing the equilibrium permit price, for example by tightening the cap) implies output reductions, we analyze the impact of labor market rigidity on this outcome showing conditions under which production reductions are avoided while abatement technologies are enhanced. Given the international rivalry context analyzed, we focus on relative levels of technology.

The paper is organized as follows. Section 2 describes the basic model. Section 3 studies optimal production decisions (the second stage of the game). Section 4 analyzes optimal technology decisions (the first stage of the game). Section 5 concludes.

2. The model

There are two countries, designated by the subscripts $n=1$, 2 (we also call them, respectively, domestic and foreign country). Each country has a representative firm whose sales are denoted by y_n. A single homogeneous good is sold in a duopolistic market. As in Spencer and Brander (1983), in order to focus on the purely rent-seeking rationale, we assume that all the output produced is for export to other countries (for simplicity, exchange rates are constant). The duopoly equilibrium arises from the sales: y_1+y_2. Cournot–Nash behavior is assumed. The revenue function is denoted by $R_n(y_1,y_2)$. The following standard assumptions apply[5]:

$$R_i^i > 0,\ R_i^j < 0;\ R_i^{ii} < 0,\ R_i^{jj} > 0 \quad \text{and} \quad R_i^{ij} < 0 \quad \forall i,j \in (1,2) \quad \text{and} \quad i \neq j$$

Outputs y_1 and y_2 are substitutes. Increasing the output of one good decreases the marginal revenue of the other good. Energy inputs (e_n), technology (x_n) and labor (l_n) are the main components in the firms' production function: $y_n = f_n(e_n,x_n,l_n)$. An essential assumption is that the production of each firm takes place in its home country.

The unit costs of energy are given by p_1 and p_2. To simplify we assume that these prices are per unit of emissions associated with a unit of energy[6](i.e. we give the price not in tons of oil but in tons of CO_2 associated with a ton of oil).

Country 1 is assumed to have an emission trading market with a binding cap on emissions (as we are under perfect information, similar results would be obtained using a tax). Hence, firms in country 1 have to pay $\beta > 0$ (permit price) whenever the number of tons of carbon emitted (e_1) is higher than a given amount of permits grandfathered E. The value of the latter variable determines if firms are "environmentally constrained" (i.e. $E < e_1$). Hence, for $E < e_1$ the firm has an additional cost owing to the need to buy permits, while for $E > e_1$ the firm has an additional source of benefits (the income of the permits sold). The domestic firm, although a duopolist in its main market, is supposed to be too small to influence the price in the emission trading market, a market that covers several sectors. Therefore, firm 1 is price-taker in the emission trading market and

[3] We follow the standard assumption that competition takes place in a third market to focus on the purely rent-seeking rationale, and to avoid the need to treat explicitly possible border tax adjustments. Thus, strictly speaking our model only applies when a European and an American firm sell in a third country (e.g. the rest of the world), although the key messages would hold if this assumption were relaxed.

[4] The European Union has ratified the Kyoto Protocol and has a working emission trading system for CO_2. The United States has not ratified the Kyoto Protocol and has not established a mandatory emission trading for CO_2 yet, although different plans to do so are under discussion (Arroyo, 2011). In any case, the examples could also be a firm in the European Union and a firm in China.

[5] Superscripts are used to denote the letter entry in a function for which differentiation is done. The number indicates the order of the letter in the definition of the function. That is: $R^1(y_1,y_2) = \partial R(y_1,y_2)/\partial y_1$, and $R^{12}(y_1,y_2) = \partial^2 R(y_1,y_2)/\partial y_1 \partial y_2$. Subscripts are used to denote the country.

[6] We could also use θe_1 for emissions and e_1 for energy but it would complicate the results with no real gain.