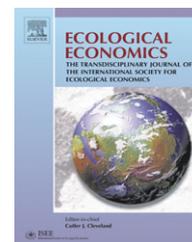


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## ANALYSIS

# Asymmetric information, signaling and environmental taxes in oligopoly<sup>☆</sup>

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## ABSTRACT

This paper examines the effects of signaling on environmental taxation in a two-period oligopoly model in which each firm privately knows whether its technology is clean or dirty, while third parties (the rival firms and the regulator) have only a subjective perception about this fact. Consequently, there are both horizontal and vertical asymmetric information, and each firm can strategically manipulate both, the competitor's and the regulator's priors. In this context, we find that each firm wishes to be perceived as a technologically clean firm in period 2 whenever the regulator's ecological conscience is sufficiently high. We also show that taxes under symmetric information are always positive, but under asymmetric information and signaling they may be negative (subsidies) and lower or greater than in the symmetric information case, depending on the ecological conscience of the regulator and the probability of firms being dirty. Finally, taxes are below environmental marginal damage, both under symmetric and asymmetric information, and signaling reinforces such under-taxation.

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## 1. Introduction

Economic activity involves not only the production of goods, but also causes negative external effects that producers and consumers often are unable to internalize by themselves. Therefore, environmental protection has become a priority and a challenge for many governments.

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Among the market-oriented instruments to protect the natural environment from the increasing cost of human behavior, pollution taxes are possibly one of the most widely used instruments.

However, the issue of imposing pollution taxes to control emissions is the target of a long-standing debate in the environmental economics literature, dating back to Arthur C. Pigou's (1920) well-known treatment of the subject. In theory, pollution taxes have many advantages when compared to command-and-control policies<sup>1</sup>, although their effects may be also distorted by multiple factors, including the market structure, the amount of asymmetric

<sup>1</sup> For instance, they allow least-cost abatement, are generally more dynamic, raise revenue for the government, provide incentives for producers and consumers alike, and, moreover, there is substantial historical experience of their application.

information, and the speed of transmission of private information.

In the present study we focus our analysis on oligopolistic market structures, and in particular on a duopolistic industry. Buchanan (1969) was the first challenging the Pigouvian paradigm by pointing out that a monopoly distorts its optimal solution by holding down its output. As such, Pigouvian taxation would lead to a second best solution in the presence of monopolistic structures. Thus, market structures seem to heavily affect taxation solutions.

The extension from monopolistic to oligopolistic structures was a natural one. Indeed, oligopolistic structures have been already studied in the context of pollution markets (Bárcena-Ruiz and Garzón, 2006; Carlsson, 2000; Katsoulacos and Xepapadeas, 1995; Kim and Chang, 1993; Levin, 1985; Simpson, 1995; Yin, 2003). However, to our knowledge, the analysis presented here departs from previous studies in significant ways. First, it deals with asymmetric information in the context of a dynamic duopoly game. Asymmetric information problems have been widely treated in environmental economics, although most applications are static (Kim and Chang, 1993; McKittrick, 1999). A salient example is that by Leung (1992) who examines a situation in which both polluter and victim have full information about each other's preferences and technology, but the regulator faces lack of information. The polluter is taxed so as to redistribute revenues between the polluter and the victim, and the victim is taxed to prevent him/her from exaggerating the claimed damage. In this context, a policy of taxing both, the injurer and the victim, leads to an economically efficient pollution level, because it helps the uninformed regulator in the case of a sequential game. Other authors discuss different possibilities in the context of simultaneous or sequential games. For instance, Barigozzi and Villeneuve (2006) focus on the signaling effect of taxes when the agents are less informed than the regulator about their consumption effects, showing that optimal taxes cannot be implemented under asymmetric information.

Our model examines a game in which each firm is privately informed about its technology, but other players can only infer such information from observation of its output level. In this context, we compare the optimal output levels and pollution taxes either in a symmetric or asymmetric information scenario. In this sense, our model allows us to understand the interaction between the firms' opportunistic behavior and the regulator's tax policy.

A second important innovative aspect in our model is that firms are asymmetric with respect to their production technologies and emissions. This is an important refinement that corresponds quite well with most market situations in which technologies are different across market players. In this sense, the only work we are aware of in which firms are asymmetric with respect to their production (and abatement) costs was conducted by Long and Soubeyran (2005). However, their contribution is fairly different to the one here presented, since they resolve the oligopolistic pollution game in a differential setting with symmetric information. Their results show, as the present research, that based on cost asymmetry, the optimal tax differs across firms.

The purpose of this paper is thus to examine the extent to which the disclosure of polluting firms' technologies affects the magnitude of environmental taxes imposed by a regulator, as compared to the case in which the information among players is symmetric. Firms that pollute in varying amounts according to their productive technology will predictably attempt to alter the amounts of their production levels -and, accordingly, their emissions as perceived by other players (including the regulator)-, by misrepresenting their technology. In other words, firms will certainly intent to influence the extent of pollution levels that other players believe they are emitting, while not necessarily altering their actual levels. This represents a significant policy-making problem when setting appropriate tax levels, since the regulator faces a conflict between expected social welfare and informational objectives that may affect the magnitude of pollution taxes. More precisely, there seems to be a reciprocal influence between the firms' opportunistic behavior and the regulator's taxing policies.

In the following model, two firms produce a homogenous good through two production periods and a regulator is concerned about the environment, using per-unit taxes to maximize the expected total welfare. Each polluting firm has private information about its own marginal and average production cost (specifically, whether it is low or high). Third parties, on the other hand, have only some prior beliefs in this respect. In particular, the regulator faces an information problem when imposing in each production period the environmental tax on each polluting firm, for the two possible cost situations (low-cost or high-cost).<sup>2</sup> The current paper examines whether optimal pollution taxes are sensitive to the assumed information structure, the above-mentioned incentives of the firms, and the flow of such information from incomplete to complete.

Our environmental tax game has the following time frame. In period 1, before becoming aware of the type of polluters in the market, the regulator announces and commits to a per-unit environmental tax for this period, and each polluting firm produces an output level which generates a given emission level. The quantity produced by each firm at the end of the first period is observed by both, the rival firm and the regulator, and this provides them with full information about their production technology and, consequently, about their emission levels. Once they update their probability assessment that a given firm uses a certain technology, the regulator announces and commits, at the beginning of the second period, to a period 2 per-unit output environmental tax. Finally, each of the firms selects the output level for period 2. In this case, environmental taxes are selected period by period as information is gathered; a policy that may be regarded as a form of short-run tax policy.

<sup>2</sup> In our model, dirty firms, which pollute a lot per unit of output, are identified as those firms that have a low marginal cost of production (due to the fact, for instance, that they do not incur in abatement costs), while clean firms, which pollute less per unit of output, are understood as those firms with a high marginal cost of production, because they face abatement costs.

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