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The switching effect of environmental taxation within Bertrand differentiated duopoly

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ABSTRACT

We investigate second-best optimal taxation of the polluting variety of a product in a Bertrand duopoly with differentiated varieties. The analysis provides novel insight on a useful social function of environmental regulation. Besides internalizing the environmental externality, the taxation of the polluting variety improves the matching of consumers and product varieties, and so creates a socially desirable business switching between the differentiated varieties.

1. Introduction

The economic literature has long recognized that the Pigovian task of internalizing marginal social damage is not the only task to be performed by environmental taxes. In most general equilibrium models where pollution is generated under perfectly competitive conditions, the environmental tax is also shown to serve the Ramsey purpose of raising public revenues in order to finance public goods other than the environment (see [37]). In this case, the second-best optimal tax must lie below the marginal environmental damage to achieve an optimal trade-off between the Pigovian and the Ramsey uses of the tax (see [9]). Furthermore, when pollution is produced by an imperfectly competitive industry, the environmental tax proves successful in correcting the distortions associated with market power in the absence of other regulatory devices. It turns out that, in general, the second-best optimal policy under imperfect competition is again to impose a tax lower than the marginal environmental damage. A general intuition provided by Buchanan [10] is that scaling down the tax below the Pigovian level solves the tendency of imperfectly competitive firms to underproduce. This rule holds true not only when pollution is generated by a monopoly (see [22,6]), but also by a symmetric Cournot duopoly (see [23]) or an asymmetric Bertrand duopoly with homogeneous product (see [34]). One exception to the rule is that pointed out by Simpson [38]: in the Cournot duopoly with asymmetric costs of production the second-best optimal tax may be greater than marginal damage so as to redistribute output from a less efficient producer to his more efficient rival.

Taking a step forward in this literature, the present analysis pays careful attention to another social function served by taxation of a polluting product. Taxation improves the matching of consumers with heterogeneous tastes and the differentiated varieties of a product by creating a desirable switching effect between these varieties. While the social

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benefit deriving from this function is acknowledged in a perfectly competitive context with clean and dirty goods (see [9]), all the aforementioned studies of imperfectly competitive markets fail to account for the substitution possibilities between differentiated varieties that environmental taxation can in fact exploit. The simple reason is that their common focus on homogeneous products cannot capture evidence that consumers perceive differences among the products of firms with different names or logos, thereby treating products as imperfect substitutes.[1] Moreover, the Cournot assumption that prices are chosen by a fictitious auctioneer has long been criticized on the grounds that no such auctioneer exists. In most real-world industries under imperfect competition, prices are chosen by producers who then commit to provide any quantity demanded at those prices.[2] Being more relevant than the Cournot approach in this respect, the Bertrand differentiated products model has successfully been applied to various industries (e.g., [8,17]).

The literature on environmental taxation of imperfectly competitive markets typically ignores other constraints, such as the budget constraints, although this is a central issue in general equilibrium models (see [9,26], or [16]). We propose here to investigate the role of second-best optimal taxation in the Bertrand context of two producers setting prices and supplying differentiated varieties of the same product at those prices, when the regulator has a revenue-raising requirement. One variety is called ''conventional'', in that it pollutes the environment, while the other variety, which we call ''green'', bundles the product with an environmental service to the buyer. By environmental service, we mean the use of recyclable materials, energy efficiency in the whole production process, the adoption of renewable sources of energy, the restricted use of chemicals or the removal of heavy metal, indeed any service that might be certified by a reliable ecolabel. This is consistent with the observation that ecolabeling is increasingly used by firms as a strategic means of vertical differentiation.[3] Besides this vertical differentiation, the green variety also differs from the conventional variety along a horizontal characteristic. Moreover, the introduction of the revenue requirement implies that, rather being simply imposed with a corrective intention, the tax must also be adjusted to account for the cost of raising funds, as commonly experienced by European policymakers in their recent attempts to introduce environmental taxes.

In our Bertrand duopoly with differentiated products, it is no longer obvious that the second-best optimal tax on the conventional variety should be set below the marginal damage. First, scaling down this corrective tax may run against the regulator's objective of raising more revenue when public funds become scarcer. In our setting, such growing scarcity requires, on the contrary, that the regulator increases the taxes. Moreover, low taxes on the polluting variety can reduce the number of consumers that buy the green variety below the social preferred level. When, for instance, the cost of tying the product with the environmental service is low or the buyers' aversion to pollution is high, or the environmental damage is severe, it can be socially efficient to encourage buyers to switch to the green variety. In that case, we show that the optimal tax should exceed marginal damage. The intuition for this result is that heavy taxation of the conventional variety makes the polluting producer less aggressive in his pricing strategy. Such a competition-reducing effect implies transfers between Bertrand rivals that achieve a socially desirable split of the market. This result is closely related to that illustrated with a numerical example by Lange and Requate [21] who investigate uniform taxation in a price-setting duopoly with differentiated products. According to these authors, the reason why the second-best optimal tax should be higher than marginal damage is to offset the extreme advantage of the polluter with respect to the private cost. This intuition however, does not always hold in our analysis. When the polluter has much lower production costs than his green rival, the marginal savings from producing the conventional variety are high, which makes this variety fairly valuable from a social standpoint. This provides the regulator with an incentive to reduce the tax on this variety – perhaps even subsidizing it – in order to divert buyers away from the green variety. Moreover, subsidies or low taxes have a competition-enhancing effect by making the polluter as well as his rival more aggressive in their pricing strategy. Thus, scaling down the tax on the conventional variety can also help the regulator to correct the distortion due to Bertrand behavior within the differentiated duopoly. In contrast, raising this tax makes the polluting producer soft in his pricing strategy, thereby decreasing the intensity of price rivalry between producers due to the strategic complementarity of prices. Hence, the '' induced'' effects of taxation recognized by Myles [28,29] for imperfectly competitive markets still occur when the tax must also correct for the environmental externality.

Besides the regulator's task of internalizing the two negative externalities generated by pollution and Bertrand pricing, attention is also paid to how second-best optimal taxation of the conventional variety is altered by the regulator's revenue-raising requirement. When circumstances require soft (severe) taxation, the optimal tax rises (falls) in response to an increase in the regulator's need for revenue. The intuition departs from that underlying the result of a fall in the optimal Pigovian tax in response to increasing revenue needs, established by general equilibrium models under perfect competition (see, for instance, [26]). When heavy taxation of the polluting producer is required under Bertrand pricing with differentiated products, scaling down the tax makes this producer more aggressive in his pricing strategy, thereby increasing the profit earned from the conventional variety as well as the surplus extracted by the regulator.

The present analysis has particular relevance at a time when policymakers need a sound understanding of how the design of environmental taxation affects economic outcomes. Recent examples include the so-called ''plastax'' imposed on

[1] In the words of Chamberlin [11, pp. 56–57], ''virtually all products are differentiated, at least slightly''.

[2] In an attempt to reconcile the Cournot model with this evidence, Kreps and Scheinkman [20] analyze a two-stage game in which firms choose capacities and then prices. Under a particular form of quantity rationing, they find that Cournot equilibrium outputs obtain.

[3] See [1,14]. Deltas et al. [14] note that the strategy of differentiating product with a green variety is now commonly used by market leaders such as Unilever, Toyota, Honda or MacDonalds, for the obvious purpose of increasing market power.