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journal homepage: www.elsevier.com/locate/irefConsumer awareness and ex-ante versus ex-post environmental policies revisited[☆]Xubei Lian^a, Qiang Gong^b, Leonard F.S. Wang^{b,*}^a School of Finance, Zhongnan University of Economics and Law, Wuhan, China^b Wenlan School of Business, Zhongnan University of Economics and Law, Wuhan, China

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ABSTRACT

In this paper, we re-investigate the strategic environmental policies in a free entry oligopoly. We consider two scenarios in which the government chooses the optimal level of tax before or after firms enter the market. We find that in both cases, the emission tax/subsidy could be provided and the optimal level of tax is always less than the marginal environmental damage. The most important result is that, regardless of the degree of the consumers' environmental cognition, the ex-post taxation case yields a lower level of tax and a larger number of firms than does ex-ante taxation. Our results have important implications on competition and environmental policies.

1. Introduction

The wave of economic liberalization now occurring around the world takes guidance provided by the WTO. The abolition of entry curbs and allowing new entries are promoted by the competition policy occurring in many imperfect-market industries. Competition policy coupled with many other intervention policies such as subsidization, tariff, and environmental regulations etc., should be scrutinized from the long-run welfare-improving standpoint. For example, the welfare effect of environmental and liberalization policies both, and the implementation of these two policies should be the major concern of policy decision-making. In this paper, we examine the strategic environmental policies in a free-entry oligopoly, wherein firms produce the differentiated goods with environmental damage that is measured by government and observed by consumers. We consider two scenarios in which the government chooses the optimal level of tax before or after firms enter the market.¹ In one model, the government liberalizes the market and then levies environmental taxes on the firms (termed ex-post taxation), while the order of the policy is reversed in the other model (termed ex-ante taxation).²

On early studies of environmental policies in oligopolistic framework, [Simpson \(1995\)](#) derived the optimal pollution for a Cournot

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¹ In [Lee, Matsumura, and Sato \(2018\)](#), a state-owned public enterprise is established before the game, private enterprises enter the market, and then the government chooses the degree of privatization of the public enterprise (termed the entry-then-privatization model). This showed that the equilibrium degree of privatization is too high (low) for both domestic and world welfare if private firms are domestic (foreign).

² Analysis of optimal taxation for polluting firms has been carried out under imperfect market structures with regulated entry and free entry. In fact, in many markets, barriers to entry are not sufficiently high to justify the number of firms in an industry as fixed ([Lee, 1999](#)).

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duopoly and found that if firms have different production costs, the optimal tax rate may exceed the marginal damage. [Bárcena-Ruiz and Garzón \(2002\)](#) analyzed environmental policy in a duopoly model with incentive schemes and showed that firm owners have to pay a higher environmental tax, and that both environmental damage and social welfare increase compared to the profit-maximization case. [Yin \(2003\)](#) examined corrective taxes under oligopoly with inter-firm externalities and pollution abatement, and showed that when externalities are substantial and/or the number of polluters is large, effluent levies on these firms do not necessarily result in a dead-weight loss. In a mixed oligopoly setting, [Bárcena-Ruiz and Garzón \(2006\)](#) explored how the decision on whether to privatize a public firm or not interacts with environmental policy, and showed that the tax is lower in a mixed oligopoly than in a private one, and that the environmental damage is greater. [Wang and Wang \(2009\)](#) re-examined whether privatization improves (or deteriorates) the environment in a mixed duopolistic framework with differentiated product and pollution abatement. [Pal and Saha \(2015\)](#) showed that when privatization and pollution tax are used together, environmental damage will be non-monotone in the level of privatization, and optimal privatization is always partial privatization. [Xu, Cho, and Lee \(2016\)](#) compared a Cournot with a Bertrand duopoly in a differentiated mixed market when both emission tax and privatization policies are used together.³

In a free-entry differentiated Cournot setting, [Fujiwara \(2009\)](#) constructed a model of polluting oligopoly with product differentiation, considering how product differentiation, together with the presence and absence of free entry, affects optimal pollution tax/subsidy policies.⁴ The signs of the short- and long-run optimal pollution taxes are highly sensitive to the parameter measuring product differentiation as well as the presence of free entry. [Hsu, Lee, and Wang \(2017\)](#) investigated the optimal environmental and privatization policies at regulated entry and free entry in a mixed oligopoly, wherein firms produce differentiated goods with environmental damage that is measured by government and observed by consumers. They showed that (i) in both mixed and private oligopoly with regulated entry or free entry, the emission tax/subsidy could be provided, and (ii) the number of the private firms at free-entry differentiated oligopoly after the public firm is privatized is socially inefficient even though the consumers have more choice of product varieties. The above papers did not consider the optimal environment policies under different game timing with free entry, which motivates us to incorporate the environmental awareness of individuals into a differentiated free-entry oligopoly, and consider the market liberalization and environmental policy under a different timing game and see the policy implications.

The environmental awareness of individuals has been incorporated into the analysis in the literature as the (perceived) environmental quality attributes that are additive to the physical quality attributes, which are assumed to be exogenously given (see [Conrad \(2005\)](#) and [Rodríguez-Ibeas \(2007\)](#)), while the notions of endogenous environmental awareness is considered by [Yakita and Yamauchi \(2011\)](#). For example, [Rodríguez-Ibeas \(2007\)](#) has considered a duopolistic model of environmental product differentiation with two types of consumers (green and brown) to analyze how environmental awareness affects the environment. He demonstrated that more environmental awareness may not be good news for the environment as the firm that produces the good without environmental attributes may increase its sales. The result depends on the degree of product differentiation and the cost to achieve it. Social welfare can also be inversely related to environmental awareness if the negative environmental effect dominates the positive market effect.

In this paper, we re-investigate the strategic environmental policies in free-entry Cournot oligopoly with environmental awareness under two scenarios in which the government chooses the optimal level of tax before or after firms enter the market.⁵ We find that the optimal taxation policy depends on whether taxation is implemented before or after the entry of firms. In both cases, the emission tax/subsidy could be provided and the optimal level of tax is always less than the marginal environmental damage. When the government chooses the level of emission tax before firms enter the market, the optimal level of tax decreases as the degree of the consumers' awareness goes higher, when the pollution is large. When the government chooses the level of tax after firms enter the market, the optimal level of tax also decreases as the consumers' cognition of pollution damage goes higher.

The most important result is that the ex-post taxation case yields a lower level of tax and a larger number of firms than does ex-ante taxation. Ex-ante taxation is preferable because the government more efficiently controls the number of entering firms, which results in a smaller number of firms, less environment damage and higher social welfare. Our results have important implications on competition and environmental policies.

This paper is organized as follows. Section 2 provides the basic model. Section 3 provides the results of the environmental policies in a differentiated oligopoly with free entry in the ex-ante and ex-post taxation cases. Section 4 presents a comparative analysis of the two cases. Section 5 presents conclusions.

2. The model

We consider an economy in which there exists n firms, producing horizontally differentiated goods which are produced by labor. The

³ [Beladi and Chao \(2006\)](#) restricted the discussion to the case of a monopoly without considering pollution abatement and proved that privatization paradoxically exerts a negative effect upon the environment. This paradox may be attributed to the failure of a monopolistic firm to control pollution.

⁴ [Lahiri and Ono \(2007\)](#) showed that in a polluting oligopoly with homogenous goods, when the number of firms is fixed, (i) a relative emission standard is welfare-superior to an emission-equivalent emission tax, and (ii) an emission tax is emission-superior to a welfare-equivalent relative emission standard. Under free entry and exit, the results are just the opposite when the inverse demand function is concave.

⁵ [Xu, Lee, and Matsumura \(2017\)](#) investigated the impact of the timing of privatization and liberalization policies on the degree of privatization and number of entering firms in free-entry mixed markets. They formulated two models: ex-post privatization and ex-ante privatization. In the former, the government liberalizes the market and then privatizes the public firm, whereas the order of the policies is reversed in the latter. They showed that ex-ante privatization yields a higher (lower) level of privatization and a larger (smaller) equilibrium number of entering private firms when foreign ownership in private firms is high (low). [Lee, Matsumura, and Sato \(2018\)](#) formulated a new entry-then-privatization model of mixed oligopolies in free entry markets, and found that the timing of privatization does not affect consumer surplus or the output of each private firm, while it does affect the equilibrium degree of privatization, number of entering firms, and output of the public firm.

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