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Environmental policies with excess burden of taxation in free-entry mixed markets

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ABSTRACT

This study investigates environmental policies in free-entry mixed markets taking account of excess burden of taxation. We consider and compare the two ex-ante and ex-post tax policies in which the government chooses the optimal environmental tax before or after private firms invest fixed costs and enter the market, respectively. When the excess burden of taxation is small (large), we find that ex-post taxation imposes a lower (higher) tax level than ex-ante taxation, which induces a larger (smaller) number of firms and a higher (lower) environmental damage. We also show that the excess burden of taxation can increase the welfare, but ex-ante taxation always yields higher welfare than ex-post taxation. Finally, we show that privatization policy in a free-entry market decreases environmental damage but increases welfare only when the entry cost is low.

1. Introduction

Since the 1980s, the waves of market liberalization and environmental protection have been salient features of economic policies in polluting industries around the world. On the one hand, government has continuously conducted market-based environmental regulation by using taxes, subsidies and cap-and-trades. For example, various studies have explored the effect of pollution taxation in imperfect competition markets and concerned about the optimal tax rate. The traditional tax rule suggests that the optimal rate is equal to the marginal environmental damage in perfect competition markets while it falls short of the marginal damage in imperfect competition markets.¹

On the other hand, technological and managerial improvement in public domains have motivated the entry of private firms having profit-maximizing incentives into the markets where public firms already exist and government regulates their activities. In the literature, many works have pointed out welfare implications of public policies in free entry markets are in sharp contrast with those in entry-regulated markets.² However, relatively few economic analyses on mixed markets where public firm competes with newly entering private firms have concerned on how an environmental policy interacts with a competition policy. The welfare effect of environmental policies in free entry mixed markets has become an important concern of policy decision-making in the polluting industries such as oil, steel, electricity and so on.

Since Mankiw and Whinston (1986) indicated the welfare loss of business-stealing effect in free-entry markets, which causes not only

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E-mail addresses: lilixu@chonnam.ac.kr (L. Xu), sangho@jnu.ac.kr (S.-H. Lee).¹ See, for example, Buchanan (1969) and Barnett (1980) for monopoly and Levin (1985) and Shaffer (1995) for oligopoly.² For example, Matsumura and Okumura (2014) compared specific taxation and volume quotas in a free entry oligopoly while Wang (2016) examined import tariff and output subsidy rates under open economy.<http://dx.doi.org/10.1016/j.iref.2018.02.020>

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less production but excessive entry under imperfect competition, many research in different fields have supported the robustness of these inefficiencies. In the literature of environmental economics, for example, [Katsoulacos and Xepapadeas \(1995\)](#) and [Lee \(1999\)](#) examined the welfare effect of environmental policies in free-entry private industries. They found that the optimal tax should be set at the marginal environmental damage because the tax effect on the output is fully offset by the effect on the number of entering firms and thus the inefficiency of less production is invariant while the optimal tax can work for reducing excessive entry.³

In the literature of mixed markets, [Matsumura and Kanda \(2005\)](#), [Brandao and Castro \(2007\)](#) and [Ino and Matsumura \(2010\)](#) examined the possible benefits of public ownership in free-entry mixed industries. They found that the existence of a welfare-maximizing public firm can induce the expansion of its output and less number of entering firms, which will fully offset the output substitution effect but the inefficiency of less production is invariant while the public firm can reduce excessive entry.⁴

However, the government's public policy causes the shadow cost of the public funds, which carries an excess burden of taxation.⁵ In the context of mixed oligopolies, for example, [Capuano and De Feo \(2010\)](#) examined the effect of the shadow cost of public funds on privatization in a mixed duopoly. [Wang and Chen \(2011\)](#) and [Matsumura and Tomaru \(2013\)](#) showed that the excess burden of taxation sharply affects the comparisons of optimal subsidy, total output, and social welfare in mixed oligopolies. Further, [Matsumura and Tomaru \(2015\)](#) examined the effect of product differentiation while [Xu, Lee and Wang \(2016\)](#) and [Lee and Wang \(2018\)](#) considered the relation with foreign competition.

This paper investigates the environmental policies in free-entry mixed markets and examines the effect of excess burden of taxation, which comes from the tax revenue and the profit of the public firm. In particular, we examine the impact of the timing of environmental taxation and compare two models⁶: ex-ante taxation and ex-post taxation. In the former, the government decides environmental tax and then liberalizes the market, whereas the order of the policies is reversed in the latter. The ex-ante case might correspond to the situation that the government is able to make a long-term commitment on the optimal tax rate before it opens the market to the newly entering private firms, who invest fixed costs to enter the market. It also represents the economic policy-neutral case where the industrial and environmental policies do not incur any political cost. However, this neutral case is not always realistic. There might be strategic feedback on economic decision from politics because of lobbying activities of firms in the regulated industries for tax policies or the government's budget constraint. Further, a change in economic environment such as technological improvement or ownership structure in the industry under open economy can affect the ex-post optimal decisions on the environmental policies. Thus, the ex-post case corresponds to this situation in which the government moves later and the thus adjustment of tax rate is easy and flexible.

The main findings are summarized as follows. First, as the shadow cost increases, public firm becomes more aggressive and thus produces more outputs, which results in that the equilibrium number of private firms always decreases under both ex-ante and ex-post taxation cases. Second, under ex-ante taxation the optimal tax should be lower than the marginal damage and the efficient departure between them increases as the shadow cost increases. However, under ex-post taxation the efficient departure depends on the entry cost and the shadow cost, and the optimal tax might exceed the marginal damage when both entry cost and the shadow cost are large. Third, ex-post taxation yields a lower (higher) environmental tax level than the ex-ante taxation when the shadow cost is small (large). It induces that ex-post taxation yields a larger (smaller) number of private firms and a higher (lower) environmental damage. Fourth, the effect of excess burden of taxation can increase the welfare, but the ex-ante taxation always yields higher welfare than ex-post taxation. Finally, privatization $n+1$ policy in a free-entry market decreases environmental damage but increases welfare only when the entry cost is low.

The remainder of this paper is organized as follows. Section 2 presents the basic model. Section 3 analyzes the *ex-ante* and *ex-post* taxation models and presents a comparative analysis of the two cases. Section 4 discusses environmental policy implications of regulated entry and privatization. Section 5 concludes the study.

2. The model

We consider a mixed market with Cournot oligopoly in which operating firms produce homogeneous products. Firm 0 is a public firm and firm i ($i = 1, 2, \dots, n$) is a private firm. The inverse demand function is $P = 1 - Q$, where $Q = \sum_{j=0}^n q_j$ is the market output and q_j is firm j 's output, $j = 0, 1, \dots, n$, respectively. Then, consumer surplus can be measured as $CS = Q^2/2$.

All firms have the same cost function,⁷ $C(q^i) = (q^i)^2/2 + F^2$, where F^2 is the entry cost of each private firm. In the analysis, following

³ In the subsequent research, it is proved that the optimal emission tax rate in free-entry markets depends on the curvature of market demand ([Requate, 2007](#)), the degree of product differentiation ([Fujiwara, 2009](#)), the output elasticity of emissions ([Sugeta, 2017](#)) and consumers awareness ([Hsu, Lee, & Wang, 2017](#)). However, all these analysis still support that the optimal tax can reduce excessive entry.

⁴ In the subsequent research, [Cato \(2008\)](#) considered environmental externalities and showed that the optimal degree of privatization is invariant in free-entry mixed polluting markets. However, [Cato and Matsumura \(2012, 2015\)](#) showed that the optimal ownership of the public firm decreases as foreign penetration increases or the import tariff rate increases.

⁵ While the profits of public firms can be used for public finance, as pointed out by [Laffont and Tirole \(1986\)](#), [Lin, Cai, and Zhou \(1998\)](#) and [Lin and Tan \(1999\)](#), the government's public policy through the public firm might cause the welfare loss. Similarly, while the emission tax revenue can provide double-dividend effect, which can be also used for public finance, as pointed out by [Bovenberg and de Mooij \(1994\)](#), [Bovenberg and Goulder \(1996\)](#) and [Fullerton \(1997\)](#), an environmental tax has its own distorting effects on labor supply, which can have the same excess burden as a tax on labor income.

⁶ [Requate and Unold \(2003\)](#) and [D'Amato and Dijkstra \(2015\)](#) examined environmental technology adoption with/without long-term commitment in which the government ex-ante commits a tax rate before the innovation takes place or adjusts an ex-post tax rate after the firms invest. Regarding mixed oligopolies, [Xu, Lee, and Matsumura \(2017\)](#), [Lee, Matsumura, and Sato \(2018\)](#) and [Lian, Gong, and Wang \(2018\)](#) analyzed the timing of privatization policy and compared the welfare effects between the ex-ante and ex-post privatization policies.

⁷ Note that we did not allow for the cost inefficiency of the public firm in the analysis. While some works argue that the public firm must be less inefficient than the private firm, not all empirical studies support this view. See, for example, [Megginson and Netter \(2001\)](#), [Lee and Hwang \(2003\)](#) and [Lee et al. \(2018\)](#). In [Appendix](#), we allow the cost difference between the private and public firms and show that our main finding is robust.

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