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Emission taxes and standards in a general equilibrium with entry and exit

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ABSTRACT

This paper studies and compares the welfare effects of emission taxes and emission standards in a general equilibrium model with two sectors in which plants can freely enter and exit. In one of the sectors plants differ in their productivity, produce differentiated goods, and generate emissions that can be reduced using an abatement technology. An emission reduction policy causes resource reallocation among plants and across sectors in two ways: a static way due to the dispersion of productivity and a dynamic way due to entry and exit. The model shows that the static distributional effect favors the emission tax, while the dynamic distributional effect favors the emission standard. Calibrated to Canadian data, the model shows that the dynamic effect dominates the static one and hence the emission standard dominates the emission tax in terms of welfare. This is the case not only in the baseline model, but also in a model with a large variation of parameter values for productivity dispersion, market power, and abatement efficiency.

1. Introduction

There has been a long debate on whether market-based environmental policy instruments outperform “command and control” policy instruments. Traditionally, “command and control” policies were predominant. Starting from the 1970s, market-based instruments started to be favored (see Nordhaus, 2007 and Stern, 2006, part IV, p. 310). However, a large literature argues that regulatory intensity standards can dominate market instruments when market power and leakage exist (see Buchanan, 1969 and Holland, 2009). We contribute to this literature by analyzing how productivity dispersion and plants' entry and exit affect the comparison between a market-base instrument (an emission tax) and a “command and control” policy (an emission intensity standard).

This paper studies the welfare effects of emission taxes and emission standards in a general equilibrium model with two sectors in which plants can freely enter and exit. In one of the sectors, which we will call the dirty sector, plants generate emissions in their production process and adopt an identical abatement technology to reduce their emissions. Since these plants differ in their productivity and produce differentiated goods, their use of the abatement technology as well as the amount of abatement input that they apply to emission reduction efforts may differ across plants and vary under different

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policies. The different reactions of plants to an emission reduction policy will cause resource reallocation among plants and across sectors.

Emission taxes and emission standards lead to different patterns of resource reallocation. We identify a static distributional effect—the reallocation among existing plants—and a dynamic distributional effect—the reallocation caused by plants' entry and exit. The static distributional effect favors the emission tax, since the value-weighted aggregate productivity remains unchanged after imposing the tax, but decreases with the imposition of an emission standard. The dynamic distributional effect favors the emission standard, since in the long run that policy leads to a smaller number of plants and larger average size than under the emission tax. The model shows that the choice between emission taxes and emission standards will depend on which distributional effect dominates.

Calibrated to Canadian data, the model shows that the dynamic distributional effect dominates the static distributional effect and, hence, the emission standard dominates the emission tax. Moreover, if we vary the parameter values governing productivity dispersion, market power, and abatement efficiency around the baseline model, the emission standard still dominates the emission tax. However, when the abatement technology becomes very efficient, the static distributional effect due to productivity dispersion can dominate the dynamic effect due to plants' entry and exit, thus turning the tax into the favored policy instrument.

Using a numerical model, this paper captures many elements shown in the literature to be important for evaluating the welfare effects of emission reduction policies, and it examines the compound effects of these elements in a unified framework. The first of these elements is the use of an optimal emission tax to correct externalities, known as Pigovian tax, which was first proposed by Pigou (1954). Buchanan (1969) introduced the idea that market power influences the optimal level of an emission tax. The inefficiency of emission standards was established by Helfand (1991) and extended to study leakage by Holland (2009). The effect of productivity dispersion and the efficiency of abatement technology on the comparison between an emission tax and an emission standard was shown in Li and Shi (2015). However, a comprehensive model with all the elements mentioned above and with free entry and exit has not been analyzed or quantitatively examined yet. The current paper introduces free entry and exit, and puts it into a general equilibrium model with market power, productivity dispersion, and efficiency of abatement technology in order to compare optimal emission taxes and optimal emission standards.

The model framework used in this paper is a Macroeconomics general equilibrium model with heterogeneous plants as in Ghironi and Melitz (2005) and Alvarez and Lucas (2007) that adopts the technique developed in the international trade models by Eaton and Kortum (2002) and Melitz (2003). The only diversion of our model from the standard Macroeconomics model with heterogeneous plants is that we include an externality in the production of dirty goods and we allow plants to abate their emissions. The volume of papers that share this type of diversion, i.e., explore the environmental issues in a Macroeconomics model, has been growing in recent years (see, for example, Tang et al., 2014; Adao et al., 2014, and Li et al., 2014). There are also some classical papers that address international trade and the emission control problem in an open economy general equilibrium model (see Copeland and Taylor, 2005 among others).

The current paper extends the general theory of Li and Shi (2015) in two ways. First we incorporate plants' free entry and exit into the model to make the model a dynamic one. Second, we calibrate the model with Canadian data and compare the welfare effects of an emission tax and an emission standard numerically. To our knowledge, the current paper is the first one that addresses the role of plants' entry and exit in the comparison between emission taxes and standards. It is also the first one that quantifies the importance of the dynamic distributional effects of plants' entry and exit for the welfare evaluation of emission taxes and emission standards in the long run. The current paper also shares some features of a Melitz-type model with Konishi and Tarui (2015), who qualitatively study how different emissions trading mechanisms affect intra-industry reallocation. However, their paper's key predictions depend to a large extent on some specific assumptions that were used to gain model tractability. For example, they assume that the firm's entry expenditure discharges the same proportion of emissions as the production input does.

This paper uses an additive disutility function from emission stock that makes it possible to study the uncertainty of the damage from emission stock, although that is not the focus of the current paper. Potentially, the model can provide new insight on the comparison between price and quantity instruments regarding plants' reaction to policies and their associated distributional and aggregate costs. This could be compared to the classical work by Weitzman (1974), who found that the shapes of the marginal abatement benefit and the marginal abatement cost are crucial for the choice between a price and a quantity instrument. With heterogenous plants and plants' entry and exit, the marginal cost from abating emissions consists not only of the marginal abatement cost, but also of the cost caused by misallocation of resources across plants and across sectors due to productivity dispersion and entry and exit. Therefore, the comparison between different policies will also have to consider both the static and the dynamic distributional effects. Our quantitative results show that if there is damage uncertainty, the emission standard is more reliable, while the emission tax may cause the realized level of emissions to largely deviate from the optimal level.

The rest of this paper proceeds as follows. Section 2 describes the model setup; Section 3 characterizes the optimal choices; Section 4 provides aggregation of variables, plants' entry and exit conditions, and market clearing conditions; it also defines the equilibrium and solves an equilibrium without emission reduction; Section 5 solves for the social planner's problem; Section 6 solves for the equilibrium under emission taxes and the equilibrium under emission standards, and it also compares the static and dynamic distributional effects under different policies; Section 7 parameterizes the model; Section 8 conducts