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Price and quantity regulation in general equilibrium

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Abstract

We consider a general equilibrium model with a production externality (e.g. pollution), where the regulator does not observe firm productivity shocks. We examine quantity (permit) regulation and price (tax) regulation. The quantity of permits issued by the regulator are independent of the productivity shock, since shocks are unobserved. Price regulation implies use of the regulated input is an increasing function of the productivity shock because firms take advantage of a good productivity shock by increasing input use. Thus price regulation generates higher average, but more variable, production. Therefore, we show that in general equilibrium the relative advantage of quantity versus price regulation depends not only on the slopes of marginal benefits and costs, but on general equilibrium effects such as risk aversion. The general equilibrium effects are often more important than the slopes of the marginal benefits and cost curves. In the simplest model, a reasonable risk aversion coefficient implies quantity regulation generates higher welfare regardless of the benefit function.

JEL classification: D8; H23; Q58; Q28

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1. Introduction

What is the optimal way to regulate an externality? When regulators have perfect information about the costs and benefits of regulation, economic theory implies both price (e.g. tax) and quantity (e.g. permit) regulation can balance marginal costs and benefits and so achieve the welfare maximizing quantity of the good with external costs or benefits. Yet most (but not all) regulation applied to firms is quantity based, from sulfur dioxide permits to government-sponsored medical research. For many externalities, general equilibrium

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effects are likely to be important. For example, sulfur dioxide is a by-product of electricity production, which is an input to production of a wide variety of goods. Production spillovers affect not just input choices of the firm, but also the return on capital and thus consumption/savings decisions. This paper provides analytic results for the relative advantages of prices versus quantity regulation in general equilibrium when regulators are uncertain about the firm's productivity shock. General equilibrium effects favor quantity regulation in the basic model for reasonable parameters.

In an important paper, Weitzman [27] argued that the equivalence of price and quantity regulation does not hold when an information asymmetry exists between the firm and the regulator over the firm's costs. Consider an externality of pollution emissions by firms resulting in lower quality of the environment. Suppose firm emissions are very sensitive to the tax on emissions, and the marginal cost to firms of reducing emissions is uncertain. Then a small miscalculation of the appropriate tax rate could result in most firms paying the tax rather than reducing emissions. The quality of the environment then suffers, reducing welfare. In this case, quantity regulation is more attractive. Conversely, if firm behavior is not sensitive to the tax on emissions (for example if few low cost ways exist for the firm to reduce pollution), then a small error in the quantity of permits issued could impose very large costs on the firms, resulting in low production. In this case, a tax is more attractive. Weitzman assumes cost and benefit functions are quadratic in the regulated input and linear in the uncertainty, and a static, partial equilibrium environment.

Thus, many authors have extended Weitzman's framework. With regard to the choice of policy instruments, Roberts and Spence [23], Weitzman [28], McKibbin and Wilcoxen [17], and Pizer [22] consider hybrid policies which combine both price and quantity instruments. Laffont [15] considers also price instruments applied to the consumer. In the area of uncertainty, Yohe [32] adds output uncertainty, while Laffont [15] differentiates between technological uncertainty and information differences. Hoel and Karp [6] considers multiplicative uncertainty and Costello and Karp [3] and Karp and Zhang [9] allow for learning to reduce uncertainty about the costs. Stavins [24] finds that the often positive correlation of environmental cost and benefit shocks favor quantity regulation for environmental externalities. Recently, Hoel and Karp [5], Karp and Zhang [9], and Newell and Pizer [19] derive results similar to Weitzman (again in a quadratic, partial equilibrium setting) where environmental benefits accrue over time. Koenig [12] considers both private and external benefits.

Empirical estimates of slopes of marginal cost and benefits are mixed across externalities. Koenig [11] and Androkovich and Stollery [1] find that taxes are generally preferred for fisheries, while Kolstad [14] finds in favor of quantity regulation for air pollutants. Watson and Ridker [26] allow for nonlinear marginal costs and benefits and obtain mixed results for air and water pollutants with quantity regulation often preferred early when regulation is less strict, while price regulation did better later under more strict regulation. Hoel and Karp [5], Hoel and Karp [6], Kolstad [13], Nordhaus [20], and Pizer [21] argue that the flatness of marginal benefits of climate change control favor price regulation.

Pizer [21,22] provides a computational analysis of price versus quantity regulation in general equilibrium for the case of climate change.[1] However, we are not aware of any

[1] As we will note below, the Pizer model differs in most other respects from the model here, which makes the results difficult to compare.