Public Policy and Environmental Research and Development

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ABSTRACT. The paper evaluates several potential public policies to increase research and development (R&D) investments with the goal of introducing innovations to reduce harmful industrial emissions. The policies—new pre-innovation taxes, more stringent emissions regulations, promotion of cooperative R&D, promotion of outside financing from other companies and from the public, diplomacy to encourage emissions regulations that are more uniformly stringent worldwide, promoting dynamic competition with appropriate antitrust policy, and promoting the dissemination of fundamental knowledge about emissions and of licensable emissions-reducing technology—are evaluated by using primary data from US industry to estimate a model of the environmental R&D investments of industry.

Key words: environmental research and development (R&D), emissions reduction, environmental regulation

JEL Classification: Q550, Q580, O300, O380, L100

1. Introduction

The purpose of this paper is to develop and discuss the policy implications of a decade-long project documenting the environmental research and development (R&D) investments by U.S. manufacturing industry. The details about that project are reported in Scott (2003); this paper uses the data described there with new specifications to provide evidence focused on the possibilities for public policy to reduce hazardous emissions by promoting environmental R&D.[1] The evidence motivates discussion of several potential public policies to increase environmental R&D, which is defined broadly to include any R&D investments with the goal of introducing innovations to reduce emissions. The policies discussed are (1) new pre-innovation taxes, (2) more stringent emissions regulations, (3) promotion of cooperative R&D, (4) promotion of outside financing from other companies and from the public, (5) diplomacy to encourage emissions regulations that are more uniformly stringent worldwide, (6) promoting dynamic competition with appropriate antitrust policy, and (7) promoting the dissemination of fundamental knowledge about emissions and of licensable emissions-reducing technology. As the paper will explain, the first of these policies—the legislation of pre-innovation taxes—is quite controversial, indeed in the present environment it is an impractical policy. Nonetheless, discussing the idea of pre-innovation taxes serves to point up the limits of policy. The other policies are far less controversial; hence they are far more practical in the cases where evidence suggests the policies would be useful.

Developing public policies to stimulate environmental R&D is important. A priori, environmental R&D should, over time, reduce hazardous industrial emissions. The hypothesis that environmental R&D will reduce industrial emissions is supported by available data. For the 15 broad Standard Industrial Classification (SIC) manufacturing industries for which data are available, the simple regression of *RDCTN8899*—the percentage reduction in emissions from 1988 to 1999—as a function of *ENVRD/SALES*—an estimate of the ratio of environmental R&D to sales during the 1990s for the companies in the industry—has been estimated in alternative ways in Scott (2003, forthcoming).[2] The estimated effect of environmental R&D intensity on the percentage reduction in emissions is fairly substantial.[3] The elasticity for the effect (the percentage change in *RDCTN8899* per unit percentage change in *ENVRD/SALES*) at the sample means is 0.41.[4]

Section 2 discusses the theory behind the model of environmental R&D. The model is then esti-

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mated in Section 3. The various public policies to stimulate environmental R&D are discussed in Section 4, and then the estimates from Section 3 are used to illustrate the potential effects of the policies.

2. Theoretical rationale for the estimable model

Investment in risky environmental R&D results in innovations—new processes or products with better environmental performance as indexed by the random variable x.[5] The probability distribution for the measure of environmental performance x is given by the probability density $f(x; \alpha)$, where greater values of the distribution's parameter α shift the probability distribution rightward over higher levels of environmental performance. The gamma distribution has the desired properties, and it is used for the probability density $f(x; \alpha)$.[6]

The parameter α is determined by the amount of environmental R&D investment R and an additional set of explanatory variables $\mathbf{X}$. Thus, $\alpha = \alpha(\mathbf{X}, R)$. Greater R&D investment, R, is associated with a greater α. Hence, if a company increases its environmental R&D, its distribution over environmental performance outcomes is shifted rightward over higher values of the index of environmental performance x. A measure of the environmental problems created by the company's operations would be among the distribution-shifting variables in the vector $\mathbf{X}$. Greater environmental problems would shift the distribution over environmental performance leftward over lower values of the performance index. One measure of those environmental problems is *NTAPC*, the number of toxic air pollutants associated with the company's operations. The more chemical emissions associated with its operations, the poorer the outcome regarding its environmental performance, other things being the same. For our estimable model using the gamma distribution, α is approximated by

$$\alpha = \alpha(\mathbf{X}, R) = AX_1^{\beta_1} X_2^{\beta_2} \cdots X_n^{\beta_n} e^{\varphi_1 D_1} \cdots e^{\varphi_w D_w} R^{\beta_R} \quad (1)$$

with the terms $X_i^{\beta_i}$ for the n positive and continuous variables, and with $e^{\varphi_i D_i}$ for each term where the explanatory variable is a qualitative (0–1 dummy) variable or where theory implies that a continuous variable should be entered in such an exponential form.

A company's market value is assumed to increase at a decreasing rate with the environmental performance x of the company's innovations. The company's market value is given by $V(x; \gamma)$, where V given x increases with the parameter γ. The value of environmental performance is modeled as

$$V(x) = \gamma - \gamma e^{-x/\theta}, \quad (2)$$

where θ is a scaling parameter.

The value parameter γ is a function of a set of explanatory variables $\mathbf{Z}$. Thus, $\gamma = \gamma(\mathbf{Z})$.

$$\gamma = \gamma(\mathbf{Z}) = aZ_1^{b_1} Z_2^{b_2} \cdots Z_m^{b_m} e^{\theta_1 S_1} \cdots e^{\theta_v S_v} \quad (3)$$

with the term $Z_i^{b_i}$ for each positive and continuous explanatory variable and with a term $e^{\theta_i S_i}$ if the explanatory variable is a qualitative (0–1 dummy) variable or, again, if theory dictates that exponential expression for a continuous variable. The value-shifting variables in the vector $\mathbf{Z}$ include, for example, the company's sales, *SALES*. We expect that larger firms will gain more value from an innovation.[7]

The expected value of investment in environmental R&D is

$$E = \int V(x; \gamma) f(x; \alpha)\, dx. \quad (4)$$

The company chooses its investment R to maximize the expected net value of the investment, E–R. Thus, the company invests until the marginal expected benefit of the last dollar invested is a dollar (that is, the company invests R such that $\partial E/\partial R = 1$). That condition for maximizing the expected net value of investment implies

$$R = g(X, Z). \quad (5)$$

With the function f being the probability density for the gamma distribution, and the function for V specified in equation (2), solving the model for a company's optimal investment in