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ANALYSIS

Do environmental regulations hamper productivity growth? How accounting for improvements of plants' environmental performance can change the conclusion

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ABSTRACT

Many economists maintain that environmental regulations hamper productivity growth; a view supported by several empirical studies on industry or state level data. However, there is little research of the relationship between the stringency of environmental regulation and productivity growth at the plant level; and the results of the few existing studies are ambiguous. Moreover, the measures of productivity growth applied in previous studies do not credit plants for emission reductions, and this may result in understatement of productivity growth. We perform regression analyses of productivity growth on regulatory stringency using plant level data. To credit a plant for emission reductions, we include emissions as inputs when calculating an environmental Malmquist productivity index (EMI); and do not include emissions when calculation the traditional Malmquist productivity index (MI). The regression analyses show that the overall effect of the regulatory stringency faced by plants on plants' productivity growth is statistically insignificant when MI is applied to measure productivity growth. However, when we apply EMI, the effect is positive and statistically significant. This indicates that not accounting for emission reductions when measuring productivity growth can result in too pessimistic conclusions regarding the effect of regulatory stringency on productivity growth.

1. Introduction

It is a concern to policymakers that environmental regulations hamper competitiveness and economic growth. Several economists have estimated the effect of environmental regulations on traditional measures of growth in total factor productivity, and their results suggest that the concern is not unwarranted (Christiansen and Haveman, 1981; Jaffe et al., 1995). Recently, however, it has been suggested that the empirically detected inverse relationship between environmental regulations and productivity growth is an almost inevitable consequence of the current methods used to measure productivity — methods that fail to account for improvements in environmental performance (Repetto et al., 1997).

In recent times, methods that account for environmental performance when measuring productivity have been developed, and most empirical studies have revealed that failure to account for emissions results in understatement of productivity growth (Weber and Domazlincky, 2001; Färe et al., 2001; Hailu and Veeman, 2000). These studies are often motivated by the conjecture that inclusion of environmental factors in measures of productivity will influence the results of analysis

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of the *relationship* between environmental regulations and productivity growth. To our knowledge, the present paper is the first to investigate this conjecture empirically; we study the empirical relationship between environmental regulations and productivity growth. To credit a firm for emission reductions, we include emissions when calculating an environmental Malmquist productivity index (EMI); and for the sake of comparison, we perform the analysis on the traditional Malmquist index (MI) where emissions are not accounted for.

There are many studies of the relationship between environmental regulations and productivity growth (not accounting for environmental performance) that employ industry or state level data, and they generally find that such regulations hamper productivity growth (Christiansen and Haveman, 1981; Jaffe et al., 1995). However, as regulations are usually set at the plant level, employing industry or state level data can be an important shortcoming. When it comes to studies of environmental regulations and traditional measures of productivity growth employing plant level data, the literature is scarce and the results ambiguous (Jaffe et al., 1995; Jenkins, 1998).[1]

Gollop and Roberts (1983) investigate the effect of firm specific environmental regulations on traditional measures of productivity growth in the US electric power industry. The authors conclude that environmental regulations have resulted in markedly lower productivity growth. Similarly, Gray and Shadbegian (1993, 2002) include analyses of the relationship between productivity growth and environmental regulations for plants in three US industries. When environmental regulations are measured by compliance costs, they tend to find a negative relationship between the degree of environmental regulation and productivity growth. However, when other commonly used measures of regulatory stringency are employed, like compliance status or the number of inspections by the regulatory agency, the estimated coefficients are generally not significant.[2]

These previous firm level studies employ traditional measures of productivity growth. We are not aware of any study that investigates the relationship between environmental regulations and a measure of productivity growth that accounts for emission reductions. The contribution of the present paper is to provide empirical regression analyses showing how the estimated relationship between stringency of environmental regulations and productivity growth can depend on whether MI or EMI is applied. Based on empirical studies elsewhere (e.g. Magat and Viscusi, 1990; Laplante and Rilstone, 1996), regulatory stringency or enforcement is assumed to rise with inspection frequency. Inspection frequency serves as our measure of regulatory stringency.

The MI/EMI type of index has advantages over other measures of total factor productivity, like the Törnquist or Fischer index: The MI/EMI type of index can be computed solely on the basis of quantities, getting around the problem of recovering (shadow) prices on emissions. Although implying that the EMI specified in this study cannot be directly related to changes in welfare, it does provide a more complete picture of changes in productivity, as emissions, which are of concern to society, are included. We use nonparametric linear programming to estimate distance functions, which are used to define the MI/EMI for each plant in each year (see e.g. Färe et al., 1994). Based on plant specific data, we estimate a technology frontier using data envelopment analysis for each industry. The MI/EMI comprises changes in plants' distance to the frontier and movement of the frontier. Contrary to econometric approaches used to estimate productivity, like e.g. Klette (1999) or Gray and Shadbegian (2002), the approach taken in the present paper requires no assumptions of the functional form of the production function. In addition, when estimating productivity growth, we avoid imposing the same production function structure on all firms within an industry. Finally, we do not need to impose optimizing behavior.

Norway's most energy intensive manufacturing industries are included in the present study. The Pulp and paper, Primary aluminum, Inorganic chemicals and Ferro alloy industries consume about 50% of the energy of the overall Norwegian manufacturing industry. These industries are major contributors to national emissions. In 2000, these four industries caused more than 80% of Norwegian manufacturing industry's emissions of SO_2, more than 50% of emissions of acids, and about 50% of the emissions of CO_2 or greenhouse gases (Statistics Norway, 2003a).

In Section 2, we present the econometric model and the data, and outline how the productivity indexes are estimated. Section 3 presents the regression results for the two measures of productivity growth on regulatory stringency. Section 4 concludes.

2. Models and data

2.1. *Econometric framework*

In this subsection we introduce the econometric model, which is applied to test the sign of the relationship between environmental regulatory stringency and productivity growth. As mentioned in the introduction, empirical studies of the relationship between environmental regulation and productivity growth on firm level data are scarce, and the results ambiguous. The differing methods applied in previous studies may be one reason for the ambiguous results.

Gollop and Roberts (1983) estimate a cost function to test for the impacts of regulatory stringency of sulfur dioxide emissions. Gray and Shadbegian (1993, 2002) let the residuals evolving from a regression of a three input production function model serve as measures of the total factor productivity levels. Then they estimate the effect of various measures of regulatory stringency on productivity growth.

[1] In the present paper, we consider one measure of economic performance; productivity growth. The literature on the relationship between regulations and other measures of economic performance is not scarce; see e.g. the frequently cited work by Jorgensen and Wilcoxen (1990) on economic growth for the overall US economy. Firm level studies of regulation and profitability or efficiency do also exist; see e.g. Brännlund et al. (1995) and Hetemäki (1996).

[2] Gray and Shadbegian (2003) is related to Gray and Shadbegian (1993, 2002) and the results indicate a negative relationship between compliance costs and productivity (see also e.g. Shadbegian and Gray, 2005, 2003; Boyd and McClelland, 1999). However, in their study of US oil refineries, Berman and Bui (2001) find that environmental regulations have increased productivity.