Accounting for loss of variety and factor reallocations in the welfare cost of regulations

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ABSTRACT

This paper develops a multi-sector general equilibrium model with heterogeneous firms to account for both the direct cost of regulations on regulated firms as well as the indirect cost associated with loss of variety and factor reallocations. The model derives an analytical marginal abatement cost function, dividing the cost according to these direct and indirect effects, and explores the implications for optimal environmental policy. The model is numerically simulated using parameters for the U.S. manufacturing sector for criteria air pollutants, demonstrating that the direct cost of regulations understates the true cost. Moreover, because marginal abatement costs vary across industries, reallocating pollution across industries to achieve cost-effectiveness can generate modest cost savings.

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1. Introduction

The direct burden of environmental regulations on regulated firms is often an imperfect measure of the social burden for a variety of reasons. Examples include interactions of regulations with the exercise of market power (Buchanan, 1969; Ryan, 2012; Fowlie et al., 2016) and pre-existing tax distortions (Bovenberg and de Mooij, 1994; Parry, 1995; Goulder et al., 1999; Fullerton and Metcalf, 2001; Goulder et al., 2016), and leakage due to incomplete regulation (Bernard et al., 2007; Holland, 2012). Despite empirical evidence that regulations cause some firms to cease operations and exit the market (Greenstone et al., 2012), studies generally abstract from firm entry-exit decisions, as well as changes in product variety. This paper adds to the literature by developing a model to account for the welfare cost associated with loss of variety and factor reallocations induced by environmental regulations, and explores the implications for optimal environmental policy.

The model can be explained intuitively as follows. Consider an industry where firms produce differentiated goods, and differences in productivity generate differences in profits, where the least productive firm earns zero profits. In effect, environmental regulations, which induce or require firms to divert productive resources to pollution mitigation, increase cost. Firms that, prior to the change in regulations, were only "marginally" profitable would be rendered unprofitable after

the change and would consequently exit the market.

In addition to the direct compliance cost, regulations therefore generate two indirect effects. First, because ex-post active firms are on average more productive than ex-ante active firms, productive resources are reallocated from less to more productive firms, resulting in higher average productivity and in turn lower prices. Second, because firms produce differentiated goods, firms exiting the market represent a loss of variety to consumers, which reduces welfare. Because the two are confounding in nature, the direct burden of regulations might understate or overstate the true, or at least more comprehensive, welfare cost.

The model also sheds light on optimal environmental policy. That is, when environmental regulations induce firm exit, imposing a uniform cost of emissions across industries, or allowing the trade of emissions permits between industries on a one-to-one basis, does not minimize the welfare cost of achieving a given level of emissions reductions. For example, the model demonstrates that industries with more differentiated products should face relatively lower cost of emissions compared to industries with less differentiated products, even when industries emit pollution with identical damages. Moreover, the second-best optimal level of pollution should account for the indirect, as well as the direct, effects of regulations.

This paper contributes to two areas of research. First, this paper contributes to the literature investigating the economic cost of environmental regulations, particularly in the context of the manufacturing sector (Greenstone, 2002; Becker and Henderson, 2000; Becker, 2005; Greenstone et al., 2012). Second, this paper contributes to the handful of studies analyzing the role of firm heterogeneity in environmental policy (Tombe and Winter, 2015; Li and Sun, 2015; Konishi and Tarui, 2015; Anouliès, 2017).

One of the most significant, and extensively studied, set of environmental regulations is the U.S. Clean Air Act and the subsequent Clean Air Act Amendments (CAAAs), and their impact on the manufacturing sector.[1] Among studies investigating the economic cost of the CAAAs, most rely on county-level variation in regulatory stringency according to national ambient air quality status (NAAQS) (attainment or non-attainment)[2] and focus on either extensive-margin effects (e.g., plant death and births) or intensive-margin effects (e.g., output and productivity), or the direct cost of mandated pollution abatement equipment.[3] For example, empirical studies document that polluting industries tend to migrate from attainment to non-attainment counties (Henderson, 1996), and non-attainment is associated with fewer firm births (Becker and Henderson, 2000; List et al., 2003). Non-attainment is also associated with greater expenditures on pollution abatement equipment among heavy emitters (Becker, 2005), although data on pollution abatement expenditures are notably incomplete. Finally, non-attainment is also associated with lost output (Greenstone, 2002), and reduced total-factor productivity among establishments in polluting industries (Greenstone et al., 2012).

What do these studies imply in terms of the welfare cost of regulations? Because pollution abatement expenditures do not fully reflect all of the costs associated with regulations[4] and "lost" output due to regulations might be offset (at least in part) by increases in output elsewhere (e.g., less polluting industries), a more reflective measure of the (intensive-margin) economic cost of regulations is the impact on firm productivity (Greenstone et al., 2012).[5] Greenstone et al. (2012) estimate that non-attainment is associated with a 2.6 percent decline in total-factor productivity (TFP) among surviving plants in polluting industries. Holding inputs constant, this corresponds to an economic cost of lost output around $11 billion in 2010 dollars.

Reducing productivity is not the only effect of regulations, however, as they also cause some firms to exit the market (Greenstone et al., 2012), particularly the least productive firms.[6] Greenstone et al. (2012) argue that because the estimated TFP effects are conditional on survival, the actual TFP effects are larger due to survivorship (selection) bias. Correcting for survivorship bias implies that non-attainment is associated with a (larger) 3.3 percent reduction in TFP, and applying the same procedure to calculate the economic cost implies that the corresponding lost output was around $14.3 billion.

While correcting for survivorship bias is appropriate to estimate the TFP effect of regulations among surviving and non-surviving firms, the welfare costs associated with reductions in productivity among surviving and non-surviving firms are not generally equal. Put more simply, once productivity is reduced to a point such that remaining in the market is unprofitable, further reductions in productivity are immaterial from a welfare point of view, at least in the long-run as the firm's factors of production would be reallocated. Moreover, when firms produce differentiated goods, firm exit would also be associated with loss of variety, which would generate an additional welfare cost. In sum, when regulations induce firm exit, the TFP effect is not a sufficient statistic for welfare, and assessing the welfare cost of regulations requires a framework that incorporates costs associated with loss of product variety and factor reallocations. This study fills this gap.

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[1] See Becker and Henderson (2000) or Greenstone (2002) for details regarding the background of the CAAAs.

[2] Non-attainment is associated with more stringent regulations because if a county is in non-attainment status, the state must implement policies to bring down air pollution to comply with federal standards.

[3] Other studies examine the cost of regulations in terms of disemployment effects and the cost of foregone earnings (Greenstone, 2002; Walker, 2013), which is beyond the scope of this paper.

[4] For example, pollution abatement expenditures do not include costs associated with changing the production process (Gray and Shadbegian, 1995).

[5] Greenstone et al. (2012) argue that their study, which estimates the effect of regulations on productivity, is the first to estimate the "economic costs" for the manufacturing sector. This paper refers to the direct effect of regulations as "cost" rather than "productivity" effects for clarity as firm productivity will vary for technological reasons.

[6] Several empirical studies document a negative correlation between productivity and plant death (see Bartelsman and Doms, 2000 for a review of the literature).