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Analysis

Absolute abundance and relative scarcity: Environmental policy with implementation lags ☆

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ABSTRACT

We study the effectiveness of environmental policy in a model with nonrenewable resources and an unavoidable implementation lag. We find that a time lag between the announcement and the implementation of an emissions quota induces an increase in emissions in the period between the policy's announcement and implementation. Since a binding constraint on emissions restricts energy use during the implementation phase, more of the resources must be extracted outside of it. We call this the *abundance effect*. In the case of multiple resources that differ in their pollution intensity, a second channel emerges: since cleaner sources are relatively more valuable when the policy is implemented, it is optimal to conserve them before the cap is enforced. This *ordering effect* tends to induce a switch to dirtier resources before the policy is implemented, compounding the increase in emissions via the abundance channel. Using the announcement lag in Title IV of the 1990 CAAA as a case study we are able to empirically show that the abundance effect and ordering effect are both statistically and economically significant. We discuss a number of alternative policy options to deal with these undesirable side effects of policy announcements.

1. Introduction

Major regulatory efforts, be they labor market reforms, privatizations, energy market deregulation efforts or overhauls of tax systems, tend to be characterized by the existence of significant lags between the announcement of the policy and its implementation. These implementation lags exist, for example, because complex policy changes require the development of institutions and mechanisms to monitor, manage and enforce the new rules, or because in many cases giving firms and consumers time to adapt to the changes increases the political palatability of the measure, or for political economy considerations.[1]

Environmental policy initiatives are no exception to this rule. For example, Title IV of the United States Clean Air Act Amendments of 1990 was phased in over a period of 10 years (Schmalensee et al., 1998), and the European Union Emissions Trading Scheme was first announced in 2001, with a preliminary 'pilot' phase in 2005–2007, and the first commitment phase starting in 2008 (Ellerman et al., 2010). The fact that some of the largest environmental policy endeavors take the form of international environmental agreements that need to be ratified by a sufficient number of signatories to enter into force does nothing to shorten the length of the implementation lags. The Convention on Long-Range Transboundary Air Pollution was agreed upon in 1979 and entered into force in 1983; the 1987 Montreal Protocol took 2 years to enter into force, with a first commitment period starting in 1991; the Kyoto protocol, signed in 1997, entered into force in 2005, and its first commitment period started in 2008.

While policies take time to implement, however, market participants respond quickly to anticipated future measures. Sometimes responses to announced policy go in the intended direction, e.g. when firms use the time allowed to develop and adopt cleaner technologies. In other cases, however, the agents' actions during

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[1] Classic references on the political economy of regulation are Stigler (1971) and Becker (1983), while Magat et al. (1986) provide an excellent early reference on the empirics of agency behavior.

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the implementation lag may have adverse environmental effects. Sterner (2004), for example, indicates that the 25% increase in the demand for chemicals containing Trichloroethylene (TCE) in 1999 in Norway might be attributed to pretax hoarding by firms who anticipated the imposition of the (very high) tax on TCE from 2000 onward. In the context of fisheries management, Loehle (2006) shows with a numerical example that implementation lags in quota enforcement may lead to the collapse of the fishery, even when the theoretically correct policy is announced. In their analysis of the effect of the US Endangered Species Act (ESA) on land development in Arizona, List et al. (2006) find evidence that listing a species under the ESA led to plots of land included in the proposed critical habitat map being developed up to 1 year earlier than comparable plots not classed as part of the critical habitat. Finally, there is abundant anecdotal evidence of hoarding behavior on the part of retailers and consumers ahead of announced incandescent light bulbs phase-outs in Australia, the EU and the US (Green, 2011).

In this paper, we focus on the effects of implementation lags in the context of environmental policies aimed at regulating the use of polluting non-renewable resources, such as fossil fuels. We use a theoretical model to show that the owners of polluting non-renewable resources have an incentive to increase early extraction in anticipation of future measures that prevent the implementation of the resource owners' initial extraction plan. As an illustration of the existence and the size of the effects we identify in our theoretical model, we study the effects of the implementation lags embedded in Title IV of the 1990 US Clean Air Act Amendments (CAAA). Our empirical findings are consistent with our theoretical predictions. Our estimates suggest that, due to the existence of implementation lags, SO_2 emissions in the US might have been 9% higher than would have otherwise have been the case. Both the theoretical and empirical results of our analysis suggest that implementation lags might have substantial effects on emissions. Hence, we also discuss the implications of our findings for the design of environmental policy, starting from a cost–benefit perspective and covering possible early-action policies suggested in the literature. We conclude with some specific implications for the design of environmental policy for non-renewable resources, when implementation lags are unavoidable.

In our analytical model, utility is derived from the use of non-renewable resources. Resource use, however, is associated with polluting emissions. We concentrate on a simple policy constraining the flow of emissions, which is however implemented with a lag.[2] We fully characterize the optimal extraction (and emission) path when policies are announced ahead of implementation. Our results show that the existence of an implementation lag affects emissions via two channels that lead to an instantaneous *increase* in emissions: an *abundance effect*, and an *ordering effect*. The former arises whenever resources are abundant, i.e. when the available stock of resources is large enough to make the constraint binding. The ordering effect, instead, emerges to different degrees, depending on how scarce cleaner resources are, relative to the overall stock. As the result of both effects, the fact that polluters anticipate the policy leads to an increase in emissions following the policy announcement, and to a sudden drop once the policy is finally enforced.

We first discuss the case in which resources have the same pollution content and show that announcing mitigation policies induces an *abundance effect*: when extraction is constrained over some period of time, more of the resource is extracted at other points in time. Crucially, we show that, along any optimal path, some of this ‘extra’ resource is consumed between the time of announcement and the policy's implementation. The associated increase in resource consumption in the interim phase may induce an increase in polluting emissions relative to the pre-announcement situation. This emissions increase due to the announcement of the policy has not been explicitly discussed in the literature until now.

The second part of the paper discusses the case of multiple resources that differ in their pollution intensity. In this context, we show that the announcement may induce an additional *ordering effect*, which increases the (expected) pollution content of resource use. When the economy faces a binding constraint on emissions at some point in the future, it may be optimal to save (some of) the cleanest resource for this phase, and front-load the use of the dirtier resource ahead of enforcement. Thus polluting emissions may increase in the period between announcement and implementation. Importantly, the ordering effect compounds the abundance effect and further contributes to the increase in emissions. Given that the goal of the environmental policy is to reduce emissions, these announcement effects go directly against the spirit of the policy.

Few papers have studied environmental policy in the presence of implementation lags. Kennedy (2002) and Parry and Toman (2002) focus on the effects of domestic action in the period between the announcement and the implementation of an internationally imposed binding cap on emissions. Both papers argue that policies aimed at emission reductions in this period may be costly and inefficient. In Kennedy's small-open-economy optimal-policy model, early domestic emission reductions have no effect on global damages. Hence, such efforts are welfare reducing, unless the associated co-benefits (e.g. reduced damages from local pollutants) are sufficiently large. In their exogenous policy framework, Parry and Toman find that early action may be undesirable if the abatement target is high, the environmental benefits are low, banking (or credits for emissions reductions) is not allowed and if there are no co-benefits (in the form of learning-by-doing, for example). Our analysis complements these contributions in that we show that, even when no additional measures are introduced between announcement and implementation, the mere existence of implementation lags in the presence of exhaustibility leads to increases in emissions, due to the optimizing behavior of resource owners.

Stavins (2006) considers regulatory delay that arises when older regulated units are subject to less stringent standards than newer ones. This differential treatment not only delays regulation but also introduces an intratemporal distortion, which makes regulation more costly. Our work contributes to this discussion by focusing on intertemporal distortions, arising from uniform regulation at some point in time in the absence of regulation early on.

Our model builds on the traditional optimal extraction framework developed by Hotelling (1931), and finds its place in the long literature that studies the problem of resource use in the presence of taxation (Sinclair, 1992; Tahvonen, 1997; Withagen, 1994). The present paper is also closely related to several recent contributions that discuss the optimal ordering of resource extraction in the context of climate change policy. Chakravorty et al. (2006) discuss a ceiling on the stock of pollution, and show that in the case of one polluting resource and a clean backstop technology, the two inputs might be used jointly during the constrained phase, even though they are perfect substitutes. Lafforgue et al. (2008) extend this analysis to the case where polluting emissions can be stockpiled in carbon sinks, and show that a sink without leakage can be treated as a second, non-polluting non-renewable resource. Finally, Chakravorty et al. (2008) study the case of two perfectly substitutable resources that differ in carbon content, and Smulders and Van der Werf (2008) study the case of imperfect substitutes without, however, discussing emissions levels. Our model is more general and more widely applicable to different types of polluting non-renewable resources. Moreover, none of these papers explicitly discuss emission profiles, nor do they focus on the effects of announcing policy in advance.

[2] In our analysis we take both the existence of the implementation lag and its length as given. A rich literature exists, however, that instead focuses on the determinants of regulatory delay in environmental policy (see e.g. Alberini and Austin, 1999; Ando, 1999; Metrick and Weitzman, 1996).