Journal of Economic Behavior & Organization 132 (2016) 193–205

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Pollution control under a possible future shift in environmental preferences[☆]

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ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form 9 February 2016
Accepted 20 May 2016
Available online 7 June 2016

JEL classification:
C61
D81
Q54

Keywords:
Pollution stock
Regime shift
Abrupt event
Dynamic analysis
Uncertainty
Environmental awareness

ABSTRACT

We examine how the possibility of a future shift in environmental preferences affects optimal pollution emissions. For example, is a more stringent carbon cap called for if excessive carbon emissions today may trigger a shift toward greener preferences in the future? In contrast to the related literature, which largely focuses on regime shifts in *damages*, not *preferences*, we find that the possibility of a shift in environmental preferences can induce higher, or lower, optimal current emissions. This hinges on an economically interesting interplay between the magnitude of the possible shift, whether the shift is endogenous, and the magnitude of environmental damages. This helps reconcile the tension between the conservationists' view of pollution reduction (to reduce damage and lessen the likelihood of regime shift) and the traditional economic rationale emphasizing risk and discounting.
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1. Introduction

Nearly every environmental management challenge boils down to a tradeoff society must make between the benefits of pollution and the damages that arise from the resulting pollution stock. Benefits from pollution accrue from economic activity, i.e., the production and consumption of goods and services. This utility society derives from polluting will depend on society's "environmental preferences," which capture society's awareness and attitudes about environmental conservation. While these preferences are almost always considered exogenous and constant, this paper takes as a starting point that there are interesting instances in which society's environmental preferences may change in the future, either due to exogenous or endogenous forces. For example, the environmental movement in the United States has been marked by apparently

☆ We are grateful to Eli Fenichel, Chuck Mason, Eric Nævdal, and participants at the, workshop on Random Events in Dynamic Economic Systems held in Knoxville, 2015; Canadian Resource and Environmental Economics, Saskatoon, 2014 and various conferences held at the University of California, Santa Barbara for their helpful comments on earlier versions of this paper.
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http://dx.doi.org/10.1016/j.jebo.2016.05.021
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discrete shifts in social preferences including the conservation movement (late 1800s), the modern environmental movement (1960s), and more recently, the environmental justice movement (1980s).[1]

We question whether accounting for the possibility of a future shift in environmental preferences may affect optimal current emissions. We focus on the possibility of abrupt future change in environmental preferences, which could be triggered by crossing a tipping point or threshold. While crossing a threshold may have important environmental consequences in its own right, we will focus instead on its economic significance: The benefits derived from polluting after the threshold is crossed are likely to be lower than the benefits derived before the threshold is crossed. The focus of this paper is on how the possibility of such a shift affects pollution decisions prior to the shift.

Consider the example of climate change. Once an uncertain threshold of greenhouse gas concentration is exceeded, a new regime may be triggered in which society demands more stringent environmental policy. Other well-studied examples of possible shifts in environmental preferences include new scientific discoveries (that affect costs or benefits from polluting), and an increase of environmental awareness, which may reduce demand for polluting goods. These are just a few examples of regime shifts that could entail changes in environmental preferences. Regardless of the specific application, the issue of regime shift in environment preferences is motivated by the idea that a society may change its environmental awareness in the future. It could also arise from policy changes that raise the cost of pollution and thus lower social welfare from polluting. To capture these diverse possibilities, we model the regime shift as a downward shift in the utility from polluting. While a small literature addresses pollution control with a smooth concave benefit function (see for example, Long, 1992; van der Ploeg and de Zeeuw, 1992; Benchekroun and Ray Chaudhuri, 2014; Dockner and Long, 1993), optimal pollution control with abrupt changes in environmental preferences has not been addressed.

To model this process, we add uncertainty about future benefits of emissions to a standard pollution control model. However, our framework may be more generally applied to the management of resources for which player actions affect the probability of regime shift. Interesting examples include the management of a resource with trade regime shift, the use of the resource of antibiotic efficacy to produce antibiotics with bacterial resistance regime shift, resource extraction with demographic regime shift, and resource extraction with a possible civil war.

Our analysis contributes to an interesting literature on resource extraction under a possible irreversible shift in consumers' attitudes towards the resource. While Beltratti (1996), Beltratti et al. (1998), and Le Kama (2001) focus on exhaustible resources, Le Kama and Schubert (2004) concentrate on renewable resources such as fish. All these papers treat the regime shift process as exogenous. In this setting, it is usually optimal to adopt cautious management prior to the shift if on average, future generations would be more conservative after the shift. In contrast, this paper addresses the optimal policy response to a possible shift in environmental preferences and we allow the regime shift process to be endogenous. Interestingly, such a possible shift induces new pollution responses compared to previous contributions.

We also contribute to an interesting and growing literature that examines the control of pollution under various assumptions about potential future shifts. In a game theoretic setting, Nkuiya et al. (2015) show that countries are more likely to ratify a climate treaty today when they face endogenous uncertainty about a possible upward shift in their future environmental damages. In that paper, the shift is captured by a positive probability that is increasing in the current pollution stock. Other authors have focused on a shift that is triggered when an uncertain pollution stock (Tsur and Zemel, 1996; Brozović et al., 2011) or flow (Groeneveld et al., 2013) is crossed.

Regardless of the type of regime shift, it is common to model the shift itself using the hazard function approach (see for example, Heal, 1984; Clarke and Reed, 1994; Tsur and Zemel, 1998; Gjerde et al., 1999; Haurie and Moresino, 2006; Nkuiya, 2015; de Zeeuw and Zemel, 2012);[2] we adopt a version of this approach. Modeling a shift phenomenon that is controlled by a hazard function allows us to transform our stochastic regime-shift model in a deterministic optimal control problem, so we can employ familiar methods. In our model, economic agents derive utility from polluting. Pollution is a by-product of economic activity and can accumulate over time. In addition to inflicting environmental damages, a higher pollution stock may also hasten the shift to the high environmental preference regime. In the climate change example, this would imply that the greater the degree of global climate change, the more likely society is to shift preferences away from pollution. More specifically, a downward shift in the benefit from the flow of pollution may occur with a positive probability via the hazard rate. We examine both exogenous and endogenous hazard rates. In the exogenous case, the likelihood of regime shift does not depend on the pollution stock (or flow). For example, the prospect of a new technological discovery that lowers the cost of renewable energy production could shift downward the demand for fossil fuel consumption. In the endogenous case, the pollution stock (e.g., carbon stock or global mean temperature) increases the likelihood of the preference shift. Whether the change in preferences is gradual or discrete will depend on the application, but historical experience suggests that discrete jumps are possible. The modern environmental movement in the United States, where the Environmental Protection Agency, the Clean Water Act, and the National Environmental Policy Act were all formed over a relatively short period of time, is thought to have been triggered by a series of environmental disasters that raised the environmental profile sufficiently to

[1] See Della Porta and Diani (2009) for an insightful introduction to social movements (and their triggers) in general, and Dunlap and Mertig (2014) for a collection of sociological perspectives on changing social preferences (among other things) in the environmental movement in the United States. Boyd and Kousky (2016) provide a thought-provoking analysis of changing environmental preferences, including a discussion of the empirical challenges in measuring such shifts.

[2] In Nkuiya et al. (2015), the threat of regime shift prevails only in the first period of their model while in the other papers, the threat prevails forever.

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