Resource and Energy Economics 39 (2015) 16–28

Contents lists available at ScienceDirect

Resource and Energy Economics

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

An optimal hybrid emission control system in a multiple compliance period model

Jongmin Yu[a,*], Mindy L. Mallory[b,1]

[a] Department of Economics, Hongik University, 94 Wausan-ro, Mapogu, Seoul 121-791, Republic of Korea
[b] University of Illinois at Urbana-Champaign, 319 Mumford Hall, 1301 West Gregory Drive, Urbana, IL 61801, United States

ARTICLE INFO

Article history:
Received 29 November 2013
Received in revised form 12 November 2014
Accepted 20 November 2014
Available online 29 November 2014

JEL classification:
L51
Q28

Keywords:
Cap and trade
Climate change
Emissions tax
Hybrid emission control
Safety valve

ABSTRACT

We characterize an optimal hybrid policy for pollutant emissions that includes a permit price ceiling and emission cap in a multi-period model. Previous studies have primarily focused on a hybrid policy of emission regulation that included an emission cap and permit price ceiling in a single period model, we extend this literature by developing such an optimal hybrid model in a multi-period framework where banking and borrowing of emission permits is allowed. In our model, we compare the case of a regulator who sets the emission cap and price ceiling to be consistent with a long run emission objective with the case of a regulator who occasionally is motivated to deviate from the optimal long run regulatory policy in order to correct for unexpected but exceptionally high emissions. Using a discrete dynamic programming model with stochastic emissions, we show that the hybrid model gives the regulator a degree of freedom in making an optimal price and quantity choice.

Cap-and-trade has been used in the European Union Emissions Trading Scheme (EU-ETS) to control carbon dioxide (CO_2) emissions in order to prevent climate change, and it has been used in the United States (U.S.) to control sulfur dioxide (SO_2) under the Acid Rain Program as a part of the 1990

* Corresponding author. Tel.: +82 10 2234 5887.
E-mail addresses: yucono@hongik.ac.kr (J. Yu), mallorym@illinois.edu (M.L. Mallory).
[1] Tel.: +1 217 372 4163.

http://dx.doi.org/10.1016/j.reseneeco.2014.11.003
0928-7655/

Clean Air Act and nitrogen oxide (NO_x) emissions in the NO_x Budget Trading Program of the NO_x State Implementation Plan.[2] Broader adoption of cap-and-trade-type schemes to reduce aggregate emissions have met resistance from industry stakeholders in part because compliance costs are uncertain. The combination of a pure cap-and-trade system with a cap on permit prices is referred to as an emission trading system with a safety valve and this hybrid system allows industries to avoid unexpectedly high compliance costs at the expense of introducing uncertainty in aggregate emissions.

The hybrid system works like a pure emission trading system under conditions when the spot price is below the ceiling, but once the price reaches the ceiling, the government provides an unlimited amount of permits at the ceiling price, effectively converting the policy to an emission tax. Therefore, in emission trading systems with a price cap, the environmental regulator has two policy parameters, the cap on emissions and the permit ceiling price. There have been studies about a price floor (Burtraw et al., 2010; Fell et al., 2012; Grüll and Taschini, 2011), but in our paper we focus on the emission trading schemes that have only a conventional safety valve. We study optimal policies in a safety valve system because safety valve provisions are often included in actual proposed emission trading legislation (the *Lieberman-Warner Climate Security Act* (2007) and *Low Carbon Economy Act* (2007) are two recent examples[3]), and the three current CO_2 programs in North America (the Regional Greenhouse Gas Initiative of the Northeast and Mid-Atlantic states, California, and Quebec) implement both price ceilings and a price floors. However, these programs only implement 'soft' price ceilings because there are only a limited number of permits the governments are willing to issue to defend the price ceiling (as in Fell et al., 2012).

For ease of exposition, in this paper we will consider a 'hard' price ceiling where the government is willing to issue unlimited permits to defend the ceiling, and we will not consider a price floor. This assumption makes the expected cost of compliance strictly less than if a soft price ceiling is imposed. However, Fell et al. (2012) demonstrated that as permits held by the government for the purpose of defending the price ceiling are increased, compliance costs decrease at a decreasing rate. This implies that, in practice, outcomes from the soft price ceiling will be identical to the outcomes from a hard price ceiling except in the case of a large emission scenario. By large emission scenario we mean that permit reserves to defend the soft price cap are exhausted and the price still exceeds the soft cap.

Additionally, all previous research on dynamic decisions under a hybrid emission trading system has considered year-to-year optimal decisions regarding emission abatement, banking, and borrowing. In this paper we consider a longer horizon where the regulator defines compliance periods that span several years (in the EU carbon market a compliance period historically has been between five to eight years[4]). It is neither politically feasible nor desirable, if stability in policy is valued, to change the emission cap and price ceiling in the middle of a compliance period. At the end of the compliance period, however, the regulator has an opportunity to take stock of the regulatory program and reassess what the proper emission cap and price ceiling should be. It is expected that there will be instances where the regulator needs to deviate from the long run optimal emission cap and price ceiling due to short run political forces or other temporary concerns. In this paper we explore how the regulator may satisfy these short run considerations and provide guidance regarding the best path back to the long run equilibrium emission cap and price ceiling.

1. Literature review

Although a number of previous studies on optimal hybrid emission control systems have considered dynamic decisions across multiple years, they have all been based on a single compliance period (Jacoby and Ellerman, 2004; Pizer, 2002; Stranlund and Moffitt, 2014; Webster et al., 2010; Grüll and Taschini, 2011; Maeda, 2012; Fell et al., 2012). It is important, however, to consider multiple compliance periods because the regulator and regulated agents renew their decisions at the end of the

[2] Information about the NO_x State Implementation Plan can be found from the EPA at http://www.epa.gov/airmarkets/progsregs/nox/sip.html.

[3] Lieberman-Warner Climate Security Act (S. 2191), and Low Carbon Economy Act (S. 1766).

[4] http://www.decc.gov.uk/en/content/cms/emissions/eu_ets/eu_ets.aspx.