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Cap-and-trade programs under delayed compliance: Consequences of interim injections of permits ☆

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ABSTRACT

Virtually every analysis of cap-and-trade programs assumes that firms must surrender permits as they pollute. However, no program, existing or proposed, requires such continual compliance. Some (e.g. the Acid Rain Program limiting SO_2 emissions) require compliance once a year; others (e.g. the Regional Greenhouse Gas Initiative limiting CO_2 emissions) require compliance every three years. The paths of emissions and permit prices would be invariant to compliance timing (Holland-Moore, 2013) if the government never injected additional permits between successive compliance dates. However, virtually all emissions trading programs require such injections through either (1) interim permit auctions or (2) sales from "cost containment reserves" intended to cap permit prices. In such cases, analyses which abstract from delayed compliance may mislead policy makers. For example, a cost containment reserve judged sufficient to cap prices at a ceiling over a year may sell out in a single day.

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The Cost Containment Reserve (CCR) was used for the first time in [the March 5, 2014 RGGI] Auction 23. The demand for CO_2 allowances from bids submitted above the CCR Trigger Price of $4.00 exceeded the Initial Offering of 18,491,350 allowances and was sufficient to purchase all 5 million 2014 CCR allowances. After the CCR was exhausted, the auction cleared at a price of $4.00 per ton. There are no other CCR allowances available for sale in 2014.—Market Monitor Report (RGGI, March 7, 2014).

1. Introduction

Cap-and-trade programs have been used in the past to solve the acid rain problem in the U.S. and are now being utilized at home and abroad to combat global warming. Such regulations may differ in their details. Nonetheless they share two important features.

First, although firms subject to the regulations are required to surrender permits to cover their emissions, they are never required to surrender permits on a continual basis ("continual compliance") but only at compliance dates (or "true ups") which recur periodically. As a result, a regulated firm may emit sulfur dioxide or carbon dioxide without possessing the permits to cover its emissions as long as it acquires the requisite permits by the compliance date. We refer to this aspect of the regulations as "delayed compliance." For example, under the U.S. Acid Rain Program (ARP) or the European Union Emission Trading Scheme (EU-ETS), compliance is required only once a year. In the case of the three federal bills to regulate carbon emissions in the U.S., none of which became law, compliance would have been required only once a year.[1] Other programs have even longer intervals between true-ups. For example, the Regional Greenhouse Gas Initiative (RGGI, 2014) has a

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[1] Waxman–Markey's "American Clean Energy and Security Act of 2009," Kerry–Boxer's "Clean Energy Jobs and American Power Act of 2009," and Kerry–Lieberman's "American Power Act of 2010."

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compliance period of three years and so does California's AB-32 (although in the latter case, a fraction of the permits must be surrendered earlier as a down-payment).[2]

These programs typically share a second feature: they mandate injections of additional permits between true-up dates. Even the older programs have auctions between compliance dates. For example, ARP holds an auction of additional permits one month after the annual true-up while EU-ETS holds weekly auctions within each compliance period. California's AB-32 has an initial allocation of permits supplemented by subsequent injections of additional permits during the compliance period, and a similar plan was proposed in the three Congressional bills which died in Congress. All four of these programs prescribe a periodic sequence of auctions.

Recently, another method of injecting additional permits within the compliance period has become popular—the sale of additional permits from the regulator's stockpile. The intention is to have a reserve large enough to keep permit prices from soaring above a designated ceiling but not so large that it would compromise the pollution cap. RGGI has its "cost containment reserve" (CCR) and AB-32 has its "Allowance Price Containment Reserve" (APCR) for this purpose. The Kerry–Lieberman bill proposed sales of permits at a fixed price over a designated time interval terminating at the end of the interval—or sooner if the cost containment reserve was exhausted. Although EU-ETS and ARP currently lack such price collars, each program has considered using them. Some scholars have argued that the absence of such a "safety valve" in the EU-ETS constitutes a serious "design flaw."[3]

All of these programs allow storage of permits ("banking") for later use and most of these programs prohibit or severely restrict the opportunity to borrow from future allocations. For the reader's convenience, we summarize the features of various cap-and-trade programs in Table 1.[4]

In fashioning these programs, policy makers often ask economists to predict the consequences of different designs. What are the consequences of different ceiling prices and the reserve sizes to defend them? What are the consequences of different auction frequencies, amounts, and minimum bids (reserve prices)?

In response, a large literature has developed analyzing safety valves.[5] Burtraw et al. (2010) find that a price collar (also called a "symmetric safety valve" in the paper) outperforms a safety valve in a static setting. Fell and Morgenstern (2010) and Fell et al. (2012a) simulate a dynamic stochastic model of a cap-and-trade program with a price collar or a safety valve.[6] Fell and Morgenstern (2010) find that price collar mechanisms are more cost-effective than both purely quantity-based mechanisms and safety-valve mechanisms for a given level of expected cumulative emissions. They also find that the combination of a price collar with banking and borrowing systems can achieve expected cost as low as a tax with lower emissions variance. Fell et al. (2012a) find that *hard* collars, which ensure unlimited supply of reserve allowances to defend a ceiling price yield lower net present value of expected abatement costs than *soft* collars, price collars with limited supply of reserve allowances, for the same level of the expected cumulative emissions. Recently, Hasegawa and Salant (2012) have shown that the price path of permits will remain constant as long as the government sells additional permits at its ceiling price and may collapse in response to government auctions even if they are anticipated. Remarkably, this entire literature (including our own contribution) has neglected to take account of compliance timing.[7]

The purpose of our paper is to explain why policy analyses assuming continual compliance may mislead policy makers if the delayed-compliance program analyzed also mandates interim injections of permits. To be constructive, we then provide a methodology for analyzing cap-and-trade programs under delayed compliance.

Before we begin, we would like to discuss briefly contributions to the literature that encourage the mistaken belief that compliance timing is an irrelevant detail. Holland and Moore (2013) is the only paper besides our own working papers to distinguish delayed from continual compliance (or, as they call it, "prompt" compliance). Their paper provides a valuable table describing key institutional features of various cap-and-trade programs. It also contains a condition sufficient for the path of permit prices and emissions to be the *same* under continual and delayed compliance. As long as their invariance condition holds, analysts who assume continual compliance when analyzing cap-and-trade programs will not introduce error even though all such programs require only periodic true-ups. However, as Holland and Moore themselves warn "this sufficient condition might not hold, for example, if the regulator imposed price regulation or if the regulator injected or removed permits into the market" (Holland-Moore, p. 679). Elsewhere, they again note the limited applicability of their theorem: "Many existing and proposed programs include such price control mechanisms" (Holland-Moore, p. 673). Finally, in their very brief Section 3.2 drawing on our prior work, they illustrate cases where the time paths of emissions and permit prices *are* sensitive to compliance timing.

Many of the simulation models in the literature (Fell and Morgenstern, 2010; Fell et al., 2012a, 2012b) also leave the impression that compliance timing is unimportant. Such models typically assume discrete time and define the period length in a way that obscures the distinction between delayed compliance and continual compliance. To understand this distinction, consider a discrete-time model where one period represents one day. If the government injects additional permits on some of the days within the next year, the policy of requiring that permits be surrendered every day to match that day's emissions (continual compliance in discrete time) *differs* from the policy of requiring permits to be surrendered once every 365 days to cover cumulative emissions during the entire year. If true-ups were required once every 365 days, injections of additional permits would occur *within* the compliance period. However, most of the discrete-time literature defines the length of each period to be the *same* as the length of the compliance period.[8] Since nothing by definition can happen *between* periods, this seemingly innocuous modeling choice implicitly prevents the examination of the consequences of a government injection of permits between one compliance date and the next.

To consider the effects of government policies conducted *within* a compliance period, we adopt a continuous-time formulation as less cumbersome than its discrete-time counterpart.

We proceed as follows. In Section 2, we present a stark illustration of the errors that result if an analyst mistakenly assumes that firms are in

[2] In addition, as Holland and Moore (2013, p. 673) note, the Western Climate Initiative (2010) and Midwestern Greenhouse Accord (2010) define three-year compliance periods in their draft model rules.

[3] Stavins (2012) regards the absence of a safety valve or price collar in the European system as a "design flaw."

[4] This table amplifies information in Table 1 of Holland and Moore (2013).

[5] For a valuable explanation of the origins of the safety-valve concept and its evolution in the climate context, see Jacoby and Ellerman (2004).

[6] In a dynamic context, intertemporal trading of emissions permits matters for economic efficiency. Cronshaw and Kruse (1996) and Rubin (1996) show that emissions trading allowing banking and borrowing of emission permits achieves the least-cost outcome. Like all dynamic analyses of cap-and-trade programs, both of these articles assume that firms are continually in compliance as well.

[7] Stocking (2012) analyzes the strategic actions of regulated firms in the presence of price controls in emissions permit markets and shows that, in attempt to reduce the equilibrium price of permits, firms may have incentive to purchase permits from the government at the ceiling price even when the prevailing market price of permits is lower.

[8] There is an interesting parallel in the literature on storage of grains. In Samuelson (1957), grain harvests of the same size occur once every year and intraseasonal demand is stationary and deterministic. The price following every harvest begins low, grows to induce intraseasonal storage despite storage costs and foregone interest and collapses when the next harvest arrives, deterring interseasonal storage. Then the cycle repeats, creating a sawtooth pattern. In a discrete-time model where one period corresponds to one season, the price each period would be unchanging, and the rich intraseasonal dynamics would be concealed. Samuelson (1971) adopted this latter approach when discussing interseasonal carryovers under uncertainty.

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