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Price controls and banking in emissions trading: An experimental evaluation

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ABSTRACT

We present results from laboratory emissions markets designed to investigate the effects of price controls and permit banking on limiting permit price risk. While both instruments reduce between-period price volatility and within-period price dispersion, combining price controls and permit banking yields important benefits. Banking alone produces high permit prices in earlier periods that fall over time, but the combined policy produces lower initial prices and lower volatility. However, banking, price controls, and the combination all produce higher between-period emissions volatility. Hence, for emissions markets that seek to control flow pollutants with strictly convex damages, efforts to limit permit price risk can result in higher expected damage.

Introduction

The highly uncertain costs of controlling greenhouse gas emissions have generated significant research and policy innovation in modifying emissions markets to contain abatement costs and limit permit price risk. While several methods for doing so have been proposed, the two most important are giving firms the ability to bank emissions permits and implementing permit price controls. [1] In this paper we provide results from a series of laboratory emissions permit markets that were designed to evaluate the relative effectiveness of these methods in terms of limiting permit price risk.

Permit banking allows firms to shift abatement across time in a cost-effective manner and to hedge against permit price risk associated with uncertain abatement costs, uncertain emissions, and other stochastic elements (Rubin, 1996; Schennach, 2000). Imposing a permit price ceiling and floor on emission trading—a so-called price collar—is a more direct way of limiting price volatility.[2] It is well known that an optimal hybrid policy of price controls and emission trading is never less efficient, and is often more efficient, than a pure trading program (Roberts and Spence, 1976). Some analyses of price

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[1] Fell et al. (2011) provided a recent literature review on alternative cost-containment approaches.

[2] Prices in existing permit markets can be fairly volatile. Pizer (2005) presents time series of permit prices that illustrate this volatility in the RECLAIM program and the NO_X Budget Trading program. Nordhaus (2007, pg. 38) estimates average volatility in the SO_2 Allowance Trading program between 1995

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controls only involve price ceilings, or safety valves (Pizer, 2002; Jacoby and Ellerman, 2004), but several simulation studies have demonstrated the cost-effectiveness of combining price ceilings and price floors (Burtraw et al., 2010; Fell and Morgenstern, 2010; Philibert, 2008).[3]

Most existing emissions trading programs allow some form of permit banking, and many recent proposals to control greenhouse gases also include some form of price control. (See Hood (2010); Newell et al. (2013) for several examples). However, little work has been done to examine the combined effects of price controls and permit banking, perhaps because of the lack of field data. Exceptions include Fell and Morgenstern (2010) and Fell et al. (2012) who conducted numerical simulations of a U.S. cap-and-trade policy for carbon dioxide with permit banking and alternative forms of price control. While numerical simulations of proposed policies provide important information about their potential performance, they are typically based on idealized behavioral and informational assumptions. Economic experiments can complement numerical simulations when field data are lacking by highlighting actual behavior under specific regulations in controlled environments.

Several studies have used experiments to study banking behavior in laboratory emissions markets. Permit banking tends to reduce permit price volatility (Godby et al., 1997; Cason and Gangadharan, 2006), but subjects are not always able to exploit the potential gains from banking (Muller and Mestelman, 1998). No one to our knowledge has used laboratory experiments to investigate the performance of emission markets with the combination of banking and price controls.[4]

In our experiments, subjects participated in a market for a limited number of permits that allowed them to produce a fictitious good. Uncertainty about future production payoffs provided the motivation for permit banking and the justification for price controls.[5] We utilized a 2×2 design (with/without banking $\times$ with/without price controls). In the two treatments with permit banking, subjects could save as many permits as they wished in a period, but could not borrow permits from future allocations. In the two treatments with price controls, subjects could buy an unlimited number of additional permits at a price ceiling, and could sell an unlimited number at a price floor. The treatment that did not allow banking and did not include price controls serves as a baseline. This design allows us to determine the independent contributions of both banking and price controls to permit market performance.

We analyze the effects of price controls, banking, and the combination on price levels, between-period price volatility (the variation in prices over time), within-period price dispersion (the distribution of trading prices within a period), aggregate emission levels, and emissions volatility (the variation in aggregate emissions over time). Permit price volatility can delay investment in abatement technologies and increase abatement costs over time (Zhao, 2003). Moreover, dynamically efficient control of a uniformly mixed pollutant requires that abatement responsibilities be distributed to minimize within-period aggregate abatement costs, which in turn requires a consistent price signal (Kling and Rubin, 1997). Hence, high price dispersion can limit the ability of emissions markets to allocate individual abatement responsibilities efficiently. On the other hand, banking and price controls make the level of aggregate emissions in a period endogenous, so these provisions can affect the environmental performance of emissions markets. For example if a price ceiling is set too low, or if firms over-use this feature, then price controls can lead to increased aggregate emissions and environmental damage.[6] In addition, containing price volatility can lead to increased volatility in aggregate emissions. Given a level of accumulated emissions over some time interval, increased emissions volatility does not affect expected environmental damage if the pollutant is a stock pollutant and there is no threat of exceeding a threshold that triggers a large increase in damages. However, if emissions produce a flow pollutant with a strictly convex damage function, then increased emissions volatility produces higher expected damage.

Our efforts yield several new results that have important implications for designing emissions markets, including

1. Both permit banking and price controls reduce within-period price dispersion and between-period price volatility. Thus, both instruments promote permit price consistency and stability. Moreover, the combination of banking and price controls leads to significantly less price volatility than either instrument alone.
2. Permit banking alone tends to lead to high permit prices in early periods that fall over time as subjects build up permit banks and then draw them down. This is consistent with a theoretical model of a policy that allows firms to save permits

(*footnote continued*)
and 2006 and finds that it exceeds the volatility of the consumer price index and the volatility of the stock price index for the Standard and Poor 500 by significant amounts, and approaches the volatility of crude oil prices.

[3] Recent theoretical papers that examine emissions markets with price controls and other cost-containment measures include Weber and Neuhoff (2010), Webster et al. (2010), Grull and Taschini (2011), and Stranlund and Moffitt (2014).

[4] We are aware of only one other experimental study of price controls in emissions markets. Perkis et al. (2012) investigated alternative price ceiling designs. They did not examine the performance of price collars (the combination of price ceilings and floors) nor did they consider permit banking.

[5] We are not aware of other laboratory experiments in which banking is motivated by uncertain production benefits. Stranlund et al. (2011) and Cason et al. (1999) motivated banking with a reduction in the supply of emissions permits in the middle of multi-period trading sessions. Cason and Gangadharan's (2006) experiments involved stochastic emissions, while subjects in Godby et al. (1997) were motivated by both stochastic emissions and a reduction in the permit supply. We focus on uncertainty in production benefits because this is what motivates theoretical models of price controls.

[6] Debates concerning price controls have highlighted the concern that they can lead to emissions exceeding the goals of a cap-and-trade policy. To address these concerns for a price ceiling, Murray et al. (2009) proposed a fixed reserve of permits that could be sold at the price ceiling in a period. Fell et al. (2012) examined the efficiency and environmental integrity of so-called "soft" price controls, which allow limited purchases of additional permits at the price ceiling and limited sales at the price floor. They showed that while soft controls effectively limit the chance that emissions will exceed targets, they are less efficient than controls that do not impose such restrictions. Our experiments do not impose these restrictions.