Signaling and Permit Banking in Emissions Permit Markets

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Abstract

In "Trading for the Future: Signaling in Permit Markets", Bard Harstad and Gunnar Eskeland find that, contrary to traditional assumptions made in environmental economics, trading in emissions permit markets is not very efficient and, under certain conditions, may become so distortionary that another policy becomes a better choice for controlling pollution. Their findings, however, rest on two key assumptions: 1) that firms are not allowed to bank permits from one trading period to the next, and 2) that even if firms were allowed to bank permits, they would not choose to do so in equilibrium. By examining theoretical and empirical evidence, I show that this second assumption is wrong. Through the introduction of permit banking into their two-period model, I will explore how the government might use such a policy to reduce distortions in trading and signaling in emissions permit markets.

Part I: Literature Review

Rethinking Tradable Permits

A traditional idea in environmental economics has been that tradable permits are perhaps the most cost-effective means by which a government can regulate emissions, since they should satisfy the equimarginal principle regarding the costs of pollution control. This assumption follows the Coase Theorem, which shows how assigning individual rights to pollution can yield the most efficient outcome regardless of initial allocation of permits. More recently, however, much of the work on tradable permits has explored what happens to permit markets when the many assumptions required for the Coase Theorem breakdown. These assumptions--perfect information, lack of market power, costless enforcement, no income effects, and no transaction costs--often do not hold in the real world (Charles D. Kolstad 2010, 267). Robert Stavins, for example, in pointing out that the “cost-effectiveness [of permit markets] [has] often been exaggerated” (Robert N. Stavins 1995, 133) categorizes transaction costs into three types: 1) Searching costs, 2) Decision costs, and 3) Enforcement costs (Stavins 1995). Robert Hahn shows how equilibrium in permit markets can be affected by simply having one firm not be a price taker (Robert Hahn 1984, 754).

From just these two examples, it is clear that permit markets are not automatically cost efficient. Initial allocation of permits matters, as does market design. If these two factors are not attended to, then permit markets lose a lot of their value as a form of regulation. Unfortunately, political factors make allocation a difficult issue to address. One of the most common means by which to achieve necessary industry support for emissions regulation is to hand out permits for free in a process known as “grandfathering”. This provides firms with a free allocation of permits which can then be used to cover pollution (Jacob Goeree et al. 2009, 1). Many of the complaints surrounding this method of allocation have to do with signaling. Giving away permits for free gives no indication as to how much they may actually be valued. Furthermore, the article that provides much of the focus for this paper argues that free allocation of permits, based on past emissions, distorts permit trading and signaling as firms emit more in order to signal a need for more free permits in the next period (Bard Harstad and Gunnar Eskeland 2010, 749). From the perspective of the economist, the auctioning of permits is better, because it provides information to market participants, it can provide revenue for the government, and it can ensure that the permits are going to those who value them most. Auctioning, however, may not be as optimal as might be thought. At least one study has found that auctioning can still lead to misallocation due to the different bidding strategies adopted by high- and low- cost polluting firms (Goeree et al. 2009). The political reality, however, seems to be that grandfathering of permits will remain the dominant means of allocation for the foreseeable future. One of the questions that this paper explores is how, given this type of allocation, the use of permit banking in market design can potentially minimize signaling distortions.

Theoretical and Empirical Evidence for Permit Banking

In this section, I will explore the theoretical and empirical evidence regarding permit banking. Through so doing, I hope to show why banking, when allowed, is a desirable equilibrium activity for firms. Intertemporal trading of emissions permits can involve either banking or borrowing. Banking is the activity of saving a permit allocated in the current period for use in the next trading period. Ideally, it means that the firm, in exchange for being able to pollute more in the future, must pollute less in the present. Borrowing is the activity of taking a permit meant to be allocated in a future trading period and using it to cover pollution in the current period. It means that a firm is willing to pollute less in the future in order to pollute more in the present. For reasons cited by Catherine Kling and Jonathan Rubin, I will not be looking at permit borrowing in this paper, as it is generally viewed as a strategy that can lead to poor environmental outcomes (Catherine Kling and Jonathan Rubin 1996, 101). If firms can move emissions completely freely between time periods then they will choose excessively high levels of damage in early periods and not enough in later periods, due to the effect of discounting (Kling and Rubin 1996).

Permit banking is considered a desirable action for firms when they face rising marginal abatement costs, falling marginal production costs, declining emissions standards, or rising output prices. It allows more flexibility in complying with emissions regulations, one of the most desirable aspects of tradable permit regulation (Jonathan Rubin 1996, p.270), and a lot of the literature suggests that permit banking brings environmental regulation closer to the least-cost solution. When a firm chooses to bank a permit, it chooses to face the cost of abatement in the current period (Rubin 1996). It will choose to do so if the cost of abatement is rising faster than the discount rate, which would be likely under a regulatory scheme where emissions caps are becoming more stringent over time. An additional benefit is that this would seem to be especially the case with the highest emitting firms. High emitting firms, it is generally assumed, have low initial abatement costs, so it is more beneficial for them to abate pollution now rather than to wait until a later time. Some more recent work has suggested that permit banking can act as a form of risk-management for firms in the case of uncertain permit allocation in future periods (Julien Chevallier et al. 2011, p4). Banking can also lower the social cost of pollution, since present social damage has a higher cost than future social damage, determined by the discount factor. Moving significant amounts of emissions to later time periods through permit banking lowers the costs of pollution to society as a whole (Rubin 1996). Robert Innes has suggested that the policy of allowing permit banking can sometimes act as a stand-in for otherwise costly enforcement (Robert Innes 2003, 562). This point-of-view is similar to the one adopted in my paper, where allowing permit banking is examined as a means of minimizing distortionary signaling.

As with most aspects of tradable permit markets, some concerns arise regarding setting levels of aggregate pollution. If too many permits are given out, permit banking does very little to reduce emissions, since firms can pollute more in both current and future periods. The European Union Emissions Trading Scheme, which does not allow banking, experienced early problems with the number of permits issued and gave out far too many; the effect was to send permit prices to near zero. One issue that will be explored in this paper is the importance of the relationship between the aggregate levels of pollution in the current period and the next period.

In addition to the theoretical evidence regarding why firms want to bank permits, there is also considerable empirical evidence suggesting that permit banking is a common activity for firms involved in tradable permit markets. The market for sulfur dioxide in the United States allowed permit banking. The sulfur dioxide market was divided into two phases, the first phase lasting from 1995-2000, and the second one lasting from 2000-2010. Towards the end of the market, there has been some concern regarding reduced trading activity and falling permit prices, but for the most part the program has been extremely successful. By the end of 2010, the permit bank was set to expire and aggregate emissions had to be at a long-term level of 8.9 million tons. The activity of banking was surrounded with a great deal of uncertainty over its environmental impacts and the degree to which it could be expected to be an "equilibrium" activity for firms (A. Denny Ellerman and Juan-Pablo Montero 2005, p.3). Banking turned out to be a significant activity, as around 30% of the permits issued in Phase I were banked for Phase II. Furthermore, the level of banking was estimated to be "reasonably efficient" (Ellerman and Montero 2005). Banking activity was also robust. Changing the level of expected "counterfactual" emissions--what emissions would be in the absence of the regulations--produced surprisingly little change in the amount of banked permits despite leading to much variation in SO2 prices and abatement levels (Ellerman and Montero 2005).

Some evidence regarding banking's effect on signaling in the SO2 market has also been presented. Banking gives participants "a greater incentive to think about their long-term position in the market", and it also serves to smooth prices from year-to-year, minimizing the types of unpredictable price plunges that have plagued the European Union Emission Trading Scheme (EU-ETS) (Dallas Burtraw et al. 2005, p.38). It has been suggested that permit banking created a kind of self-reinforcing loop in terms of SO2 prices, since firms, holding on to unused permits, had an interest in making sure that those permits maintained and increased value across time spans (Burtraw et al. 2005). As would be expected, the dirtiest, highest emitting firms cleaned up the most, especially in the Phase I period.

My argument, then, is as follows. Since it is clear that firms, if allowed, can be expected to engage in some form of permit banking, and that the degree of banking is robust, an assumption that firms would not want to bank permits in equilibrium is not a correct assumption to make.

"Trading for the Future: Signaling in Permit Markets"

Before adding permit banking to their model, I will give an overview of the methods and main results of "Trading for the Future: Signaling in Permit Markets".

Modeling their permit market along similar lines to the EU-ETS, the authors try to understand trading activity in a market with imperfect information about each firm's type. Through backward induction, they find that, although the allocation and trading in the last period is efficient and the permits "implement the first best" (Gunnar and Eskeland 2010), trading in the first period is distortionary. If the value of a future permit is high, then firms seek to use more permits in the current period to increase the allocation of free permits that they will receive at the start of the next period. In addition to using the permits that are allocated to them, high-cost firms are willing to trade for many more permits than they normally would otherwise; there is too much trade as the price of permits is higher than the marginal value of abatement. They have to pollute more to "separate" themselves from low-cost firms, who are also tempted to pollute more by the high future value of permits; the high-cost firm "pollutes so much that the low-cost firms are...indifferent" about attempting to disguise themselves as a high-cost firm (Gunnar and Eskeland 2010). Thus, in their model low-cost firms are selling too many permits and high-cost firms are buying too many permits (Gunnar and Eskeland 2010). High-cost firms are "trading for the future" or, more accurately, the future permit allocation. The authors develop cases in which permit trading should be prohibited, as well as cases in which it should be completely abandoned. There are also extensions of the framework, but this is as far as my use of it will go. The main policy recommendation is that "the government should commit to not intervene in the market for a larger number of years" (Gunnar and Eskeland 2010), since it is the anticipation of frequent free permit allocation that results in the distortionary signaling. In the following sections, I will add the option of permit banking to the above model.

Part II: The Model

The Setup

This is a game with two players, the group of profit maximizing firms and a welfare maximizing government. It is a signaling game involving incomplete information. The two key characteristics that I am attempting to add to the model presented by Harstad and Eskeland are the allowance of banking and a commitment to an aggregate number of permits in the second period on the part of the government. The consequences of not having this commitment will be considered later on in my analysis and results section.

The Firms

There is a set of *i* firms, such that,

$$\forall i \in I, \theta_i \in \{\underline{\theta}, \overline{\theta}\}$$

meaning each firm is either a high-cost polluter or a low-cost polluter. If a firm is a high-cost polluter, this simply means that abatement comes at a high cost for them. The reverse is true for the low-cost polluter. To make this a game of incomplete information, a condition needs to be implemented such that each firm's type is unknown to the government and should be "revealed" through their choices. This condition is

$$\Pr(\theta_i^+ = \underline{\theta}) = \begin{Bmatrix} s + (1-s)k \text{ } if \text{ } \theta_i = \underline{\theta} \text{ } and \\ (1-s)k \text{ } if \text{ } \theta_i = \overline{\theta} \end{Bmatrix}$$

which reads as the probability that the firm will be a low-cost polluter in the next period. If it is a low-cost polluter in the current period, then the probability is given by $s+(1-s)$, and if it is a high-cost polluter in the current period, then the probability is given as $(1-s)$. The firms seek at all times to maximize intertemporal profit, given by

$$\Pi_t = \pi_t + \delta\pi_{t+1}$$

with δ as the discount rate on future profits. In what follows, any variable with a superscript + will be a variable of the second period. Each firm chooses an emission level x_i in the first period and x_i^+ in the second period. Firms are uncertain of their future permit allocation; permit banking, however, provides a means by which they can determine a partial amount of the permits that they will have in the second period. Let $b(t)$ be the size of a firm's permit bank, with the condition in place that $b(t) \geq 0$, which is just a way of saying that borrowing of permits is not allowed. So the total number of permits available to the firm in the next period will be

$$T^+ = q_i^+ + b(t)$$

The Government

In this model, following Harstad and Eskeland, I treat the government as a welfare maximizing central planner that seeks to maximize the expected utility of the firms, subject to a policy commitment to a future aggregate permit level. They are distributing permits over two periods, and the permits are distributed for free in each of the two periods. Another point of departure is that I will treat the utility that the government seeks to maximize as strictly synonymous with the profit function of the firms, instead of adding a "disutility" of pollution on the part of each firm's owner. I think that this is a reasonable omission because the government has already set aggregate pollution targets for each period in a way that the value of clean air has already been considered.

The Market

Q is the aggregate number of permits allocated in the first period, and q_i is the number of permits distributed to each firm. The sum of permit allocations is Q, or the government sets $q_i, s.t. \sum_0^n q_i = Q$. The government has also committed to a policy such that $Q^+ \leq Q$. One of the assumptions of this model is that abatement costs are rising from one period to the next, and this reduction in aggregate permits is partially responsible. Abatement costs can be thought of as the foregone benefit of pollution. Furthermore, marginal abatement costs should also be rising, since the foregone benefit of the next unit of pollution is higher as firms pollute less and less. Abatement costs are reflected in the price of permits, given by p and p^+ for each of the respective periods. The price should rise from period to period, or

$$p^+ > p, where\ p^+ = F(p, Q - Q^+)$$

Note that p^+ is an expected value, treated as a function of p and the difference between the aggregate permit levels in each period. The function should be increasing for both variables, represented as,

$$\partial p^+ \big/ \partial p > 0 \quad , \quad \partial p^+ \big/ \partial Q - Q^+ > 0$$

from which the intuition can be drawn that as $Q-Q^{+}$ increases, the expected value of p^{+} increases. Another way of thinking about it is that as the aggregate quantity of permits in the next period decreases, $Q-Q^{+}$ increases, as does p^{+}.

Part III: Model Analysis and Results

Equilibrium

Signaling games such as this usually have one of three types of equilibrium: separating equilibrium, pooling equilibrium, or semi-pooling equilibrium (Walter Nicholson and Christopher Snyder 2008, p.276). Using the Intuitive Criterion, Harstad and Eskeland argue that the equilibrium will be in separating strategies. This simply means that the government, observing a certain level of emissions, concludes that a firm is high-cost since that level of emissions “can never be optimal for the low-cost type” (Harstad and Eskeland 2010). In other words, the government would expect that high-cost polluting firms are going to pollute more, since it is more costly for them to not pollute. Based on this information, they will then allocate permits for the next period. This should still be the equilibrium action even if adding permit banking and policy commitment to the model.

Decisions

When the firm receives a permit in period one, it can use it to cover pollution, trade it away, or bank it. It will do so according to the following conditions, where $F(x_i, q_i)$ is the production function of the firm (with x_i being pollution level and q_i being permits), *E* just denotes an expected value, and δ is the discount rate:

1) It will use the permit to cover pollution if:

$$F(x_i,q_i) > p \times q_i \quad and \quad F(x_i,q_i) > \delta(p^+ \times q_i) \quad and \quad F(x_i,q_i) > \delta F(x_i^+,q_i)$$

2) It will sell the permit if:

$$p \times q_i > F(x_i,q_i) \quad and \quad p \times q_i > \delta E(p^+ \times q_i) \quad and \quad p \times q_i > \delta F(x_i^+,q_i)$$

3) It will bank the permit if:

$$\delta F(x_i^+,q_i) > F(x_i,q_i)\ and\ p \times q_i \quad or \quad \delta E(p^+ \times q_i) > p \times q_i\ and\ F(x_i,q_i))$$

Condition (1) says that they will use a permit if the production value in the current period is greater than the market price to sell the permit, the expected permit price in the second period times the discount rate, and the production value in the second period times the discount rate. Condition (2) says that the firm will sell the permit if that value is greater than the current period production value, the expected price in the second period times the discount rate, and the expected production value in the second period times the discount rate. Condition (3) says that the firm will bank the permit if either of the expected values are greater than both possible uses in the current period. In terms of permit banking, the two extreme cases would be when no permits are banked or when all permits are banked. The second case can be ruled out, since the discount rate on future income should ensure that at least some permits would be used. What about the first case? This was the case argued for in the assumption in (Harstad and Eskeland 2010). Looking back to the conditions, we find that zero permits will be banked when

$$\forall \overline{\theta} \in \left\{\underline{\theta},\overline{\theta}\right\}, F(x_i,q_i) > \delta E(p^+ \times q_i) \quad and \quad F(x_i,q_i) > \delta F(x_i^+,q_i)\ for\ all\ q_i$$
$$and$$
$$\forall \underline{\theta} \in \left\{\underline{\theta},\overline{\theta}\right\}, F(x_i,q_i)\ and\ p \times q_i > \delta E(p^+ \times q_i) \quad and \quad \delta F(x_i^+,q_i)\ for\ all\ q_i$$

where it is implied here that high-cost polluters will not sell permits, at least in the first period. This is a reasonable expectation. So if the use of all permits in the current period is greater than their potential use value in the next period, then no permits will be banked. Low-cost firms will trade away their excess permits, and high-cost firms will use them to increase their free allocation for the next period. When would this occur? Since p^+ is treated as a function of the current price and as a function of the difference between aggregate permits in period one and aggregate permits in period two, it is an increasing function of p and a decreasing function of Q^+. When $Q^+ = Q$, therefore, $p^+ = p$. Since the discount rate is applied towards any decision involving p^+, $p \geq p^+$ for all q_i. Low-cost firms, then, would like to use or trade away all of their permits in the event that no difference exists between the aggregate permits allocated in each period. For any Q^+ such that $\delta F(p, Q - Q^+) \times q_i > p \times q_i$, low-cost firms will likely bank a certain amount of their permits. Would they be tempted to imitate the high-cost firm? This would not be an optimal choice. It would require them to use all of their permits to cover pollution, but since high-cost firms will always value permits more highly than the low-cost firm, then they could get a better return on their excess permits by either banking them or trading them. So as long as the above condition is satisfied for excess permits, the low-cost firm will not try to imitate the high-cost firm.

The High-Cost Firm

What about high-cost firms? It is possible, although unlikely, that they would be sellers of permits in the second period. Thus, the relation $F(x_i, q_i) > \delta E(p^+ * q_i)$ is unlikely to be satisfied for any value of $\delta E(p^{+} * q_i)$ --the high-cost firm will always receive a higher value from the permit by using it in the current period when compared to selling it in the next period. In order to minimize the distortionary signaling seen in the model without permit banking, when high-cost firms were using all of their permits and trading for more in order to receive a better future allocation, the goal is to get the high-cost firm to act in such a way that they pollute the minimum amount required to separate themselves from the low-cost firm. The condition we are searching for is, for at least some q_i,

$$\delta F(x_i^{+}, q_i) > F(x_i, q_i)$$

Since $Q^{+} \leq Q$, the assumption that marginal abatement costs are rising holds. This means that, again subject to the discount rate, at least some units of pollution in the future will have a higher value than present pollution units, or

$$\exists x_i^{+} \in X^{+}, \delta F(x_i^{+}, q_i) > F(x_i, q_i)$$

In a model that disallows permit banking, this relationship breaks down and is responsible for the trade distortion. Firms were polluting more in the present in order to increase their future allocation of permits and the ability to pollute more in the future. With permit banking, there is the option of polluting less in the current period in order to pollute more in the later period. Of course, this also depends on the value of Q^{+}. When it is sufficiently lower than the aggregate level of permits in the current period, a firm may pollute less than it would otherwise in order to save for pollution in later periods. The expected value of an individual permit given out in the current period should be significantly greater than the value of the permit in the current period, once the discount rate is taken into effect.

To think of it another way, when Q^{+} is low, the banked permit will be worth close to one permit in the next period. Without banking, a used permit is worth the pollution it covers *plus* the value of whatever extra permit it might gain for use in the next period through signaling. This is to be contrasted with a value of zero for the permit if it is not used. To represent this valuation decision, we can use the following

$$F(x_i, q_i) + s(q_i^{+}) > 0$$

where $s(q_i^{+})$ is the value provided by signaling and 0 is, in this case, the value of the permit if it is held. With banking, this changes. The firm will use permits so long as

$$F(x_i, q_i) + s(q_i^{+}) > \delta F(x_i^{+}, q_i)$$

where $s(q_i^{+})$ has a much smaller value because the signaling relationship is not nearly as close to one-to-one. If, for example, the aggregate number of permits provided in the second period is half of the aggregate number of permits provided in the first period, then signaling in the first period can provide the firm with, at most, 1/2 an extra permit for each permit used to signal. Banking should be a much more desirable action on the part of the high-cost firm in this case. So if we define an excess permit as any permit for which, in the current period,

$$\delta F(x_i^{+}, q_i) > F(x_i, q_i)$$

is satisfied, then it becomes a question of the firm solving a value relationship of the extra value provided from polluting one more unit of pollution now plus the signaling value of the permit, or $s(q_i^+) \times x_i^+$. To bank the permit, the high-cost firm needs

$$s(q_i^+) \times x_i^+ < q_i^+ \times x_i^+$$

Results

When permit banking is allowed, it has the potential to mitigate the likelihood of the distortionary signaling seen in the model without permit banking. One of the basic problems in the model without banking was that an expected value of future permits that was high made trade distortionary in the first period because high-cost firms, in order to get a better free allocation in the next period, ended up using more permits than they would have otherwise. In this model, an expected future value of permits that is high should encourage firms to use less permits in the current period. Low-cost polluting firms hold on to their permits and trade less in the present period, since they will be more valuable in the next period. High-cost firms are encouraged to save more of their permits to cover pollution in the second period. For permit banking to work well, however, the government needs to commit to a policy such that $Q^+ \leq Q$, since both expected permit price in the second period and expected abatement costs in the second period, and consequently the decisions of the respective firms, depend on the relationship between the aggregate amount of permits in each period.

Part IV: Conclusion

This is a strictly two-period approach and has not been extended into a scenario of permit banking across multiple periods. The study of banking behavior in this scenario would be very valuable as this is the type of structure used in the European Union's Emission Trading Scheme. My intuitions here are that, as long as there is a reliable commitment to lower aggregate emissions, then abating more pollution in the first period remains a desirable choice for firms since abatement costs are lowest, although it would be interesting to see how adjusting the length of the trading periods would influence this decision. More specific advice in terms of setting Q and Q^+ would also be very helpful, but this may be a decision best handled by scientists.

Another interesting approach would be to create more types of firms in order to make the results more realistic, or to allow borrowing and see what that might do to signaling behavior. There is also the option of allowing firms to bank permits at a discount, meaning that if they banked a permit for use in period two then that permit would be worth less than one permit in the next period, say three fourths of a permit, for example. By the reasoning of this paper, such a policy would likely increase the incentive to use the permit in the current period, although it would still be an improvement over the scenario without banking when the future value of the permit is zero. For the most part, my work reflects the work of Harstad and Eskeland because it emphasizes the degree to which permit market design influences outcomes in the market and the behavior of firms. I have simply shown how permit banking can feature as a very useful aspect of a permit market, especially one in which distribution may not be done by auction.

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