Chapter 70

TRADING INSTITUTIONS AND EMISSION ALLOWANCES

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Nearly 30 years ago economists first proposed tradable emission allowances as a regulatory tool to achieve environmental goals at lower costs than command and control regulation (Dales, 1968; Montgomery, 1972). Policy-makers experimented with tradable emissions during the 1980s with limited success (Hahn, 1989), but this approach was not implemented on a wide scale until in the 1990s. There are now numerous emission allowance trading programs being implemented or designed in the U.S. and abroad at both the federal and local levels. Unfortunately, most policy-makers and many economists fail to appreciate the importance of trading institution and instrument design when translating the (institution-free) theoretical properties of emission allowance trading to practical applications. Consequently, the development of several trading programs has been handicapped when regulators have not adequately accounted for the incentive and efficiency properties of trading mechanisms and instruments. Experimental economics provides a valuable tool to inform and guide the development of these new market-based approaches, because laboratory results can help determine the relative performance of alternative trading institutions and other rules that govern trading.

Plott (1983) was the first to use laboratory methods to evaluate the potential performance of emission allowance trading. He employed the oral double auction institution, and found that overall efficiency levels (after the first two periods) increased from 34.4 percent for a command and control "standards" policy to 98.3 percent for a tradable emission allowance policy. His study was not motivated by a specific emissions trading program, and this impressive performance of allowance trading is probably due in part to his use of the highly efficient double auction institution. More recent laboratory studies have evaluated features of the trading institutions implemented or planned for specific emissions trading programs, beginning with the sulfur dioxide emissions allowance market created by the Clean Air Act Amendments of 1990 ("the Act").

1. The Federal Sulfur Dioxide Allowance Program and the EPA Emissions Trading Auction

The Act instructed the U.S. Environmental Protection Agency (EPA) to conduct annual sealed-bid/sealed-offer auctions to ensure the availability of allowances and to provide clear price signals to the evolving allowance market. The first auction was conducted in March of 1993 at the Chicago Board of Trade. Franciosi et al. (1993) conducted an

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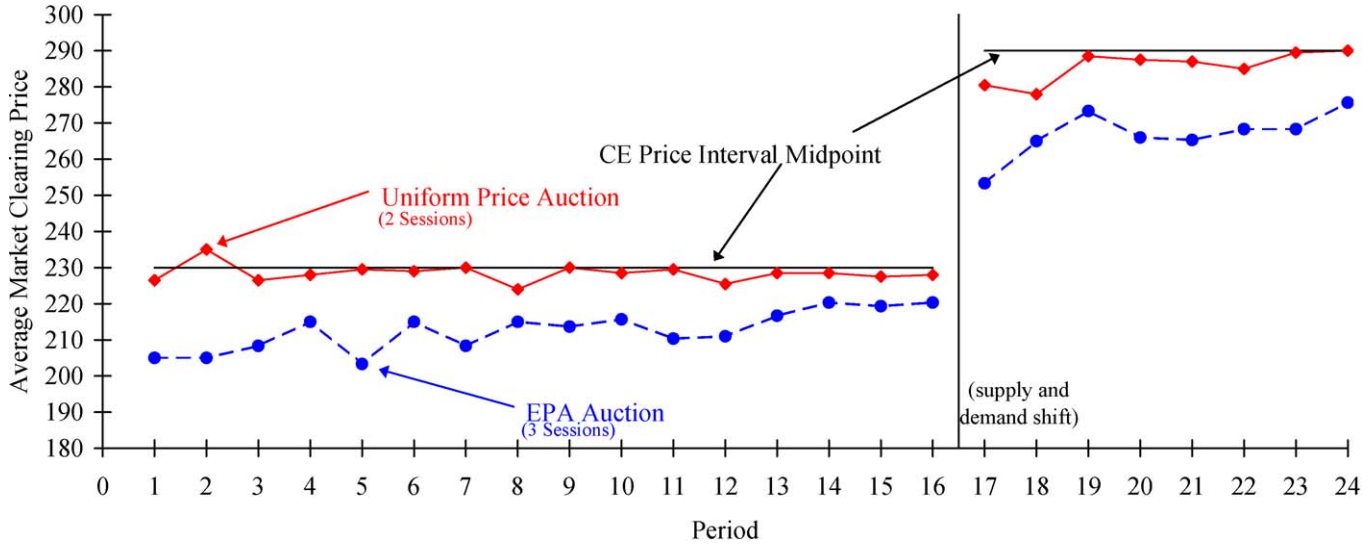
experiment during the development of the EPA auction rules that captures an important revenue neutral feature of the EPA auction proposed by Hahn and Noll (1982). EPA withholds between two and three percent of the available allowances from firms and sells them in the annual auctions. These auctions are revenue neutral because EPA distributes the sales proceeds to the firms who had ownership rights to these withheld allowances. Franciosi et al. compare the performance of the revenue neutral sealed-bid auction to an alternative no-rebate version, and find little difference in either prices or market efficiency. However, because it was conducted before the EPA auction rules were finalized, their study did not capture an important feature of the EPA auction. In particular, all of the experiments in Franciosi et al. (1993) used a uniform pricing (also known as "competitive") rule, in that all successful bidders paid a common market-clearing price; by contrast, the EPA auction in the field employs a discriminative price rule, in which all successful bidders pay their bid price.

Vickrey (1961) first identified the importance of these differing rules, and Cox, Roberson, and Smith (1982) studied these differences in the laboratory. The discriminative price rule creates an incentive for buyers to submit bids below their opportunity cost of emission control so that they receive gains from trade. The EPA auction has an additional odd feature that creates strong misrepresentation incentives on the seller side as well: Sellers who offer units voluntarily to the EPA auction receive the bid price of a specific buyer. Sellers with the lowest asking prices receive the highest bids, which Cason (1993, 1995) shows creates an incentive for sellers to submit offer prices below their true cost of emission control. Theoretical analysis indicates that since both buyers and sellers have an incentive to submit bids and offers below true abatement cost, equilibrium prices in this EPA auction are biased downward.

Cason and Plott (1996) compare the performance of this EPA auction to an alternative uniform price sealed-bid/sealed-offer auction. This uniform price auction is used, for example, by specialists on the New York Stock Exchange to set daily opening prices based on limit orders submitted by traders prior to the opening. It has superior theoretical incentive properties relative to the EPA auction because only the marginal traders affect the uniform price (Rustichini, Satterthwaite, and Williams, 1994), and it performs well in the laboratory even in "thin" markets with constantly changing supply and demand conditions (Cason and Friedman, 1997).

Unfortunately for the EPA, the Cason and Plott (1996) experiment indicates that human subjects understand the differing incentives of these two institutions. In the EPA auction treatment, buyers and especially sellers grossly underreveal their true valuations for emission allowances in their submitted bids and offers. By contrast, in the uniform price auction, the marginal buyers and sellers submit bids and offers that more accurately reveal their values and costs. Figure 1 illustrates the resulting difference in transaction prices in the two treatments due to the differing revelation incentives. This figure presents average market clearing prices in a "constant aggregate" environment in which aggregate demand and supply remain constant across periods, except for one unannounced shift before period 17. Uniform price auction transactions occur very near the competitive equilibrium (CE) midpoint in nearly all periods, while the EPA auction



Source: Cason and Plott (1996).

Figure 1. In the EPA auction buyers pay their bid price, and the lowest seller asks receive the highest buyer bids; this results in a downward bias in market clearing prices, compared to the uniform price auction in which all trades occur at one price.

prices remain below the CE price interval in most periods.[1] Price performance results are similar in a "random draws" environment in which supply and demand shift randomly each period due to independent and identically distributed draws of values and costs from announced distributions. Although market efficiency differences for the two institutions are not as pronounced as the price differences, efficiency of the uniform price auction exceeds that of the EPA auction except in the initial periods in the constant aggregate environment.

When confronted with these findings, officials in the Acid Rain Division of EPA emphasized that the wording of Act required use of a discriminative price auction. The Act states that "allowances shall be *sold on the basis of bid price*, starting with the highest-price bid and continuing until all allowances for sale at such auction have been allocated" (emphasis added).[2] However, in late 1994 the General Accounting Office (GAO) issued a report critical of the EPA auction based on the surprisingly low observed auction prices as well as these laboratory findings (GAO, 1994). Attorneys at the GAO concluded that this wording is sufficiently vague to permit the EPA to modify the auction rules, and they recommended that EPA should "change the design of the auction so that it is a single-price auction" (GAO, 1994, p. 59). In response, in June 1996 the EPA formally proposed changing the rules of their auction to a uniform price auction, and this change is likely to take effect beginning in 1998 (Federal Register, 1996). While this positive impact of laboratory results on public policy is refreshing, it is unfortunate that the EPA – unlike the Federal Communications Commission prior to the broadcast spectrum auctions – did not consult auction theorists and experimental economists prior to conducting many auctions with an inferior design.

Fortunately, this EPA auction is only one mechanism through which firms can trade emission allowances. Firms can also trade allowances on alternative, private markets, and recent evaluations suggest that non-auction trading is growing significantly (Joskow, Schmalensee, and Bailey, 1998). At present these alternative trading opportunities occur through decentralized "search" or "brokered" markets, with substantially higher transaction costs than centralized auctions. Nevertheless, these markets may evolve into centralized exchange markets. Franciosi, Isaac, and Reynolds (1999) use laboratory methods to study the interaction of the EPA auction (but without voluntary units offered for sale) with a computerized double auction market. They find that double auction prices consistently exceed the EPA auction prices, a puzzling result replicated by Cason, Elliott, and Van Boening (1999).

Both the Franciosi et al. and Cason et al. studies allow for allowance "banking" across periods which is permitted in the sulfur dioxide allowance trading program. Banking allows firms to carry forward unused allowances for use in future years, which can help mitigate allowance price volatility due to emissions uncertainty. Cronshaw and

[1] The CE "interval" (not shown) extends ten experimental francs above and ten francs below the CE midpoint on the figure, since a range of prices can clear the market.

[2] Clean Air Act Amendments of 1990 (Public Law 101-549), Sec. 416(d)(2). See Hausker (1992) for an analysis of the political economy of this decision by Congress.

Brown-Kruse (1999) focus on the role of allowance banking, and they find that the combination of banking and allowance trading allows subjects to improve efficiency relative to baseline sessions with only banking permitted.

2. Other Emission Allowance Trading Assessments: China, Ontario and Los Angeles

Rich and Friedman (1998) also use laboratory methods to evaluate the performance of a new auction designed for trading emission allowances, compared to the uniform price auction. They study the matching market institution, which is used by the Chinese environmental protection agency for allowance trading. In this institution, like the U.S. EPA auction, buyers and sellers submit sealed bids and offers and successful buyers pay their bid price. The key difference is that the matching market institution matches the highest bid to the highest offer less than that bid, and then matches the second highest bid to the second highest remaining offer less than that bid, etc., until no further trades are possible. Depending on the exact incentives these rules generate (which have not been fully worked out in theory), this institution could increase transaction volume relative to the competitive equilibrium volume. This institution has been implemented on a pilot basis for five cities, and is being considered for widespread allowance trading throughout China.[3]

Rich and Friedman find that this new institution is significantly less efficient than the uniform price auction, and leads to bids and offers that reveal less of the underlying values and costs compared to the uniform price auction. The matching market auction also generates greater price and transaction volume variation. On all of these performance measures, it appears to be an inferior trading institution to the uniform price auction.

Researchers at McMaster University have conducted a series of laboratory experiments that evaluate proposals for a nitrous oxide allowance trading program in southern Ontario. Their research introduces new trading institutions and tradable allowance instruments not present in the U.S. sulfur dioxide allowance trading program. Muller and Mestelman (1994) permit the simultaneous trading of coupons (the right to emit a certain quantity of emissions in a specific year) and shares (a claim to stream coupons for future years). Their coupon is equivalent to the allowance traded in the U.S. They employ a market institution that differs from other research because the Canadian proposals do not specify specific institution rules. In Muller and Mestelman (1994) trading occurs in an open outcry market similar to pit trading on commodities exchanges, and transaction prices were not revealed publicly in a systematic fashion.[4] They observe

[3] Rich and Friedman also note that a variant of this matching market institution is used by the Australian Stock Exchange to open trading, and has been proposed to open trading on Nasdaq.

[4] It should be emphasized, however, that this trading institution differs from a decentralized search market because subjects in the open outcry "pit" can obtain transaction price information indirectly by overhearing others' negotiations, and can observe others' willingness to pay and accept as they search for transaction partners. This information is not available if traders are not centralized.

improved trading efficiency relative to the Cronshaw and Brown-Kruse (1999) and Franciosi, Isaac, and Reynolds (1999) studies, which used the same parameters. They also find little opportunity for arbitrage in the relative share and coupon prices.

Godby et al. (1997) also allow for trading in shares and coupons, but they employ a computerized double auction for trading. This study also introduces uncertainty in emissions control as a treatment variable. Carlson and Sholtz (1994) point out that this uncertainty can occur in the field because facilities' knowledge of their future emissions is imprecise, and because information on present emissions often arrives with a lag. Godby et al. (1997) find that this uncertainty leads to significant price instability when allowance banking is not permitted. This instability arises because the market must clear each period, and the uncertainty is resolved only after some transactions take place. Their experiment demonstrates that allowance banking is effective in eliminating this price instability, since it allows traders to reallocate allowances across periods.[5]

Emissions uncertainty was also considered in the design of the Regional Clean Air Incentives Market (RECLAIM), an allowance trading program in the Los Angeles Basin intended to reduce the emissions of sulfur oxides and nitrogen oxides. In this case, the local Air Quality Management District (AQMD) wisely solicited assistance from experimental researchers at Caltech prior to implementing their proposals, and laboratory experiments were used directly to improve several aspects of the allowance instrument. For example, the AQMD ruled out bankable allowances, because of fear that banked allowances could permit emissions to exceed federal standards in future years. This eliminated one possible regulatory strategy that could help reduce allowance price instability in the presence of emissions uncertainty.

In experiments reported in Carlson et al. (1993), the Caltech team demonstrated that allowances with staggered issue and expiration dates avoided the need for banking and were effective in smoothing out price instability due to emissions uncertainty. This proposal was adopted in the final design of the RECLAIM program, and consists of Cycle 1 allowances (which could cover emissions between January 1 and December 31) and Cycle 2 allowances (which could cover emissions between July 1 and June 30). This dual set of trading instruments does not reduce uncertainty, but it accommodates it better. The availability of two substitutable allowances to cover emissions eliminates end-of-year shortages or surpluses of allowances, which are the cause of the price instability.

The RECLAIM program began in January of 1994, and trading occurs through brokers or directly between firms. In order to facilitate trading directly between firms,

[5] Godby, Elliott, and Brown-Kruse (1997) investigate the potential impact of market power on allowance trading, which can arise when a small number of firms represent a large share of the total emissions in a region. For example, in the proposed Ontario market for nitrogen oxide allowances, Ontario Hydro accounts for over one-half of the total emissions. Godby, Elliott, and Brown-Kruse (1997) find that this power can affect market outcomes in the presence of asymmetric information (i.e., when the dominant firm knows the competitive fringe valuations). They also show that this problem is exacerbated by the potential use of market power in downstream product markets, because the dominant firm can manipulate the allowance market to raise rivals' costs.

the AQMD designed an "electronic bulletin board" where potential traders can post proposed terms of trade and find other interested transaction parties.[6] To date, this bulletin board market has seen limited activity. Cason and Gangadharan (1998) conduct an experiment to compare the performance of the bulletin board market institution to a computerized double auction, and find that prices reflect underlying market conditions equally well in both trading institutions. This experiment also examines the impact of trading restrictions imposed across two zones of the Los Angeles Basin to avoid trades that lead to emissions migration that could harm air quality. The results suggest that properly-designed restrictions that permit some trading across zones can improve efficiency, relative to more severe restrictions that prohibit any trading across zones.

3. Summary

In the frictionless world of theory without transaction costs, allowance trading offers the potential of billions of dollars in savings when compared to traditional command and control regulation. It is therefore not surprising that regulators have embraced this approach in recent years to reduce the pain of achieving specific environmental objectives. This short review highlights the fact that policy-makers must recognize that "the devil is in the details," and that several intermediate steps are necessary when translating these plans and schemes from the theorist's blackboard to the field. For example, regulators need to carefully consider the design of any new trading institutions and allowance characteristics. Failure to consider these details can lead to poorly designed trading institutions – such as the EPA auction – which can slow the development of the market and require redesign after only several years of operation. By contrast, sufficient consideration of incentives and sponsoring laboratory experiments when appropriate can lead to a better design of allowance characteristics – such as in the RECLAIM program.

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[6] Recently, several other assets have traded through bulletin board markets, such as small stocks, foreign stocks, and limited partnerships on Nasdaq.

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