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Consignment auctions of free emissions allowances

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ABSTRACT

While the initial distribution of emissions allowances is usually thought to be independent of the emissions outcome, free allocation can affect the efficiency and fairness of allowance trading. Inefficiency may result from thin allowance markets, poor price discovery, and regulatory or organizational complexities that hinder the recognition of opportunity costs. Concerns about fairness may result from intransparency in the process of transferring substantial allowance value. We explore the role of consignment auctions in mitigating these concerns. These revenue-neutral auctions return the financial value of allowances to their original holders while revealing prices and directing allowances to their highest-valued use. They also can be used to support a minimum price when allowances are freely distributed, which may facilitate program linkage. Consignment auctions have minimal administrative costs and do not necessarily involve government. Experience indicates that they can play an important role, especially in new markets.

1. Introduction

Emissions allowance trading is becoming an increasingly relevant policy mechanism as jurisdictions plan for compliance with their climate-related, nationally-determined commitments under the Paris accord. These policies establish an emissions budget (cap) for a set of sources and issue emissions allowances for each allowable unit of carbon dioxide (CO_2). Emitting firms must surrender allowances corresponding to the quantity of emissions they produce in each period. Firms are expected to search for the lowest-cost way of complying with the emissions budget by reducing emissions and by buying or selling allowances.

An important feature of emissions allowance trading is the initial distribution of allowances. Allowances have been allocated to entities for free in many previous North American emissions trading programs for various pollutants and in the EU Emissions Trading System for CO_2. Sometimes this is done with the rationale of providing compensation to the affected industry or achieving political buy-in. Auctions are often used alongside free allocation to distribute allowances. However, while auctions have become the dominant approach in these existing programs (Burtraw and Sekar, 2014), free allocation continues to be prevalent and is a feature of the expected cap-and-trade program in China, which will be the largest in the world when it takes effect in the next couple of years (Duan, 2015). Free allocation is also a feature of the trading program in the Republic of Korea, which will phase in an auction slowly over time, the trading program in the City of Tokyo, and other programs.

The emissions outcome, under certain conditions, is thought to be independent of the initial distribution of emissions allowances (Montgomery, 1972; Hahn and Stavins, 2011).[1] Depending on the context, however, free allocation can influence the efficiency of allowance markets.[2] Experience indicates that firms receiving a large allocation relative to their compliance needs may engage in fewer transactions, possibly resulting in a thin trading market and hindering the clear identification a market price. This, in turn, may prevent firms from recognizing the opportunity cost of using emissions allowances and from engaging in efficient trades. These factors may raise the cost of emissions trading programs and undermine their long-term success.

Allocation decisions may also affect the perceived fairness of allowance markets. Firms that do not receive free allocation or are new to the market may worry that allowances will not available. In addition, under free allocation the initial distribution of allowances

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[1] The "independence property" in standard economic theory implies that in an efficient market with well-designed property rights, emissions should be independent of the initial allocation. Other studies support or do not reject the independence property (Reguant and Ellerman, 2008; Fowlie and Perloff, 2013). In a laboratory experiment, Murphy and Stranlund (2005) find that net sellers of allowances tended to sell fewer allowances than would be expected in an efficient market and had fewer compliance violations than net buyers. If used as a production subsidy, allowance distribution can be used to change the distribution of emissions across regulated sources without changing the overall level of emissions from these sources (Fischer and Fox, 2007; Burtraw et al., 2015).

[2] The public finance literature has focused on the general equilibrium advantages of raising revenue through the sale of allowances in order to decrease other taxes in the economy (Goulder, 1995); however, we do not consider revenue-raising options in this paper.

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affects who bears the burden of the program. However, the assignment of substantial wealth that occurs with allowance allocation is often masked in the administration of a program. Transparency of allowance allocation and the process by which this allocation is determined will influence perceived fairness and is ultimately valuable to the success and durability of the program.

In this paper, we explain how consignment auctions may offer a simple, virtually zero-cost, market-based remedy that mitigates many of the issues that may surface with free allocation. A consignment auction is a small, revenue-neutral addition to the design of an emissions market. Recipients (regulated firms or other parties) of free allowances are required to submit them to an auction. Based on the auction-clearing price, the original holder of consigned allowances is fully reimbursed by receiving revenue from the auction equal to the allowances submitted multiplied by the auction price. The entity may choose to buy allowances in the same auction and would pay a net-zero price on allowances it sells and repurchases. Hence, in a consignment auction, the initial holders of emissions allowances capture all the value of allowances originally allocated to them for free and they have the opportunity to acquire allowances they require for compliance. Because entities make and lose no money from allowances they sell and repurchase, the importance of a consignment auction in the design of an emissions market may be unintuitive. However, by ensuring that some or potentially all allowances enter the market, this approach improves the transparency of the program, the functioning of the market, and the ability of firms to recognize and act upon the least expensive opportunities for compliance.

A consignment auction is simple to run at minimal administrative costs for all parties, and the government does not need to be involved. In fact, in the first decade of the US sulfur dioxide (SO_2) trading program consignment auctions were run by the Chicago Board of Trade at zero cost, and two other firms also offered to run the program for free. In California, the CO_2 consignment auction is run independently by the Western Climate Initiative, Inc. It provides a straight-forward way to introduce a minimum price to a trading program even with free allocation, which can facilitate linkage with other programs.[3] Compared to a revenue-raising auction that might require legislative authorization, the revenue neutrality of the consignment auction and its potential administrative independence from government ensures that it cannot be construed as a tax and implies that it likely does not require the legislative authorization that may be needed for a revenue-raising auction (Peskoe, 2016).

Economists typically favor the use of auctions for the initial distribution of emissions allowances for a number of reasons, including the ability to raise revenue (Cramton and Kerr, 2002). A consignment auction does not raise revenue, but like other auctions it inoculates a trading program against many efficiency and fairness issues that could be associated with free allocation. In addition, there are long-term benefits to reducing even short-term inefficiencies, such as improved long-term capital decisions, lower allowance prices, and improved market competition, which make future programs and policies more politically feasible. For programs that plan to phase in a revenue-raising auction, a consignment auction provides a way to introduce the methodology. Trading programs using free allocation in lieu of revenue-raising auctions may therefore benefit from adding a role for consignment auctions for all or some of allowances that are distributed for free.

In brief, consignment auctions appear to offer a nearly zero-cost way to improve the operation of an emissions market and the decision-making process of regulators and firms. Hence, they may play an important role whenever free initial distribution of emissions allowances is feature of an emissions market. In this paper, we describe how consignment auctions have improved the functioning of past SO_2 and CO_2 markets by supporting price discovery and market liquidity and allowing minimum prices to be used in markets. Next, we describe general concerns about the efficiency and perceived fairness of markets where emissions allowances are initially distributed for free. We explain the potential role of consignment auctions in overcoming these concerns through increased transparency and reduced uncertainty in the identification of a market price. We then review specific obstacles to efficient decision-making at the regulatory and organizational levels. Even the suspicion of these obstacles affects the choices of policy-makers, and the attributes of consignment auctions would help mollify these concerns.

2. Price discovery and market liquidity

Two central components of an efficient allowance market are the early discovery of an allowance price close to the long-term equilibrium price path and early, as well as sustained, market liquidity. These components are essential to ensuring efficient long-term investment planning and the use of allowances for their highest-valued purpose in the market (Hahn and Noll, 1982).

In a system involving free allocation of emissions allowances, a portion of freely allocated allowances may be used directly for compliance and therefore may never enter the market. If this occurs on a large scale, the lack of visible and plentiful transactions may hamper the discovery of the marginal cost of abatement and the market price of an emissions allowance (Stavins, 1995; Hahn and Stavins, 2011). Firms wishing to engage in the market are presented with the burden of both identifying the opportunity cost of abatement options and finding market opportunities in an area that is not their core business. Successive bilateral trades in a thin (illiquid) market may lead to wide variance in prices that reinforces firms' reluctance to engage in transactions. These factors may further decrease the frequency of trades and result in lower market participation (Hahn and Noll, 1982). Fewer trading partners may be detrimental to the development of a liquid market in which money can be easily converted to allowances and allowances to money (Holt et al., 2007). The illiquidity of the market may be further exacerbated through the banking of allowances, which enables firms to retain and use their freely allocated allowances for years rather than engaging in the market.

Several of the limitations of trading programs that rely on free allocation were observed in the early years of the SO_2 cap-and-trade program, which was created under the 1990 amendments to the US Clean Air Act and took effect in 1995. In the program, free initial distribution of allowances was coupled with increasing stringency for compliance over time, with the intent to encourage early emissions reductions and banking of allowances. The incentive to bank early emissions allowances was supplemented by an allocation of bonus allowances to firms for preferred compliance choices (primarily flue gas desulfurization, or scrubbers). The result was that some firms could plan for compliance, go it alone, and not engage in trading (Burtraw, 1996; Ellerman, 2000). The thin market that existed in the early years of the program posed a concern for other firms that needed to purchase allowances or to demonstrate guaranteed access to allowances in order to acquire project financing (Hausker, 1992), and it appears that it also increased the overall cost of the program, as measured by the difference between the marginal cost of abatement among firms during the first few years of compliance (Carlson et al., 2000; Ellerman et al., 2000).

The SO_2 program, which relied entirely on free allocation to distribute allowances to incumbent firms, also required that 2.8% of the allowances issued every year be submitted for sale to a revenue-neutral consignment auction. Private allowance holders also could consign allowances for sale in the auction. The proceeds from the auction were returned to industry or other sellers in proportion to their original ownership. For a decade, the auction was run independently of the government at zero cost by the Chicago Board of Trade. EPA took over the operation of the auction in 2006 and also found the

[3] California provides information on allowance consignment requirements and auction participation in its Guidance for Allowance Consignment to Auction. (Accessed 26 May 2016.) https://www.arb.ca.gov/cc/capandtrade/auction/consignment_guidance.pdf

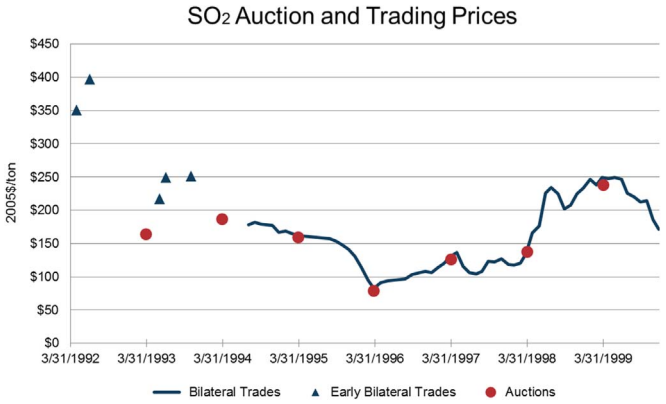

Fig. 1. Auction and Bilateral Trading Prices from 1992 to 1999. Auction price data: "SO_2 Allowance Auctions: Annual Auctions," https://www.epa.gov/airmarkets/so2-allowance-auctions#tab-2 (accessed May 11, 2016). Spot market price data: Figure 7.1 (Ellerman et al., 2000). *Note*: prices mentioned in the text are in current year dollars.

administrative cost of the program to be trivial; EPA staff informally estimate the administrative costs to be one month per year full-time equivalent of staff time. Consignment auctions were largely required to address concerns of independent power producers (electricity generation companies not associated with an incumbent regulated utility) that they would not have easy access to allowances since they were not offered allowances for free. In practice, observers noted that the consignment auction performed two additional valuable and unanticipated functions. First, it primed the pump for trading, so to speak, by forcing a redistribution of allowances. Second, as a consequence of the pump priming, the auction contributed to the discovery of a market price at a time when expectations about compliance costs were varied across the industry (Hausker, 1992; Ellerman et al., 2000). Soon after the administration of the first two annual consignment auctions, the secondary market became liquid, and within three to four years trading became accepted and widespread (Kruger and Dean, 1997). This price discovery function of auctions has also been demonstrated in laboratory settings (Burtraw et al., 2011). By enhancing price discovery in a context with free allocation, the consignment auctions played an important role in the transition from autarchy to a liquid market with stable prices in the SO_2 program.

The role of consignment auctions in the SO_2 program is illustrated in Fig. 1. Bilateral trades preceding the first consignment auction for SO_2 allowances in March 1993 were sparse, and their prices were high and varied. In the first auction in 1993 the schedule of bids to purchase allowances was quite diverse, indicating a wide variation in opinions about compliance costs and general expectations about the market. This auction achieved a clearing price of $131 per ton, one-quarter of previous estimates of compliance costs and one-third of the price of bilateral trades that had been reported in the trade press (Burtraw, 1999). By 1994 the price of bilateral trades flattened out considerably, but the 1994 auction-clearing price of $150 was still 10% lower than the prevailing cost of bilateral transactions. Both of the first two auction results generated concern that the auction was not properly reflecting the value of emissions allowances (Cason, 1993, 1995; Cason and Plott, 1996).[4] However, by August 1994, the prices reported by the three brokerage firms for allowance trades in the spot market were almost identical to the level established by the 1994 auction, and the price path of bilateral trades became smooth, reflecting the increasing liquidity of the market and the growing consensus about the marginal cost of abating emissions (Holt et al., 2007). Although the auction included only a small portion of all allowances, the overall program was large, so the volume of consigned allowances was substantial. In addition, the consignment auction was relatively large compared with allowance trading activity in the spot market in the early years of the program because most allowances were allocated directly to the firms that needed them for compliance and firms initially exhibited autarchic behavior. By 1995, the secondary market had matured considerably. In virtually every year since 1995, the auction price has been nearly coincident with the spot-market prices in the surrounding months or has been in line with a trend in these prices.

In retrospect, it appears that the auction contributed importantly to price discovery and the emergence of an active secondary market (Ellerman et al., 2000). Similarly, in a laboratory setting, Holt and Shobe (2017) find consignment auctions improve measures of market performance compared to free allocation alone.[5] This evidence also suggests that the consignment auction did not disrupt price-setting behavior in the spot market and, furthermore, that the auction reflected willingness to pay in a similar manner to the spot market.

Designers of California's CO_2 cap-and-trade program recognized the value of consignment auctions in improving the market functioning of the SO_2 program, and in response created a "monetization requirement" that involves using consignment auctions for a majority of allowances distributed to the electricity sector (17 CCR § 95892) (Burtraw and Szambelan, 2012; Economic Allocation Advisory Committee (EAAC), 2010). In California, allowances associated with the electricity sector are directed to local distribution companies, which are the retail companies that send consumers their electricity bills. About two-thirds of consumers are served by private investor owned utilities that are regulated by the Public Utilities Commission and are required to consign their allowances to auction.[6] The revenue from the auction is returned in proportion to the original holders of allowances, and the utilities are directed to use that value "for the benefit of ratepayers." The allowance value is used for various purposes including a large portion that appears as a dividend payment once every six months on customer bills (Air Resources Board (ARB), 2015). After the program was extended to cover emissions from natural gas in 2015, natural gas suppliers were also required to consign a portion of the allowances they received for free. As a result, in California the consignment auction serves the dual purposes of ensuring a liquid market and directing allowance value to intended uses.

3. Minimum prices

Emissions trading programs set a cap on overall emissions, but these programs co-exist with other regulations and evolving market conditions, such as changing fuel prices and advances in technology, that affect emissions and production from the regulated sources. In

[4] The SO_2 auction employed a somewhat unusual design in which purchasers paid what they bid, and the total revenue collected was distributed to the original owners of allowances in proportion to their contributions to the auction. In contrast, the California consignment auction trades at a uniform price that clears the market, a design that is generally recommended as less open to strategic or behavioral considerations (Cramton and Kerr, 2002; Holt et al., 2007). Throughout this paper, we describe attributes of a consignment auction assuming a uniform price auction design is implemented.

[5] In a paper comparing free allocation with a consignment sale to a revenue-generating auction, Dormady and Healy (2015) find that a revenue-generating auction outperforms free allocation with a consignment sale. The authors do not make the comparison between free allocation with and without a consignment sale that we make here. Khezr and MacKenzie (2016) find that a consignment auction may lead to a price above that of a revenue-raising auction in the sale of multiple units, such as emissions allowances, but the revenue-raising auction equilibrium price is below the efficient price, so the welfare effects are ambiguous. In their laboratory experiment, Holt and Shobe (2017) find that consignment of only a share of the allowances may lead to a higher price than with consignment of all allowances, which they associate with the competitive equilibrium.

[6] About one-third of consumers in the state are served by publicly owned utilities that may use allowances directly for compliance. Investor owned utilities own only a small amount of emitting fossil resources and may purchase allowances at the auction sufficient for their compliance obligation. Most electricity sector emissions come from facilities owned by independent companies that rely largely on the auction to obtain allowances.

virtually every existing program these factors have put downward pressure on allowance prices (Burtraw et al., 2010; Koch et al., 2014). If the emissions cap is not adjusted, the allowance price may fall to a level where it fails to incentive innovation and investment in long-term abatement technology; even the potential for a decline in future prices may hinder investment decisions. Falling allowance prices may undermine the market-based policy and make the role for other regulations ever more important, creating a cycle that erodes the influence of carbon pricing.

Where, for efficiency reasons, the desire is to rely increasingly on carbon pricing in lieu of direct regulation, there are various potential remedies to the problem of a low and falling allowance prices. An obvious approach would be to adjust the emissions cap, but this requires administrative action that may be unreliable and untimely, and relying on this may foster uncertainty about the future of the program that may further undermine investments (Salant, 2016). As an alternative strategy, the EU Emissions Trading System will introduce a market stability reserve mechanism in 2019 to support the allowance price by constraining the quantity of new allowances that are issued when the volume of unused allowances in the market exceeds a specified value (Hepburn et al., 2016). However, the most direct approach is the enforcement of a minimum price in the allowance market. This approach is used in the North American carbon trading programs, which implement a minimum price through a reserve price in their auctions.[7] The reserve price is a value below which bids to purchase allowances will not be accepted. If there is an insufficient number of bids (reflecting willingness to pay for allowances) to exhaust the supply of allowances in the auction at a price at or above the reserve price, some of the allowances are not sold and the supply of allowances in the market is reduced.

The literature has previously suggested that a minimum price is not plausible in programs that rely on free allowance allocation because, in the absence of an auction, maintaining a minimum price would require the government to buy back previously freely allocated emissions allowances from firms in the market. This could put an unsustainable fiscal burden on government (Baumol and Oates, 1988; Pizer, 2002). However, a consignment auction enables a minimum price in a trading program with free allocation through the introduction of a reserve price in the auction, and it does not require a role for government and imposes no fiscal burden. If the reserve price is binding, some portion of the allowances in the auction would not be sold and the supply of allowances in the market would be reduced.

The price floor does not necessarily work to the detriment of regulated firms; indeed, in many cases the firms that consign allowances to the auction might benefit from a price floor. One might expect the initial holders of freely endowed allowances, as a group, to be net sellers in the consignment auction especially if new facilities do not receive an allocation. The selling firms will therefore benefit when total revenue from the consignment auction increases. A binding price floor will increase the price and decrease the quantity of allowances sold in the market. Therefore, because total revenue is equal to the product of price and quantity, it is possible for a price floor to induce either a positive or a negative effect on the total revenue in the current auction.[8] When the effect on revenue is positive, enforcing a price floor by constraining the allowance supply resembles the outcome from strategic behavior of a firm seeking to exercise market power by reducing the supply of a commodity to drive up its price. By analogy, firms that are net sellers of allowances could benefit financially when the minimum price is enforced even if some of their allowances go unsold.

The change in total revenue depends on whether the price moves towards or away from the unit elastic portion of the demand curve for allowances, that is, the point on the demand curve where revenue would be maximized. In many cases one might expect the demand for emissions allowances to be inelastic because the opportunity for emissions abatement at least in the short run is limited (Borenstein et al., 2016); consequently total revenue would be likely to increase when the price floor is triggered. In other words, firms that are freely endowed emissions allowances and are net sellers in the allowance market would likely benefit from the introduction of a reserve price in a consignment auction.

In recent experience, the sale of consigned allowances has coincided with the sale of newly issued allowances within the same auction platform. In California, the auction of allowances from these different sources occurs simultaneously and if the reserve price is binding a priority for sale is given to the consigned allowances, which must be sold entirely before the sale of additional allowances can occur. Consequently, when the price floor is binding it is possible that all or a large number of the freely allocated allowances that are consigned to the auction will be sold but some or all of the allowances held by the California Air Resources Board will not be sold. This has occurred in several recent auctions and the higher allowance price that resulted from the minimum price in the auction has unequivocally increased the value of freely endowed allowances.

The ability to maintain a price floor in programs where some allowances are distributed for free is a key benefit of consignment auctions. It also may make it possible to link a program with free allocation with existing programs that have a price floor as part of their auction design.

4. The transparency and operation of emissions markets

In addition to facilitating a functioning market, a key contribution of consignment auctions is the introduction of transparency in the initial distribution of emissions allowances and the resulting distribution of value. Binmore and Klemperer (2002) criticize the administrative decision that determines free allocation as a "beauty contest" involving an "opaque process that leads to political and legal controversy, and the perception, if not the reality, of favoritism and corruption." Nonetheless, policy preferences in many circumstances lean toward free allocation. A consignment auction can enable free allocation to be achieved while improving transparency because the auction makes more visible the value of allowances and how that value is initially distributed. The auction also helps the regulator observe the compliance decisions of regulated entities and monitor the success of the market; for example, outcomes of an auction are taken as evidence about the state of the market by monitors in existing trading programs.

By design, consignment auctions ensure equal access to emissions allowances for all existing and newly regulated entities. This prevents entities that receive free allowances from "hoarding" allowances to limit their availability as a barrier to entry. The potential inability to access allowances, and in turn, project funding, was a worry of independent power producers in the SO_2 program that motivated the requirement of consignment auctions in the program (Hausker, 1992). Even in a reasonably liquid market, smaller market participants, which have less capacity to coordinate trades and may not be willing to engage with private brokers, may face especially high barriers to trade. For example, minimum volume requirements may have limited the use of brokers by small participants in the EU Emissions Trading System (Convery and Redmond, 2007). In addition, smaller firms without the opportunity to conduct intra-firm

[7] The North American programs are the Regional Greenhouse Gas Initiative in the northeast United States and the California, Quebec, and Ontairo programs in the Western Climate Initiative. California and Quebec currently hold joint auctions, and Ontario, which began its trading program in 2017, plans to link its program to California and Quebec in 2018.

[8] In addition, if unsold allowances are reissued in a future auction, firms may benefit from additional revenue at a later date. In this case, prioritizing the sale of one entity's consigned allowances over another's may have more of an impact on the stability of the stream of revenue than of the total revenue received over several auctions.

trades among facilities may face capital constraints.[9] Smaller firms may face higher transaction costs (Jaraitė-Kažukauskė and Kažukauskas, 2015) that can hinder the development of an efficient carbon market and prevent the functioning of allowance markets (Stavins, 1995; Hahn and Stavins, 2010; Liu et al., 2012). Increasing the number of trading partners and the availability of information may reduce uncertainty and the "search and information" component of transaction costs (Stavins, 1995). In essence, consignment auctions serve a brokerage role, relieving firms of some of the burden of coordinating trades, which may also be reflected in a reduction in private brokerage fees.

Smaller market participants may also feel they lack expertise on the auction process and may therefore worry about their ability to acquire their necessary allowances in an auction. By adapting a feature of auctions for US Treasury bonds, consignment auctions can be designed to explicitly protect small firms. This is enacted by allowing firms with this concern to submit infinite bids for a portion of their consigned allowances, which guarantees this portion is returned to them at the market-clearing price. The consignment auction might also follow the procedure used in US Treasury auctions and limit single entities to a maximum percentage of the allowances for sale at a given auction. Other features of auction design may be introduced to meet program objectives, such as a minimum reserve price that serves as a price floor.

5. Recognition of opportunity cost in compliance decisions

The economic efficiency of market-based regulations requires decisions made by regulators, firms, and individuals to be based on the opportunity cost of using allowances for compliance versus adopting measures to reduce emissions. In a competitive market it is assumed that firms recognize the opportunity costs of using freely allocated emissions allowances, but laboratory evidence supports the observation from the SO_2 trading program that this recognition can be expected to emerge over time but may not occur at the outset of a program (Wråke et al., 2010). Outside of a competitive market, however, regulatory rules, which, for example, govern cost recovery in the US electricity sector, may distort incentives away from market opportunity costs or may alter the risk-reward payoff of buying or selling allowances. The decision-making behavior within firms may introduce similar distortions that are manifest in the inability to recognize fully or make decisions based on the various opportunity costs present in planning for compliance with environmental regulations. Even at the individual level, behavioral elements such as the endowment effect, where one overestimates the value of something in one's possession, may obscure recognition of opportunity costs and inhibit market activity. Hence, even in a functioning market with transparent price information, barriers at the regulatory, firm, or individual level may inhibit efficient transactions. We suggest that consignment auctions may help mitigate these barriers.

5.1. Regulatory barriers

One type of barrier to an efficient allowance market may arise from the regulatory structure of industry. For example, regulated electricity providers may be discouraged from completing transactions because doing so puts them at greater risk for regulatory challenges (Hausker, 1992). Regulatory reviews for recovery of costs often penalize utilities for uneconomic transactions but rarely reward them for economic ones. Ex-post movements of prices in commodity markets are sometimes the basis for such reviews, thereby imposing asymmetric incentives for firms. State public utility commissions often prevent investors from profiting from allowance sales, so utilities have little incentive to risk regulatory scrutiny if the sale of allowances turns out to be uneconomic ex post (Bohi and Burtraw, 1992). Therefore, utilities may engage in fewer transactions than would be efficient. If regulatory authorities are required to approve compliance plans before trades are conducted, delays may also prevent efficient transactions from occurring. Reducing these delays may reduce transaction costs for firms (Stavins, 1995).

Consignment auctions help the market sidestep the disincentive for regulated firms to engage in economic transactions and avoid any potential regulatory-imposed delays in transactions by requiring utilities to sell the allowances they are freely allocated and to repurchase the allowances they need for compliance. Because transactions must be made regularly, this program design may normalize trading for entities receiving free allowances and may limit the perceived risk of regulatory scrutiny regarding uneconomic transactions that ex post turn out to be uneconomic.

5.2. Organizational barriers

Even in a competitive market, the value of freely-endowed emissions allowances may not be properly recognized and acted on by the firm, which relies on decision-making processes that are necessarily limited. When described on the level of the individual, this limitation is often characterized as bounded rationality (Simon, 1955, 1979) and refers to the notion that individuals have a limited capacity to make "rational" decisions due to cognitive constraints, finite time, and lack of complete and free information. The theory suggests that deviation from rational behavior is not necessarily normatively inferior to a strict adherence to rational choice theory; costs of time and the delay in decision-making, costs of information, and cognitive and computational costs all may prevent rational theory from being an optimal, or indeed a possible, decision-making framework (Simon, 1955; Radner, 1996).

In the presence of economic and cognitive constraints on the decision-making process, individuals act not as optimizers but as "satisficers," engaging in the decision-making process until a decision is made that meets a certain threshold of criteria. Individuals behaving in a boundedly rational way may make decisions based on rules of thumb, or "heuristics," and other behavioral phenomena (Simon, 1979). Recognizing the inadequacy of rational choice theory to capture human behavior, additional economic theories of human behavior have emerged in the last several decades. A component of prospect theory, one of the central theories of behavioral economics, is the idea that the value function that represents utility (well-being) under gains and losses is concave for gains and convex for losses. This asymmetry implies that individuals may have different attitudes toward potential gains and losses, and it introduces a special weight on regret and other aspects of human behavior (Kahneman and Tversky, 1979; Kahneman et al., 1991).

These phenomena also occur at the level of the firm. In a large organization, decisions are simplified through satisficing by individual agents, the creation of concrete, achievable goals, and the division of decision-making among agents in a network of communication (Simon, 1979). Radner (1996) highlights two ways in which bounded rationality may explain why organizations, especially large ones, deviate from the behavior predicted by rational choice theory.[10] First, the decision-making processes of individual actors is constrained, and information within firms is necessarily decentralized. Therefore, communication costs lead to decision-making in which only some information is used

[9] Dardati and Riutort (2015) note that overall capital expenditures under the SO_2 program were higher in firms receiving free allowances, especially in smaller firms, possibly because allowances lessened financial constraints. If capital constraints are a justification for free allocation, the desired capital liquidity would be preserved with the inclusion of a consignment auction.

[10] Radner contrasts *costly rationality*, in which costs of information and communication prevent all relevant information from being known, with *truly bounded rationality*, in which the implications of knowledge are complex and difficult to interpret.

to inform each decision. Second, the structure of the firm and the limited information of its workers pose too complex a problem for the organizer of the firm to solve in a way that can be modeled by rational choice theory.

In addition to these organizational constraints, workers in an organization have objectives that differ from the objectives of the firm manager or owner (Simon, 1979; Radner, 1996; Malloy, 2001). The decision to focus on one objective over another is itself a resource-allocation decision made by the firm and by individual managers. Malloy (2001) notes that for an abatement opportunity to be acted on, the person managing environmental decisions (the "gatekeeper") must recognize the opportunity as worthy of attention given her personal objectives, which are likely narrowly defined as meeting compliance while minimizing costs. If it is not considered a mandatory compliance cost, the opportunity must also out-compete other investments in the firm's "internal capital market." Various case studies indicate that firms face a two-edged constraint on investments that are aimed at what might be perceived as secondary goals, such as emissions reduction, in contrast to the primary goal of maintaining market share. In times when economic activity and sales are low, firms do not have unassigned revenues; in times when economic activity and sales are high, firms have to compete furiously for market share. The payoff to chief executive officers and managers is typically much more closely tied to visible short-run measures of market share than to longer-run issues associated with compliance planning (Sorrell et al., 2004). Abatement opportunities in firms receiving free allowances may suffer both because they represent a diversion of revenue away from measures that would further strategic goals and because they are not seen as necessary for compliance (Malloy, 2001).

Observing these behavioral phenomena empirically is challenging, but several studies provide evidence that they may be important to understanding behavior in an allowance trading market. Hennlock et al. (2016) examine the abatement choices made by managers and senior advisors of Swedish firms involved in environmentally hazardous activities. When asked to make abatement decisions in response to economically equivalent price or performance incentives, participants exhibited attentional and judgment biases, focusing on different factors depending on how the policy choice was presented. This study highlights the importance that the framing of a policy can have on the salience of different factors that go into making decisions.

There is considerable empirical evidence that the behavior of firms in existing cap-and-trade programs is not necessarily consistent with the recognition of opportunity costs, especially at the outset of trading programs, although distinguishing whether this is attributable to the regulatory setting or firm behavior is ambiguous (Burtraw, 1996; Carlson et al., 2000; Rose, 2000; Arimura, 2002; Swinton, 2002). For example, a survey of manufacturing firms from six EU ETS countries found that most firms banked allowances, did not trade in the EU market, and only traded excess supply exceeding around 5000 allowances. In addition, most did not pool allowances across facilities within a firm, and 30% of firms did not treat carbon allowances as a financial asset, instead acting only to comply with the regulation (Martin et al., 2014).

Consignment auctions may change the way firms act in the allowance market by making the decision to buy or sell allowances more salient and moving it to a higher organizational level.[11] In the SO_2 market, as utilities witnessed the emergence of a stable allowance price that was first identified in the consignment auctions, compliance planning moved from a responsibility left primarily to environmental managers to become a component of strategic planning, and allowance costs came to be viewed in a similar way to fuel costs (Kosobud and Zimmerman, 1997; Kosobud, 2000).[12] Beyond this increase in salience, just as consignment auctions may alleviate regulatory scrutiny, they may also alleviate concerns of organizational scrutiny of the decision-maker within the firm, who may otherwise be motivated to preserve the status quo (Malloy, 2001).

5.3. The endowment effect

Based on behavioral phenomena that we describe, consignment auctions may be important not only because they make the allowance price more salient but also because they frame the sale or acquisition of allowances in a different way. For example, the endowment effect, status quo bias (Hahn and Stavins, 2010), and loss aversion (Kreutzer, 2006), stem from the shape of the value function and all may pose barriers to transactions in firms receiving free allowances (Kahneman and Tversky, 1979; Kahneman et al., 1991). In the case of cap and trade, receiving free allowances may affect how the value of those allowances is perceived. People may experience loss aversion, in which one is more averse to losing something (in this case, an allowance) than to gaining it, and status quo bias, in which, because of aversion for losses and less-than-equivalent desire for gains, there is a tendency to favor the status quo. In addition, as noted by Thaler (1980), out-of-pocket costs are perceived as losses, while opportunity costs are perceived as forgone gains, leading to an overestimate of the value of items in one's possession. Firms receiving allowances for free may therefore exhibit this endowment effect and fail to sell as many allowances as would be efficient. While limited, there is some evidence that firms receiving free allowances engage in less environmental innovation than other regulated firms and also anticipated that future policy will be less stringent (Martin et al., 2013).

Importantly, however, the endowment effect does not apply to situations when goods are expected to be resold (Kahneman et al., 1990; Kreutzer, 2006). Kreutzer (2006) suggests that the ability to convert allowances to cash through market transactions may therefore mitigate the endowment effect. Following this logic, a consignment auction would be expected to reduce the endowment effect in two ways. First, by ensuring the liquidity of the market, it would create an assurance of the ability of firms to engage in this allowance-to-cash conversion; and second, by requiring that firms receiving free allowances immediately sell and repurchase allowances in consignment auctions, it would build an anticipation of resale into the process of receiving free allowances, even if some allowances would need to be repurchased for compliance.

6. Conclusions and policy implications

We find consignment auctions to be a simple element of good design for cap-and-trade programs that involve free allocation. Economists have highlighted the benefits of using a revenue-raising auction to distribute allowances, and the use of auctions in emissions trading programs has become increasingly common over time. For example, the EU ETS has evolved from relying almost entirely on free allocation to using auctions to allocate more than half of allowances that will enter the market in 2017 (Löfgren et al., 2015). However, most programs have begun by relying mainly on free allocation for the purpose of either providing compensation to affected industry or achieving political buy-in. China is expected to use free allocation when it launches the largest trading program in the world in 2017.

[11] Mallow (2001) notes that moving the actual decision to a manager level may not be desirable: "Capturing the production-department manager's attention for a modest cost reduction may be difficult. To the extent that the overhead account is associated instead with higher organizational levels, such as the division, group, or corporate level, the mitigation is likely to be less and less pronounced." A distinction in the SO_2 program is that involvement of higher organizational levels enabled consideration of a broader range of potential compliance activities, such as engaging in the allowance market.

[12] This well-documented trend coincided not only with the maturation of the allowance market but also with the advent of electricity industry restructuring and growing competition following passage of the 1992 Energy Policy Act (Rose, 2000).

Many other programs use free allocation, often as a starting point from which they will phase in auctions over time. Free allocation not only foregoes the opportunity to raise revenue, but it also can introduce a number of efficiency and fairness concerns. The use of consignment auctions may remedy most of these concerns. Consignment auctions are simple and revenue neutral, so regulated parties retain the value of freely distributed emissions allowances. They are virtually zero-cost and do not have to be administered by the government.

This paper highlights the benefits of consignment auctions, especially for emerging trading programs. These benefits fall within three broad categories: directly improving the functioning of the market, increasing transparency and fairness, and reducing obstacles to the recognition of opportunity costs that stem from regulatory barriers and organizational and individual behavior. A key reason these benefits can be achieved in consignment auctions is that these auctions bring to the market all the information that is available privately to market participants. Consignment auctions may be particularly important in new programs and programs with a smaller number of allowances and trading partners.

It is unclear to what extent the size of the consignment auction determines its ability to capture these benefits. The successful SO_2 trading program relied on a relatively small consignment auction as a portion of total allowances, but due to the overall size of the market a small consignment auction may have been sufficient in this case. The relationship between the size of the consignment auction and its ability to improve price discovery and firm behavior may be a question for future laboratory experiments; other benefits, such as market liquidity and the increased transparency of the market may be assumed to increase with the size of the consignment auction. In general, there are no clear drawbacks to establishing a larger consignment auction.

The benefits of consignment auctions come at very little cost or risk to firms, which receive the same value under free allocation as they do under free allocation with consignment auctions. Indeed, both firms receiving and firms not receiving free allowances may benefit from reduced transaction costs compared with the need to rely on bilateral market transactions (especially in the absence of a well-identified market price). Consignment is expected to frame compliance decisions in a way that reduces managerial and behavioral barriers to an efficient use of freely allocated emissions allowances and to help promote innovation. Experience and literature suggest that consignment auctions for ideally all or at least some portion of freely allocated emissions allowances be included as a standard element of cap-and-trade program design.

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