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The Chicago VOC Trading System: The Consequences of Market Design for Performance

by

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Abstract

The Chicago cap-and-trade approach to regulating stationary source VOC emissions in the Chicago ozone non-attainment area is a pioneering program that could set a precedent for other urban areas troubled by high ozone concentrations. It holds out the promise of cost-effectiveness, innovation stimulation, and flexibility compared with traditional regulation. To appraise this program design and evaluate these objectives, this study analyzes four years of data since the inception of the program in 2000. The data reveal that while emissions are far below the cap, there are unexpectedly large banks, startling expirations, and low prices of tradable permits, all inconsistent with an effective market.

We find that the market as designed has been constrained from reaching its objectives by the continuance and extension of an underlying layer of traditional regulation, and to a lesser extent by over-allotment of tradable permits. That is, traditional regulation and over-allotment, combined with a market design calling for a small reduction in emissions from baseline and a one-year limit on banking, explain the incongruous outcomes recorded in the market. This study explores the evolution of this particular market design and presents statistical evidence in support of the hypothesis that the performance of a cap-and-trade market is very sensitive to design features when combined with other regulatory measures.

The study concludes that the market as presently designed falls far short of achieving cost effectiveness, innovation stimulation, and flexibility. The policy recommendations include that the cap be significantly tightened, perhaps in a series of steps, and the banking horizon be extended to three years or more. Such redesign should enable the cap-and-trade approach to assume its proper role in helping to achieve the new eight-hour standard for ozone concentrations.

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Introduction

An important reason attention has been focused on the Chicago area cap-and-trade program, designed to reduce stationary-source VOC emissions in the local ozone non-attainment area, is that no other area of the country has yet proved that VOC emissions trading would work in any significant fashion as an alternative to prescriptive regulation. This suggests that there may be difficulties in implementing VOC emissions trading (Lents 2000). However, there exist strong pressures for introducing this innovative regulatory measure, perhaps the major ones being the relatively stubborn nature of urban ozone and smog problems, the unfavorable impact of these pollutants on human health and esthetic considerations, and the varying and mounting marginal costs of reducing these pollutants by traditional regulation (Stavins 2000). The question becomes: can decentralized market incentive regulation help achieve these VOC reductions in a cost-effective manner? After four years of recorded performance, 2000 through 2003, of this pioneering approach, enough data are available to begin to search for answers.

First, in terms of the attainment of several important environmental objectives, the three years for which aggregate data are available, 2000 through 2002, appear to have witnessed VOC emission reductions in each year, as revealed in table 1. These emissions were far below allotments of tradable permits and thus even further below the baseline of historical emissions. These lowered aggregate emissions have not been associated with observable spatial hot spots, or neighborhood increases in emissions during this period, nor were inter-temporal hot spots or spikes recorded. To the extent that baseline emissions were not seriously overstated, the air was cleaner and health benefits enhanced at the end of this period with respect to this pollutant, a precursor of low-level ozone. It is easy to conclude that this new decentralized emissions trading measure has achieved

[1] The authors are associated with the Department of Economics, University of Illinois at Chicago and Dominican University. We appreciate valuable support for this research from the Illinois Environmental Protection Agency and the Department of Economics. We have benefited from presentations and ensuing comments before various groups over a number of years, the most recent being a presentation to the Division of Air Pollution Control of the Illinois EPA on August 25, 2004. Kosobud's work was also supported by the Environmental Defense organization and Scott's work by the Institute of Environmental Science and Policy at the University of Illinois at Chicago in association with the National Science Foundation. All correspondence should be sent to Kosobud at the Department of Economics (M/C 144), University of Illinois at Chicago, 601 South Morgan Street, Chicago, IL 60607-1721, USA. Electronic Mail: kosobud@uic.edu, hhstokes@uic.edu, ctalla@dom.edu, and bscott4@uic.edu

this improvement in air quality and is therefore to be considered a success. The intense local debate about this program prior to the start of the market has largely been turned aside by these emission reductions.

What is open to serious question, however, is the extent to which this particular market design and mechanism is responsible for these results. Equally important is the question of whether this market has fulfilled its promise in all respects as a new regulatory policy instrument. These promises included, in addition to emission reductions, cost effectiveness, innovation stimulation, and flexibility compared with traditional regulation. Answering these questions by probing the market data more deeply is the objective of this study. We will find that there are reasons other than the market and market cap that explain much of the emission reductions, and that there are constraints on market decisions that explain many of the market outcomes that are difficult to rationalize in terms of cost minimization incentives. These reasons and constraints, not market incentives, can account for much of the apparent and startling emission reductions, the enormous banks of tradable emission permits, the large expiration of valuable permits, and the lack of demand which led to very low permit prices being recorded during the first three years.

In an earlier study we developed a cost minimization model of the cap-and-trade market that led to predictions of market events so far from observed values that we abandoned that model and adopted the wider framework of this paper (Kosobud, Stokes, and Tallarico 2001). Our revised major hypothesis explaining the puzzling performance of this cap-and-trade market is that the continuance and extension of traditional regulation on emitters acted in concert with the market design to constrain market incentives and participant decisions. That is, traditional regulation was binding on participants, not the market that featured a proposed modest emissions reduction and a one-year limit on banking. We also investigate the hypothesis that the agency's baseline determinations for individual participants were overly generous or excessive; that is, officially approved baseline emissions were larger than actual emissions during the historical period. The consequence would be that the allotments of tradable permits calculated from the baselines resulted in a large surplus of tradable permits that bore heavily on the market. We present a statistical analysis of these ideas that confirms our major hypothesis.

This study is organized, first, to present data on official baselines and allotments, aggregate emissions, and market activity for the first three years for which we have agency data. Then, we proceed to describe the pressures on the regulatory agency during the evolution of the particular design of the cap-and-trade market that includes the determination of baselines, the decision on the cap, and the banking horizon. Next, we develop our hypotheses and explain the datasets in preparation for statistical tests. These datasets include measures of the effects of traditional regulation and possible excessive allotments on four years of individual participant transactions data. Among the statistical techniques chosen to test these ideas will be ordinary least squares (OLS) and probit regression analysis that seem well suited to the distributions and character of key variables. The study ends with suggestions for public policy changes that could improve market performance, especially in light of the implementation of the forthcoming eight-hour standard for low-level ozone concentrations.

The Anomalous Three-Year Record: 2000 to 2002

Table 1 presents basic aggregate data on baselines and allotments and on market activity over three years in the Chicago six-county urban ozone non-attainment area. We have relied on data provided by the Illinois EPA in its annual performance reports, but have assembled the information in a new format to bring out more clearly the puzzling results of this period (Illinois EPA 2001, 2002, 2003).

The first category presents the baseline or benchmark emissions of market participants in tradable permits or Allotment Trading Units (ATUs) each measured as 200 pounds of VOC emissions. This aggregate value was based on the average of 1994 through 1996 emissions with some important exceptions that we shall explain later. This aggregate value is the sum of individual participant baselines determined by the Illinois EPA. Estimation of VOC emissions is difficult at best, as continuous emissions monitoring is feasible in only a few instances. Participants had every reason to negotiate for the largest baseline possible as allotments derive from that value, and the agency, in an effort to secure support for a new and innovative program, had reasons to accede to requests. The aggregate baseline varies slightly from year to year as negotiations continue over the historical period, as a few new emitters enter the market, and as a few old drop out when their emissions declined below the threshold.

The second category presents aggregate allotments of tradable ATUs to emitters. Those with emissions greater than 15 tons of VOCs during the ozone seasons were required to participate in the market, while those with emissions between 10 and 15 tons could opt in voluntarily. Allotments were to be a 12% reduction from baselines, a determination by the agency thought necessary, in conjunction with traditional regulation of mobile and small area VOC sources, to reach attainment of ozone standards by 2007. Stationary source emissions made up about 20% of all VOC emissions. In addition to the negotiations over baselines, there were further agency adjustments to individual participants by allotting permits in full for hazardous air pollutant emissions (HAPs), subject to the most stringent controls, and allotting permits in full for any emissions limited by new, more advanced control technologies that performed better than traditional regulation. Therefore, the aggregate reduction, the difference between categories 1 and 2, is about 10%, somewhat less than the policy goal of 12% (Illinois EPA 2002).

The third category presents data on aggregate emissions during each year as measured by ATUs retired (returned) to the government by market participants for each 200 pounds of VOC emissions as measured during the ozone season from May through September. Emissions were self-reported with monitoring checks by the agency. As ATUs may be banked for a year, retirements to cover emissions after the first year may be made with current or previously allotted permits as noted. The deep reductions in emissions as revealed in this category, far below the requirements of the cap, make up one of the

Table 1
Market-Wide ATU Transactions and Prices for the Years 2000 - 2002
(In ATUs or ATU equivalents: an ATU = 200 pounds of VOC emissions)

Category	Year 2000	Year 2001	Year 2002
1. Baseline in ATU units	105,479	107,777	108,718
2. Allotted ATUs	95,398	97,124	98,164
3. ATU retirements (reported emissions)	59,112	51,622	50,985
3.1 Vintage 2000 ATUs	59,112	21,407	
3.2 Vintage 2001 ATUs		30,215	31,575
3.3 Vintage 2002 ATUs			19,410
4. ATU transactions			
4.1 ATUs transacted	1,643	3,702	4,483
4.2 Number of buyers	29	25	31
4.3 Number of sellers	22	21	23
5. Banked ATUs			
5.1 Vintage 2000 ATUs	37,435		
5.2 Vintage 2001 ATUs		73,401	
5.3 Vintage 2002 ATUs			82,358
6. Expired ATUs			
6.1 Vintage 2000 ATUs		13,924	
6.2 Vintage 2001 ATUs			33,760
6.3 Vintage 2002 ATUs			
7. ATU prices			
7.1 Average price	$75.87	$51.93	$32.85
7.2 Price range	$50 to $150	$38 to $100	$20 to $50
7.3 Vintage 2000 price	$75.87	$50.54	
7.4 Vintage 2001 price		$63.93	$32.06
7.5 Vintage 2002 price			$31.04
8. Number of participants	179	172	172

Notes: The internal consistency of the table is affected by several types of transactions not enumerated, as explained in the text. Sources: Illinois EPA Annual Performance Review Reports, 2001, 2002, and 2003.

central puzzles of this period. These reductions were on average about 50% of the aggregate baseline and a slightly higher percentage of the allotment during the four years.

The fourth category presents data on market transactions of ATUs available for use during the year, one of the important decisions made by emitters. As is readily apparent, these transactions were a small share of allotments being less than 5% in all four years.

The fifth category presents aggregate banks of ATUs at the end of the ozone and reconciliation periods. It is worth repeating that under current rules, dated ATUs may be banked for only one year after issue so that each banked permit must be used in the following period, or it will expire. Consequently, another puzzle of the market performance is the rapid growth of banked ATUs to the point that, at the end of 2001, they were larger than emissions in 2002. The problem for participants with such large banks is that many of them will expire.

The participants' decisions to trade, reduce emissions, or bank ATUs as revealed in categories 3, 4 and 5 should be tightly interrelated if cost minimization is the objective. One consequence of cost minimization is that all banked ATUs of vintage t must be used in t+1 to avoid expiration. This did not occur and resulted in a large number of expirations.

The sixth category presents data on expirations of valuable tradable permits and, as mentioned, should equal zero if the cost minimization identity were to hold. It did not for each of the years following the first year when no prior banks existed. Instead expirations grew in magnitude year by year to the extent that vintage 2001 permit expirations in the year 2002 made up over a third of vintage 2001 allotments. This is among the most perplexing inconsistencies of reported market activity, as it would seem to amount to giving away valuable permits. We consider asymmetric transactions costs at a later point as one possible explanation of this puzzle, but we find that the large emission reductions are largely due to traditional regulation. These reductions lead to such large volumes of banked ATUs that expirations of permits inevitably follow.

Note that the number of vintage banked ATUs need not equal exactly the next year's sum of the same vintage retirements or expirations because a number of banked permits could be donated to community groups as a contribution to cleaner air. These contributions, which would have public relations value if not tax implications, were small in number during the three years. Another small discrepancy affecting the internal consistency of table 1 arises when several participants acquired additional ATUs from a special set-aside account at prices above market. However, these transactions explain only some of the inconsistencies of table 1, which can amount to about a 3% difference between sources and uses of ATUs. These inconsistencies have been called to the attention of the agency.

The seventh category presents data on ATU average prices calculated by the agency from individual transaction prices after the transactions period closed. Individual prices of transactions are not reported. The steady decline in average price from about $76 in the first year to less than $33 in the third is a trend and level that no one would have predicted at the start, including the authors. Prices were not reported for intra-firm transactions nor were prices included when ATUs were purchased from the agency's special set-aside account. There were several transfer agreements involving multi-year ATUs the prices of which were also not included in the averages.

Several more comments are in order on the price patterns of category seven. As permits of two vintages could be traded after the first year, given the banking rule, there are in effect two different commodities with a different time dimension during those following years. Given that a permit that could be used in a current or subsequent year provides more options than a permit that will expire at the end of the current year, the observer would predict the former would command an equal or higher price than the latter. That was true for 2001 when the differential was over $13 a permit. That was not true for 2002 when the difference was reversed. This is a kind of backwardation that is difficult, if not impossible, to explain or interpret in any optimizing framework, and creates another puzzle in the pricing realm.

The final category presents data on the number of emitters that participated in the market. Those facilities with emissions under 15 tons during the season were not required to participate in the market nor were emitters that reduced their emissions by more than 18% by the baseline determination period. The number of emitters could change as new emitters located in the area or emitters that qualified dropped out, or emitters opted in, but the number of such changes was relatively small. There remained 179 market participants in the year 2000 that varied widely in size, in SIC classification, and in production processes and inputs that gave rise to VOC emissions. This diversity meant that numerous, different, and expanded traditional regulations were applied to these specific sources of emissions. As these regulations play an important role in our analysis of market performance, we provide a more detailed description of them in a later section.

The observer who notes only category three and reads that emission reductions were well below the cap might conclude that all was well with the use of the cap-and-trade market to reduce VOC emissions, and that the present design could be recommended to other cities looking for cost-effective control of this precursor of low-level ozone concentrations. In the format that we have prepared, categories four through seven raise serious questions about that conclusion and convince us that the work has just begun in understanding this new regulatory measure, with its particular design, before recommending adoption elsewhere. A closer examination not only of emission reductions but also of huge banks, very large expirations, and very low prices is required and undertaken in this study.

A Post-Mortem on The Early Market Modeling and Forecasts of ATU Prices

At first glance such deep emission reductions from stationary sources far beyond the cap could be considered a contribution to cleaner air and a benefit to the public's health. On reflection, such deep reductions raise questions about the relationship between marginal control costs of stationary sources and emission reductions. Reductions could be characterized as "excessive" if they required higher marginal control costs than warranted, and thus would be an unwise use of resources. If balancing health benefits and control costs indicate that such deep reductions are in the public interest, then why was the cap, a public policy decision, chosen to make such a small reduction in emissions? We describe how the cap was chosen in a later section and find that the deep emission reductions were not mainly the result of the cap as chosen since the cap was binding on only a small proportion of emitters. What was mainly binding on source emissions, as we shall demonstrate, was the extensive traditional regulation.

Were these emission reductions from stationary sources far below the cap properly anticipated when policy decisions were made about the market design? There seemed to be other concerns as the agency developed the new program as only a part, and not the major part, of its efforts to reach ozone attainment. The Illinois EPA was concerned about several matters: the acceptance of the innovative regulation, the accurate certification of emissions and their conversion to tradable permits, the appropriate monitoring procedures to track the quantities and location of transactions, and the effective enforcement structures to create incentives for adherence to market rules. In deciding upon the final design, the agency seemed concerned about such negative outcomes as the generation of hot spots, or neighborhood increases in emissions, and the occurrence of inter-temporal spikes in emissions due to market trading.

When it became apparent that emissions were far below baseline with none of the adverse results that concerned the agency, the result was welcomed and greeted as a benefit to cleaner air. The fact that the cap-and-trade market as a regulatory tool was not operating effectively in the present circumstances was evidently not a matter that attracted much attention in the light of the achievement of emission reductions.

One of the imperfections of the cap-and-trade market in these circumstances was that many participants were not equating marginal control costs to the tradable permit price; that is, the market price was not binding. Marginal control costs were being determined in most cases by the requirements of traditional regulation, which differed widely in their impact on individual emitters. Equality of marginal costs is a requirement for cost-effective allocation of emission reductions among emitters. Many of the early studies of the Chicago approach were based upon theories of the functioning of an ideal market with prices and transactions based upon cost-minimizing calculations and expectations of participants. In other words, they were normative studies and not based upon an examination of the detailed market design and setting. In particular, they ignored the role of traditional regulation. Their primary aim was to estimate ATU prices based on engineering studies of control technologies, both existing and emerging.

An early study of the Illinois EPA using 1996 engineering data on various control technologies estimated that the marginal control costs of reducing VOC emissions in SIC classifications would be about $2,580 per ton, or $258 per ATU (Illinois EPA 1996). A study by the World Bank based on different marginal cost data estimated prices not far from this value (World Bank 1994). A study carried out by researchers using a linear programming model to illustrate the use of new control options for VOC reductions estimated the marginal control cost to be in the same range (Evans et al 1997). A survey of marginal control costs around the US in 1999 yielded a median price estimate of

$3,500 per ton of VOC emission reductions with a range from $2000 to $13,000; that is a median of $350 per tradable permit with a range of $200 to $1,300 (Cantor Fitzgerald 1999).

What was abstracted from these modeling efforts was the continuance and significant extension of traditional regulations that took place during the 1990s (US EPA 2004a, 2004b). In the models it was as if the cap-and-trade approach, a decentralized measure, was to operate at a level beyond or above centralized measures, making its own and separate contribution to emission reductions and cost-effective control. Operating in this market, participants would equate marginal control costs to observed permit prices, and marginal control costs would be determined by the 12% reduction from benchmark emissions required by the cap. It greatly simplified the modeling and the determination of an equilibrium price to assume that this reduction was binding.

Could these early and erroneous forecasts of high VOC marginal control costs have led participants to expect high tradable permit prices, which were later not realized, and hence to initiate emission reduction efforts based upon both existing and new control measures? It is difficult to get direct evidence on this hypothesis without sample surveys of participants' intentions, but there are a number of persuasive reasons that militate against this view. One important reason would be the small size of the emission reduction required by the cap that would seem to leave little incentive for significant control expenditures. In addition, many important emitter decisions about control of VOC emissions were made well before details of the design of the market were available and well before price forecasts were available. We devise a test that shows little significance of marginal control costs in determining transactions to be reported in a later section.

While these modeling efforts by academic researchers were underway, assuming an unconstrained market design, a great deal of detailed work by the Illinois EPA was also underway on the actual design of the market in the light of their concerns. These design decisions were also subject to ideas, pressures, and constraints from a number of constituencies that would be affected by or were interested in this new approach.

The Evolution of VOC Cap-and-Trade Market Design and the Underlying Traditional Regulations

The market design, (Emissions Reduction Market System or ERMS), while inspired in general by the sulfur dioxide cap-and-trade approach, was not mandated by the federally legislated CAAA of 1990. It was worked out in detail locally over a number of years by the Illinois EPA, a product of an elaborate procedure of technical air-shed modeling, discussions with advisory groups of concerned interests, and advice from a special expert design team. Needless to say there were divergent ideas presented to and pressures on the agency in making a number of important decisions on the pollutant to be covered and the basic design of the market. We focus in this account on these market design options, the final decisions made on these options, and the bearing these decisions had on the performance of the decentralized market in the context of continuing centralized federal and state regulations.

The design process was carried out by a small team in the Illinois EPA headed by the director. The first effort proposed was to develop a cap-and-trade approach to controlling NOx emissions locally (Gade 1993). This was due in part, perhaps, because of the earlier unsuccessful effort to use a cap-and-trade mechanism in the Los Angeles area to limit VOC emissions, there called reactive organic gases (ROG). The complexity of the sources of VOC emissions may have appeared daunting: they were generated by a wide diversity of emitters, many of them small; they arose from an even wider variety of production processes and inputs; and they were subject to an extensive range of traditional regulations, some of them applicable to the hazardous air pollutants (HAP) that comprised a sub-set of VOC emissions.

In the Los Angles area, a number of participants from the business community had complained of the proposed tradable permit allotments and baselines, and several influential environmental groups had been concerned with hot spots that might result from autonomous and anonymous market decisions. The proposed market was abandoned and traditional regulation continued (Lents 2000). Representatives of the Illinois EPA had visited Los Angeles to discuss the cap-and-trade market and the demise of this early program was likely a matter of concern.

Furthermore, a number of attempts by the US EPA to launch VOC open market rather than cap-and-trade emissions trading in several states had achieved few transactions and little success in scattered applications around the country. NOx emissions, also a major precursor of urban ozone, on the other hand, arising as they do from combustion in steam generating boilers of electric utilities and large manufacturing installations, may have appeared a more feasible line of attack for this decentralized regulatory measure (Gade 1993).

One of the problems soon uncovered by the Lake Michigan Air Directors' Consortium, in their air-shed modeling of precursors of low-level ozone, was that the incoming levels of NOx concentrations to the Chicago non-attainment region were high, leaving little scope for a local market mechanism (LADCO 2000). The idea of a national rather than local effort to control NOx emissions secured support among state environmental regulators and the important Ozone Transport Assessment Group (OTAG) was formed with US EPA sponsorship to study sources of emissions and the movement of NOx concentrations around a large region. The Illinois EPA Director was named the chair of OTAG and the results of this study became one of the foundations of the present national NOx control strategy that includes an option for states to participate in a NOx cap-and-trade market managed by the US EPA (OTAG 1997).

Given the LADCO results, the emissions trading group within the Illinois EPA turned their attention in 1994 to the possibility and design of a local VOC cap-and-trade market. The authors of this study were fortunate in being able to participate in the design team discussions and in the dialogues with interest groups. Among these groups we found it difficult to detect a ground swell of support for the idea. The local environmental community was suspicious of an autonomous and anonymous market in place of more traditional regulation, but if such a program were to be devised the cap should be a significant reduction from benchmark emissions, the market should be subdivided into separate areas to prevent hot spots, and banking should be viewed with great suspicion and, if permitted, hedged around with limitations to prevent temporal spikes in emissions. Perhaps most important, traditional regulation in all its forms should be continued in full force.

The business community seemed divided; large businesses were generally favorable and argued for a smaller reduction in emissions under the cap, a unified market, and the option of a long banking horizon for tradable permits. Small businesses, in particular, seemed more concerned about baselines, allotments, and the availability of tradable permits. One business environmental manager, anticipating the continuance of traditional regulation, wrote, "This new system will not achieve its maximum potential for air quality improvement because of the fact that it is an overlay on the existing technology-based command-and-control system" (Zosel 2000).

Among government regulators there was a diversity of concerns, as mentioned, about this change in regulatory control. The environmental impact of this innovation was being questioned. Certification of identifiable tradable permits requires a degree of accuracy of estimation of baseline emissions and of allotments among emitters. Such identification and certification would be essential if non-emitters were to participate in the market. Monitoring procedures, based on source self-reporting, would have to assure compliance with market rules and the tracking and location of transactions. Incentives both negative and positive would have to be created in developing enforcement rules. Few of these administrative procedures had been worked out in the case of a VOC cap-and-trade program.

The Final Market Design

The threshold level of 10 tons of VOC emissions during the five-month ozone season as a requirement for participating in the market was established to exclude small emitters. This reduced the 1,958 stationary sources identified in the 1990 VOC inventory to 283. Further reductions in numbers occurred due to negotiations over existing controls and prior emission reductions so that finally 179 participants were included in the year 2000 start date, which was a delay of one year from the original plan given the number of decisions to be made and the complexity of the negotiations among all concerned parties (Illinois EPA 2000).

What emerged from these negotiations was a cap-and-trade market with compromised features reflecting different and what seem now to be contradictory points of view. There was a clear statement that market participants were to continue to be subject to existing and evolving traditional regulation. The continuance of traditional regulation effectively limited the purchase of permits by a participant for use during any one year, as emissions could not exceed the level specified by centralized regulation. The market was not fragmented, but covered the entire non-attainment area. The apparent cap was set at a 12% reduction from baseline emissions calculated for each participant as the average of historical 1994-1996 levels. Baseline emissions were subject to negotiation, complicated in many instances because of the difficulty of measuring emissions. In addition, there were important exceptions to be granted to participants from the 12% cap.

In recognition of company concerns, certain participants were given 100% of their baseline HAP emissions in tradable permit allotments due to the stringent technology requirements on these emissions. Participants installing advanced control technologies prior to the start of the market beyond those required of traditional regulations were also given tradable permit allotments in full measure of the emission reductions attributable to these technologies. Companies that could demonstrate unusual conditions during the baseline period were allowed to substitute years in the interval 1990 through 1997. The aggregate cap was thus about a 10% reduction from negotiated baseline values, an indication of business concerns about the effects of the magnitude of the cap on control costs and their competitive status vis-à-vis other emitters in regions not implementing VOC cap-and-trade markets.

Did these exceptions plus any bias in overstating baseline emissions of participants lead to an over-allotment of free tradable permits? Such an over-allotment would help explain the deep emission reductions that occurred during the period 2000 to 2004[2]. Obtaining reliable numbers on VOC emissions is not a trivial exercise. The volume of emissions that were certified for each participant was obtained both from the 1970 inventory, based on a variety of estimates, and the better quality annual emission reports required from emitters starting in 1992. Our statistical tests of the over-allotment hypothesis, reported in a later section, do not provide strong support of the view that over-allotment was a major cause of the market's puzzling performance.

Banking was to be allowed in the ERMS program but only for one year beyond the date of issuance of a dated tradable permit, in sharp contrast to the SO2 market where dated tradable permits could be held indefinitely. While banking was considered important by the business community in furthering inter-temporal cost effectiveness, it was strongly criticized by the environmental community as threatening spikes in emissions. Dated permit allotments were assured for future years and could be traded but not used in the current year to cover emissions. The one-year banking horizon compromise was destined to affect emitter decision-making in significant ways after the start of the market.

In an effort to assure additional market liquidity, trading was open to non-emitters. The number of ATUs traded was to be reported for individual emitters in the annual reports. Individual prices of transactions were not to be reported to the public, but averages for the year would be reported by the agency at the end of the year in its annual performance reports. There would be no auction of permits to aid price discovery, but a voluntary electronic bulletin board, maintained by the agency, was established to list bids and offers. In recognition of the concerns of the business community about the availability of tradable permits, a separate account managed by the agency was established to sell

[2] This seems to be the explanation favored by the personnel of the Division of Air Pollution Control of the Illinois EPA, which now manages ERMS, as stated in a meeting of August 25, 2004.

permits at a stated high price or 50% above market, whichever was lower. This account was funded by a small deduction from company permit allocations (Illinois EPA 2001).

Certification of emissions by assigning numbers to each ATU allowed tracking of emissions and their sale to non-emitters. Transactions were to be reported to the agency, but pre- or post-trade approval was not required. Monitoring of these transactions by the Illinois EPA together with the annual emission reports of emitters was to provide information on trading progress, as revealed in table 1, and also provide information of the location of transactions and any possible hot spots. Enforcement rules included sample checks on reported emissions and penalties for emissions not covered by ATUs.

The market thus began with dual rules: one set of rules imposed by prescriptive regulation, the other imposed by incentive-based regulation. Participants were expected to conform to Maximum Achievable Control Technology or MACT standards set by the US EPA for HAP emissions, and Reasonably Achievable Control Technology or RACT standards for other VOC emissions set by the Illinois EPA, and other prescriptive regulation. Participants were expected to conform to market rules, record keeping, and emissions reporting required by the cap-and-trade system. Within these complex constraints, participants were free to buy, sell, or bank credits up to a year, and to decide on emissions control levels, hopefully, with control cost minimization objectives in mind. The inevitable tension in the regulating community between using traditional regulation to control emissions and prevent pollution problems from arising and allowing a permissive market program to determine these variables was not resolved, but co-existed in the conflicted market design.

The diversity of these participants and their responses to market forces in the light of traditional regulation and market design features pulling in different ways would become a matter of key importance in determining the performance of the market. It will be recalled that the SO2 cap-and-trade market was also subject to an underlying and continuing level of traditional regulation. However, the cap in the second phase of the program was about a 50% reduction in emissions from baseline SO2 emissions in the 1980s, and clearly was more binding than traditional regulation on most emitters (Ellerman et al 2000). In addition, these emissions were measured by means of more reliable, continuous electronic monitoring.

The Diversity of Participants and Their Varied Market Participation

VOC traditional regulation applies specifically to particular production processes and inputs of stationary sources limiting the rate of emissions per unit time or the quantity of VOCs in an input, and not, typically, the volume of emissions. Given the wide diversity of VOC emitters by size, production processes, and use of inputs, the application of traditional regulation is mainly a long and complex list of regulatory requirements for particular control mechanisms or inputs such as after-burners, liquid absorbers, cans of paint, and the like. As controls generally apply to specific processes and inputs and not to participants, the result is that different participants experience different levels of controls. Furthermore, as these regulations change over time at an uneven rate, and emitters change in size at an uneven rate, it becomes difficult to predict exactly which emitters will be affected most. The phrase that “one size fits all” under command-and-control regulation applies only to emitters with identical production functions. It follows that neither are marginal control costs equated under traditional regulation nor are control costs minimized in the aggregate.

As previously mentioned, sources in the Chicago region varied widely in a number of dimensions: in size, in SIC classification, and in production processes and inputs. They range from leather goods and plating shops through refineries, food products, and drug companies subject to varied RACT controls, and other regulations. Furthermore, about half of all sources have some hazardous air pollutants, such as benzene, among their VOC emissions subject to the tighter standards of MACT controls, and other regulations. This disparate assortment of sources of VOC emissions contrasts with sulfur dioxide emissions arising largely from the burning of coal in steam boilers and with NOx emissions arising largely from combustion in steam boilers.

One convenient and summary way to depict some of this variation is by Lorenz Curves in which emissions size is aligned with market variables. Size of emitter was measured as a ratio of each emitter’s ATU allotment in 2001 divided by the maximum ATU allotment in 2001. The distribution of participants by size in figures 1a, 1b, and 1c reveals many small firms and about 20 large firms. Participants are arrayed by size along the horizontal axis and fractions of them are calculated from smallest to largest. Then, fractions of tradable permit allotments, emissions, banks, purchases and sales, and expirations of permits calculated for each size fraction are revealed on the vertical axis.

For the year 2000, as portrayed in figure 1a, we may estimate that the smallest 50% of participants had less than 25% of allotments, emissions, and banks, whereas the top 10%, about 20 firms, had some 50 % of these variables. In sharp contrast to the curves for emissions, allotments, banks, and expirations, are the curves for tradable permit buys and sells. They reveal a more even distribution among the participants by size; in fact, the top 10% of the firms had relatively few buy but more sell transactions. We interpret these buy and sell curves as indicating the different pressures of traditional regulation on emitters of different characteristics; those buying ATUs during the period were less affected by prescriptive rules and had higher levels of emissions relative to allotments and those selling were more affected by prescriptive rules and had lower levels of emissions. These hypotheses are subject to further testing in a later section.

The profiles are similar for the year 2001 where we have added expirations of vintage 2000 credits to figure 1b. Again, the top 10% accounted for close to 50% of allotments, emissions, banks, and expirations, but few of the buys. Again, larger emitters had relatively more sell transactions. We note from the curve for expirations of credits that the larger participants, specifically the top 20% of participants by size, allowed about 70% of the total expirations to lapse (as may be estimated from figure 1b). Our hypothesis is that traditional regulation bore more heavily on these larger emitters leaving them with a surplus of ATUs, many of which they were unable to sell.

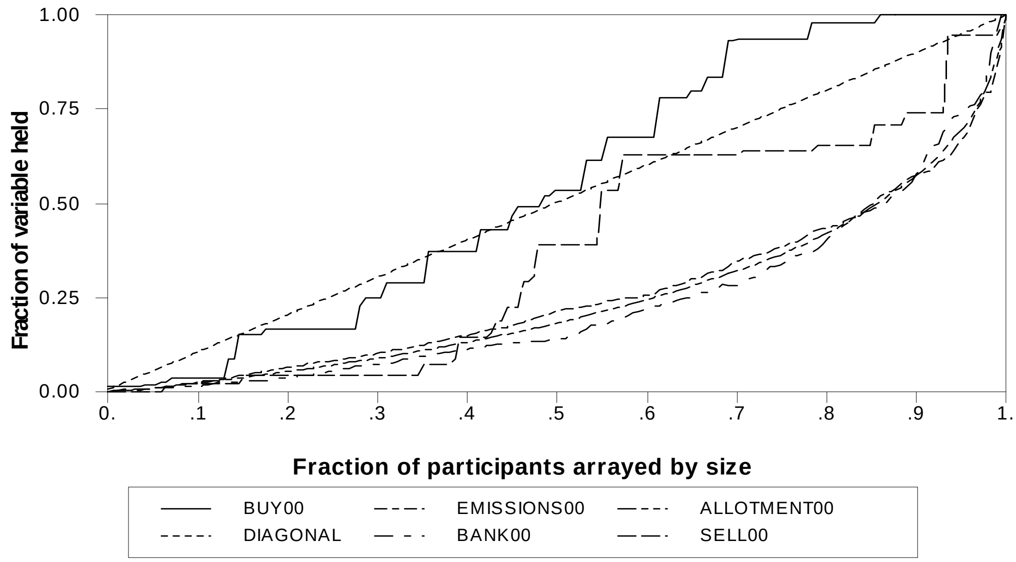

Fig. 1a. Holdings of dependent variables by participant size in 2000

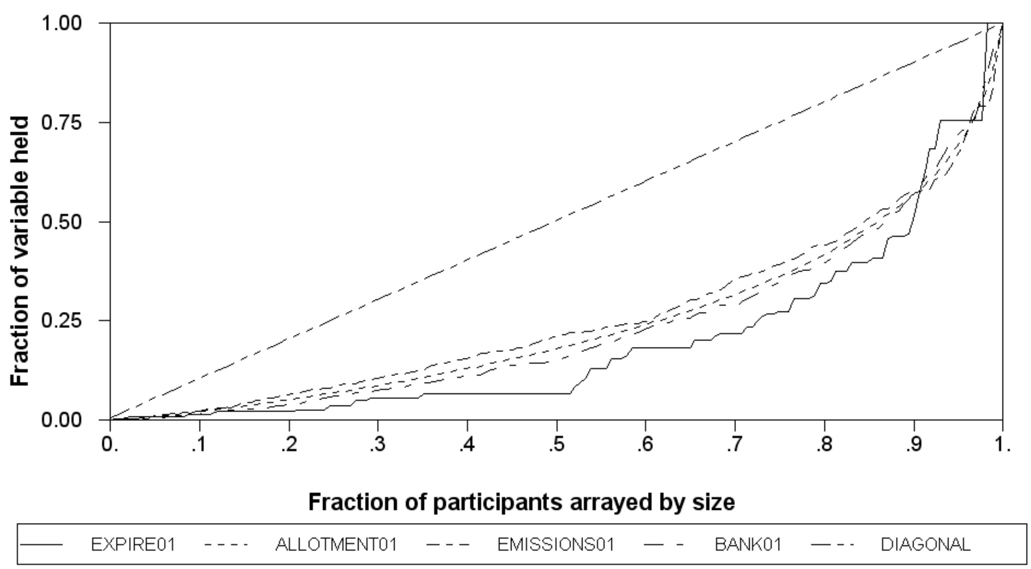

Fig. 1b. Holdings of dependent variables by participant size in 2001

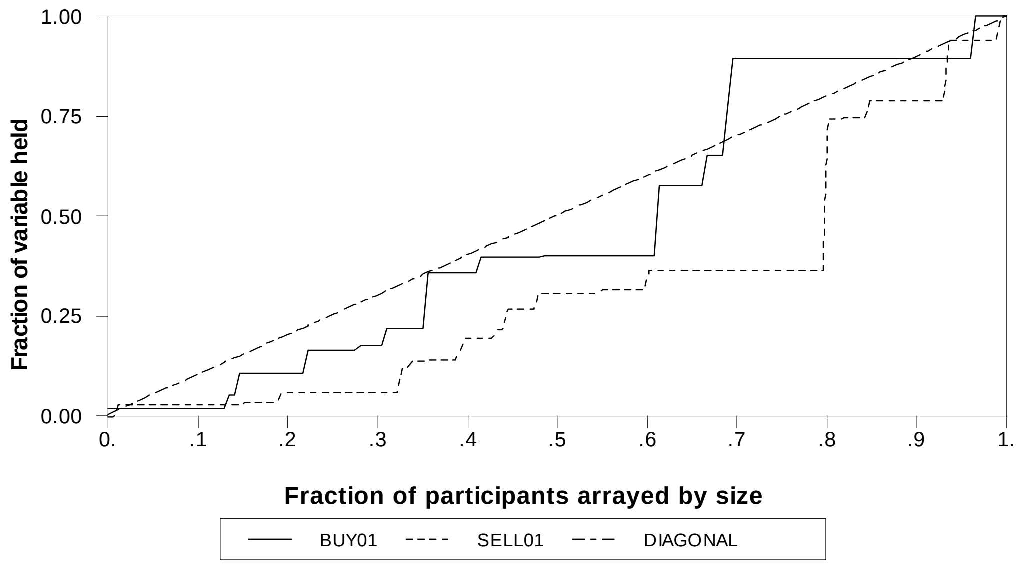

Fig. 1c. Holdings of dependent variables by participant size in 2001

What the Lorenz Curves do not tell us are the reasons for the transactions among the few emitters who entered the market, and more important, the reasons the vast majority of emitters did not enter the market. As a first step in this direction, we have identified four important factors or variables affecting these groups and their market transactions differently, and we now turn to ways to measure these variables.

Our account of the pressures of prior and continuing centralized regulation imply that those emitters with the greatest reduction of emissions from this factor would be most likely to sell, and those with the smallest reductions or no reductions at all would be most likely to buy ATUs. In addition, to the extent that traditional regulation was the important binding factor driving emissions below allotments, a large surplus of ATUs would be created making it difficult for the majority of emitters wishing to sell ATUs to enter the market at all. The competing hypothesis is that excessive baselines and exceptions to the cap affected market performance. The recession that began in 2001 could also play a role and could be expected to stimulate ATU sales of participants more sensitive to the cycle and stimulate ATU purchases of those less sensitive. Finally, the cap-and-trade rules could be binding on some of the participants least affected by centralized regulation. Our task is to measure the relative importance of these four forces on market transactions.

We provide in a later section a more complete probit and traditional regression analysis of the significance of these variables in affecting transactions together with other possible variables affecting participant decisions. At this point we present a description of how we propose to estimate the variables representing these forces, and provide a preliminary test of their importance.

For the first variable, traditional regulation, we divide individual participant emissions during 1998 by their baselines as determined by the Illinois EPA generally in the period 1994-1996. We believe the lower this ratio the more the continuing pressure of extended traditional regulation on emission reductions during this period. The measure is taken to be exogenous to market transactions as the market design in 1998 was in the development stage with few of its features finally determined. We have labeled this variable REG for traditional regulation.

Note our hypothesis assumes that the numerator has been reduced by traditional regulation whereas the competing hypothesis assumes that the denominator has been increased by excessive baselines. We experimented with several measures that seemed related to the over-allotment view recognizing that, without direct evidence, it would be a difficult task. We tried a ratio of emissions exempt from the cap, as explained earlier, to the stated baseline emissions, and variations on this theme, but none of these variables proved superior to the REG variable. We finally settled on a dummy variable coded one for those participants with HAP emissions on the basis that their individual emissions reduction would be less than 12%, leaving them with excess ATUs to sell and less incentive to buy. This variable is coded HAPDUM.

To estimate the recession variable, we calculate the ratio of 2001 emissions to 2000 emissions and argue that it reflects the impact of the recession on production and hence on emissions. Emissions were already so reduced by traditional regulation by 2000 that it seems conservative and safe to attribute most of further reductions to the recession. Continuing traditional regulation was also likely to play a role in this time period, but we adopt a conservative stance toward attributing any further explanatory power to it. The recession can be considered exogenous in our estimation method. We have labeled this variable DIP.

For the influence of the cap, we calculate the ratio for each participant of 2000 emissions divided by 1998 emissions. While traditional regulation would continue to exert its sway, we adopt the conservative position that any emission reductions participants undertook in this period reflected the market cap and any price expectations. We have labeled this variable ERM (emissions reduction market). Construction of all these variables required spreadsheets with individual data for which we are indebted to the Illinois EPA.

A closer look at the frequency distributions of these variables could provide valuable information about the differing impacts on emitters and their market decisions. These distributions, presented in table 2, reveal that these pressures on emitters varied widely among individual emitters. Perhaps most surprising is the wide-ranging impact of the REG variable in reducing emissions before the start of the ERMS program. This finding stands in stark contrast to the frequent statements that command-and-control regulation is a “one size fits all” regulation. On the contrary, the distribution indicates that 22% of emitters had emission reductions by 1998 of 40% or below baseline volumes, 43% of emitters had reductions of 60% or below, and 74% of emitters had reductions of 80% or below. Only 14% of emitters reported emissions greater than baseline values by 1998.

Table 2
Frequency and Cumulative Distributions of Emitters
for REG, ERM, and DIP Ratio Intervals

	Frequency Distributions			Cumulative Distributions		
Ratio Intervals	REG	ERM	DIP	REG	ERM	DIP
0.0 to 0.2	15	5	11	15	5	11
0.2 to 0.4	22	12	4	37	17	15
0.4 to 0.6	36	23	13	73	40	28
0.6 to 0.8	51	28	29	124	68	57
0.8 to 1.0	21	30	50	145	98	107
1.0 to 1.2	13	30	36	158	128	143
1.2 to 1.4	3	17	17	161	145	160
1.4 to 1.6	3	5	6	164	150	166
1.6 to 1.8	2	3	0	166	153	166
1.8 to 2.0	0	6	0	166	159	166
2.0 to 2.2	0	2	0	166	161	166
2.2 to 2.4	0	2	0	166	163	166
2.4 to 2.6	1	0	0	167	163	166
2.6 to 2.8	0	1	0	167	164	166
2.8 to 3.0	1	0	0	168	164	166
3.0 and above	0	4	2	168	168	168

Notes: N = 168 emitters for whom all data were available. The REG mean = .672 and the variance = .155. The ERM mean = 1.401 and the variance = 17.59. The DIP mean = .902 and the variance = .246. Ranges for the three series are (.00613 – 2.811), (.0103 – 49.25) and (0.0 – 4.592) respectively.

The spread of the emitters among the ERM intervals can be interpreted as an indication of the differences in marginal control costs, and the spread of the DIP variable as an indication of the varying impact of the recession.

One plausible hypothesis is that the emission size of participants in the market would be highly correlated with emission reductions prior to the start of the market, the larger the emitter the larger the proportion of reductions. We have provided a test of that hypothesis in figure 2 where an array from smallest to largest measured by emissions size of all 168 emitters is plotted along the abscissa and the REG ratio along the ordinate. There is little drift to lower REG ratios of 1998 to baseline emissions along the axis.

What is more revealing about figure 2 is the vivid portrayal of the wide diversity of REG ratios among emitters. If each bar initially were a nail at unity, it is as if the hammer of traditional regulation had struck widely different blows on the nails driving most of them below unity, and some very much below. We interpret this as evidence for the idea that traditional regulation is geared to processes and inputs and not to enterprises. Some caution is advised in this interpretation as some emitters may have experienced output, product, or production technique changes that explain some of this variation. However, these changes during this period of prosperity more likely explain the few ratios greater than unity.

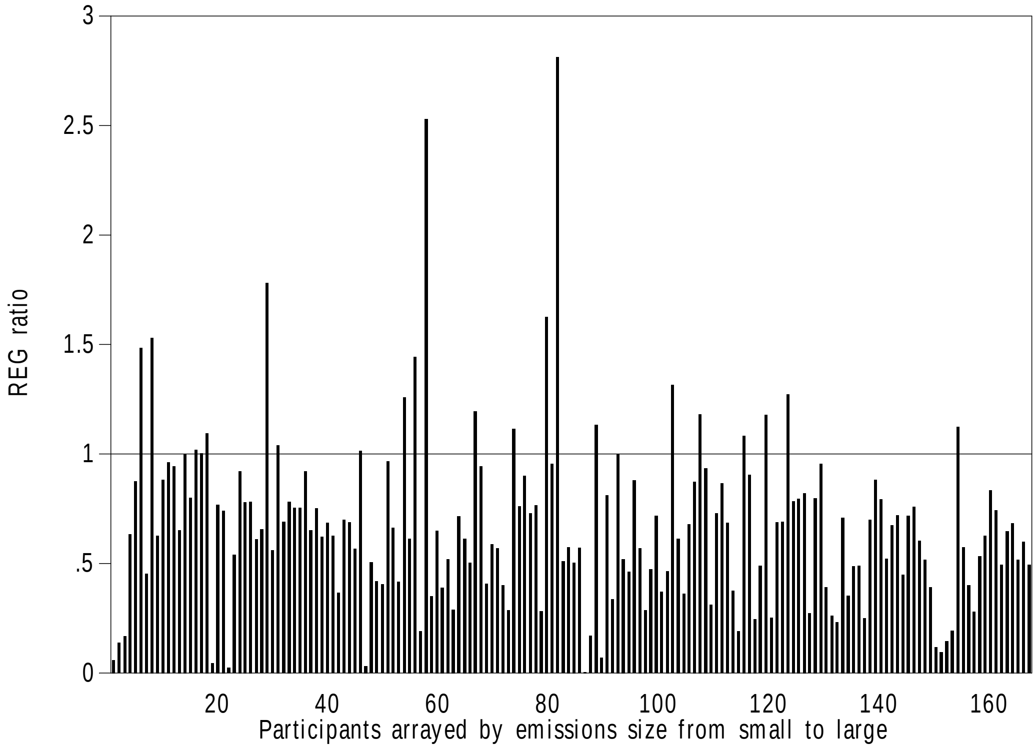

Fig. 2: Variation in REG ratios by emissions size of participants

Our hypotheses have now been sharpened to state that the variables, REG, ERM, HAPDUM, and DIP, have affected the market transactions of emitters, and more specifically, that they affected buyers and sellers of tradable permits differently. For our next test of this hypothesis, in table 3 we have grouped participants by their involvement or lack of it in the market and calculated the median values of the ratios for each group. We use the medians because of a few outlier observations affecting the mean.

The relevant feature of table 3 is its confirmation that the ratio for traditional regulation, REG, reveals the most dramatic difference between buyers and sellers, as hypothesized. Those emitters with the lowest ratio, indicating that traditional regulation bore most heavily on their compliance decisions in reducing emissions, were more frequently in the market as sellers, and those emitters with the higher ratios, indicating that traditional regulation was less pressing, were in the market more frequently as buyers. These differences were significant at the 95% confidence level.

Another interesting feature not revealed in table 3 is that very few emitters were both buyers and sellers during the four years. The occurrence of both persistence of buying or selling and the widely divergent REG ratios of buyers and sellers is not accidental. The pressures of traditional regulation on most emitters led them to have such a surplus of ATUs that they either sold, or tried to sell, ATUs during the entire period. For those fewer emitters with less pressure from traditional regulation, it was a buyer's market. Participants were buyers because of above average growth of output or below average impact of traditional regulation, and, perhaps, less sensitivity to the recession. The opposite is true for the sellers who had a surplus of tradable permits that were very difficult to sell in the chronic buyer's market.

Table 3
Median Ratios of ATU Buyers and Sellers
2000 Through 2003

	Number of Emitters	Percentage of Emitters	REG Ratio	ERM Ratio	DIP Ratio
Buyers in any one or more years	29	17.3	0.935	1.078	0.933
Sellers in any one or more years	31	18.4	0.518	0.834	0.911
Never a buyer or seller	108	64.3	0.637	0.850	0.836
Totals	168	100			

Note: the number of emitters in table 3 is different from the number of participants in table 1 because this table includes only emitters for whom we had complete data of the kinds required. Several emitters shut down their operations but continued to sell their ATUs. These shut downs deserve separate investigation, but we have deleted them from our sample on the grounds that their economic calculations differed from continuing emitters. The number of buyers and sellers will also differ between tables 1 and 3 because we count as a buyer or seller any emitter who transacted in one or more of the three years in table 3 compared with counting only those buyers or sellers who transacted in just one year in table 1.

In fact, the great majority of participants who were neither buyers nor sellers had on the average a surplus of tradable permits that were not sold and therefore expired after a year. It is apparent that the transactions costs were very different for these two groups of transactors; that is, transactions costs were asymmetric during this period. The few buyers could check the bulletin board and find a number of sellers willing to sell, and then negotiate from strength over price. For buyers, search, negotiation, and settlement costs were at a minimum. For sellers, these costs were much higher as most frequently no buyers were listed on the electronic board and they would have to contact the full list of participants. Few brokers were active in the market, and if they had any interest it was in finding buyers. Given the declining price of ATUs during the period, it is likely that most sellers felt it was not worthwhile to pursue the matter.

Emitters with the lowest ERM ratio, reflecting the effect of the cap-and-trade market in the decisions to reduce emissions, entered the market more often as sellers, and emitters with higher ratios entered the market as buyers. The difference is more marked than in the case of the recession variable but less marked than in the case of the traditional regulation variable. Emitters with the lowest DIP ratio entered the market as sellers more often, and emitters with higher ratios entered the market as buyers more often, but the difference is much less marked than either the case of the REG or ERM variables, indicative to us of the lesser impact of the recession on emission reductions.

For a deeper probing into the reasons participants did or did not participate in the market, we turn to a more detailed statistical analysis of variables that affected individual participant decisions

Statistical Analysis of Individual Emitter ATU Purchases and Sales, and Further Tests of Our Hypotheses

We can more fully exploit our data on individual participant transactions over the four years, or lack of such activity, by incorporating our ratio variables with other plausible determinants of transaction decisions. As we mentioned, we shall utilize two statistical tools well suited to our variables, probit and traditional regression, to test for significance and for the quantitative contribution of each variable to a reduction in unexplained variation of transaction activity.

We have estimated a measure of the variation of marginal control costs among emitters by making use of a World Bank study of these costs by Standard Industrial Classification (SIC) groups, and assigning the measure to each participant in a particular group (the WBMCC variable). As mentioned, we have also identified participants with HAP emissions among their VOC emissions and assigned a dummy value of unity to those identified (the HAPDUM variable).

For the dependent variables, we have chosen the number of ATUs bought or sold by individual emitters during each of the four years, which yields eight variables suitable for traditional regression analysis since we view the explanatory variables as orthogonal to the disturbance term in each equation, thus avoiding the issue of single equation least squares bias. To reduce the influence on the regression of a few emitters with large transactions, we have also chosen probit analysis by coding a unit value for individual participants that bought ATUs in each of the four years, and then coding a unit value for each participant that sold. This yields eight additional variables suitable for probit regression.

Our hypotheses were that the effect of traditional regulation, the REG variable, would be positive and significant in its role in the buy equations, and negative and significant in the sell equations. That is, the lower the ratio the less pressure to buy, and the more pressure to sell. Given the fact that it was very much a buyer's market during the four years, we were less sure of the significance of the sell equation results. The HAPDUM variable was created to capture an aspect of excessive allotment of tradable permits. Our hypothesis was that this dummy coded 1 for participants with HAPs would yield a negative coefficient for ATU purchases because of excess ATUs, and a positive coefficient in the sell equations because emitters would try to sell these excess ATUs.

The ERM ratio variable ought to have negative signs for sellers and positive for buyers, a reflection. This could be due to innovative efforts to reduce emissions and profit from sales on the part of emitters who could lower costs, or to avoid reducing emissions on the part of emitters who had difficulty in this endeavor. That is, the lower this ratio the more effective had been the innovative efforts and the more ATUs there would be to sell. The WBMCC variable was introduced to measure the strength of the theoretical argument that high marginal cost emitters would more likely buy (a positive coefficient) and low marginal cost emitters would more likely sell (a negative coefficient). We believed the DIP variable would have similar impacts on buys and sells, although probably less significant given the relatively shallow nature of the recession.

The results are presented in tables 4A and 4B. Note that we have been able to obtain additional transactions data from the Illinois EPA web pages for the year 2003, whereas the aggregate data for 2000 through 2002 were obtained from the previously listed Performance Reports. The result most worthy of note, in our view, is the significance and importance of the variables reflecting traditional regulation. The REG variable is positive, significant at the 95% level, and most important in the buy equations, and negative and significant in the sell equations, both in the probit and traditional regression analysis, as hypothesized. By importance we mean that it makes the largest contribution to a reduction in unexplained variance for almost all of the dependent variables. As an indication of its importance we find that the REG variable entered first in a stepwise regression in all but one equation, contributing over 50% of the explained variation. The one exception occurred in the sell 2001 equation, where it came in second to HAPDUM.

The HAPDUM variable was not significant in the OLS Buy equations and of the wrong sign in the first year. It was the wrong sign in the probit equations and significant in the first year. In the OLS Sell equations, the HAPDUM variable was of the wrong sign in all of the years and significant in two of the years. These results also held in the probit equations. Our interpretation of these unexpected results is that the HAPDUM variable may be indicative of the constraining effect of traditional regulation rather than over-allotment. That is, the stringent MACT controls required full use of allotted ATUs and left little maneuvering for the market.

The market variable, ERM, contributed explanatory power to the buy equations especially significant in the probit regressions. That the ERM variable was more significant in the probit equations is consistent with our Lorenz Curve findings that large emitters were less frequently buyers than others. A few large emitters with large ERM

Table 4A
Determinants of ATU Purchases
2000-2003

OLS Estimation Results

	Dependent Variables (N = 168)			
Explanatory Variables	Buy 2000	Buy 2001	Buy 2002	Buy 2003
REG	26.035	32.482	40.412	40.588
	(5.337)	**(4.229)**	**(3.765)**	**(2.543)**
HAPDUM	4.043	-1.397	-3.996	-2.423
	(1.058)	(-0.232)	(-0.475)	(-0.194)
ERM	1.347	1.315	1.537	1.129
	(2.963)	(1.836)	(1.536)	(0.759)
WBMCC	0.012	0.052	0.038	-0.003
	(0.542)	(1.446)	(0.75)	(-0.042)
DIP	1.754	5.519	14.933	17.815
	(0.471)	(0.941)	(1.823)	(1.462)
CONSTANT	-15.561	-20.675	-29.113	-24.579
	(-2.786)	**(-2.351)**	**(-2.369)**	(-1.345)
Adjusted R-squared	0.148	0.108	0.009	0.002

Probit Estimation Results

	Dependent Variables (N = 168)			
Explanatory Variables	Buy 2000	Buy 2001	Buy 2002	Buy 2003
REG	2.468	1.273	1.183	1.294
	(4.942)	**(3.439)**	**(3.491)**	**(3.669)**
HAPDUM	0.770	0.104	0.391	1.294
	(2.314)	(0.319)	(1.316)	(0.380)
ERM	0.120	0.86	0.093	0.083
	(2.285)	**(2.211)**	**(2.066)**	**(2.182)**
WBMCC	0.002	0.002	0.002	0.002
	(1.246)	(1.589)	(1.322)	(1.384)
DIP	0.280	0.286	0.504	0.627
	(1.049)	(0.921)	**(2.195)**	**(2.282)**
CONSTANT	-3.958	-2.891	-2.961	-3.172
	(-5.841)	**(-5.404)**	**(-6.000)**	**(-5.924)**

Table 4B
Determinants of ATU Sales
2000-2003

OLS Estimation Results

Explanatory Variables	Sell 2000	Sell 2001	Sell 2002	Sell 2003
	Dependent Variables (N = 168)			
REG	-14.907	-42.621	-48.972	-51.552
	(-2.099)	**(-2.066)**	**(-2.934)**	(-1.753)
HAPDUM	-6.921	-34.336	-28.710	-0.547
	(-1.245)	**(-2.125)**	**(-2.197)**	(-0.024)
ERM	-0.704	-2.141	-2.253	-2.012
	(-1.063)	(-1.114)	(-1.449)	(-0.734)
WBMCC	-0.008	-0.020	-0.018	-0.001
	(-0.249)	(-0.206)	(-0.137)	(-0.008)
DIP	1.715	-18.983	-14.673	-19.752
	(0.316)	(-1.206)	(-1.152)	(-0.880)
CONSTANT	22.721	86.538	85.892	88.494
	(2.794)	**(3.664)**	**(4.495)**	**(2.629)**
Adjusted R-squared	0.001	0.003	0.006	0.005

Probit Estimation Results

Explanatory Variables	Sell 2000	Sell 2001	Sell 2002	Sell 2003
	Dependent Variables (N = 168)			
REG	-1.337	-1.806	-2.079	-2.077
	(-2.499)	**(-2.946)**	**(-3.319)**	**(-3.460)**
HAPDUM	-0.184	-0.898	-0.675	-0.272
	(-0.681)	**(-2.867)**	**(-2.322)**	(-0.989)
ERM	-0.217	-0.365	-0.429	-0.271
	(-0.938)	(-1.429)	(-1.659)	(-1.097)
WBMCC	0.001	-0.0001	-0.002	-0.00004
	(0.943)	(-0.036)	(-0.806)	(-0.025)
DIP	0.096	0.211	-0.005	-0.486
	(0.371)	(0.741)	(-0.017)	(-1.324)
CONSTANT	-0.211	0.377	0.818	0.908
	(-0.426)	(0.723)	(1.490)	(1.662)

ratios but few buy transactions could affect the OLS results. For the 15% or so of emitters not deeply constrained by traditional regulation, the market offered opportunities for purchases that could have reduced their control costs as reflected in these equations. These variables lost their significance in the sell equations, indicative of the difficulty of selling ATUs in a buyer's market for those emitters affected by traditional regulation. The marginal control cost variable (WBMCC), the best estimate we could obtain, revealed no significance indicating to us that marginal control costs were driven higher than ATU prices by traditional regulation. The option of increasing emissions to reduce costs was limited because of traditional regulation. We also note that the adjusted R^2 is much less in the sell equations, again evidence of a buyer's market.

The DIP variable proved to have little explanatory power and proved to be significant in only two of the buy (probit) equations. Its role as an explanation of the performance of the market was limited in our findings.

A further note on our probit results is in order. The OLS models reported above are subject to the attack, as we have mentioned, that there may be a few large firms in the market that might skew the results. To test if our OLS results are sensitive to possible firm-size related outliers, we have run probit models for the same model. Here the left hand side is not the amount the firm bought or sold but whether in fact it bought or sold. In place of predicting the amount bought or sold, we are predicting if in fact a firm will be a buyer or seller (Greene 2004).

Our probit results generally confirm the OLS results. For example, the REG variable is highly significant and of the hypothesized sign in all buy equations. In all sell equations it has the expected sign and is significant in all but one sell equation. The ERM variable is again positive and significant in the probit buy equations, and although not significant, it is of the expected negative sign in the sell equations. Generally consistent results were obtained for the variables WBMCC and HAPDUM. The DIP variable reveals more significance in the probit results for the years 2002 and 2003, indicating to us that those participants experiencing limited impacts of the recession (with high ratios) were first back in the market. Overall, our probit models suggest that we can have additional confidence in the primary OLS results.

Conclusion and Policy Recommendations

Our main theme has been that both maintenance and extension of traditional regulations before and during the four-year start-up period of the Chicago VOC cap-and-trade approach when combined with key market design features have constrained its performance and greatly limited its cost-effectiveness, innovation stimulation, and flexibility. Our HAPDUM variable when interpreted as a proxy for over-allotment was of the wrong sign. However, the signs are consistent with the hypothesis that the HAPDUM variable may be interpreted as another measure of the binding effect of traditional regulation. In this context we note that the HAPDUM coefficients are significant in two of the four years.

A basic difficulty of the over-allotment hypothesis is that participants appear to have made little effort to use any excess ATUs they might have had to cover emissions but allowed them to expire. More detailed data on individual emitter marginal costs and more information on transactions costs would be desirable, but we do not believe they would alter our results and conclusions. Nor do we believe that if the present cap-and-trade market were to continue without redesign would the picture be changed in the future. The enormous banks and low emission levels would continue to dominate the scene, resulting in more expirations and continuing low prices of ATUs.

Few, roughly 15% of all emitters, entered into transactions. This low percentage makes any estimate of control cost savings compared with traditional regulation an exercise in small numbers. Estimating savings without transactions due to the decentralization of decision-making seems another low-payoff exercise due to the massive emission reductions well before the start of the market.

It might well be asked whether the ERMS program is a decoration on the face of traditional regulation that serves little purpose other than to be in accord with the latest regulatory fashion. It was an innovative undertaking implemented at considerable effort with appreciable ingenuity by the Illinois EPA. The problem was the compromised design indicating how sensitive a cap-and-trade market can be to design features. Any reasonable benefit cost appraisal would point toward discontinuance of ERMS without loss in air quality. It was supposed to be an emissions reducing, cost-effective, innovation stimulating, and flexible tool, which it has not been by any evidence we have seen or been able to muster. Few, if any, large urban areas are likely to adopt such a facade.

Should ERMS be scrapped? We believe there are several good reasons to answer no to this question. It was an achievement of the Illinois EPA to pioneer in implementing the program, and now that it is in place and has received general acceptance, if not wholehearted approval, it can be the foundation for further improvement. There are several directions in which this improvement could take place.

One course of action would be to relax the traditional regulations in force or set them aside to make way for the market. However, neither the environmental community nor the regulating community would support such a relaxation.

Another course of action recognizes that the new national NOx control program nearing full implementation presents new opportunities. The Illinois EPA had chosen to participate in the US managed cap-and-trade program based on state NOx budgets. The relationship between these two major precursors of urban ozone, NOx and VOC emissions, is an important and complicated one. Reductions in NOx emissions call for a reexamination of the proper level of VOC emissions. This proper level is also affected greatly by a new public policy that calls for a new eight-hour standard for urban ozone concentrations, a reduction of about one third from the prior standard. These developments have important implications for a redesigned ERMS program.

A change of the cap is clearly a priority issue for redesign. However, the proper cap is not a simple calculation. It seems clear that a substantial tightening of the cap is in order. Building on the experience of the SO2 cap design, this could be accomplished in a series of steps. As more is learned about the relationship of NOx and VOC precursors to low level ozone concentrations, the caps could be set as an important part of the eight-hour attainment plan. Some revision of baselines that seem far in excess of realistic historical values might accompany the changed caps. Even though there has been a dramatic aggregate reduction in VOC emissions among the stationary sources now covered by the market, some emitters, especially those not deeply affected by traditional regulation, may resist such a cap tightening. It will be recalled that the distribution of emission reductions brought about by traditional regulation varies markedly among emitters. Revision of the banking horizon may provide a trade-off for these and other emitters.

Extension of the one-year banking horizon should improve inter-temporal decision making significantly. The environmental community may be concerned with inter-temporal spikes, which have not emerged in the aggregate data so far. However, there are other measures to deal with possible spikes, such as constraints on the use of banks if they mount to high levels. If an infinite horizon of tradable permits is unacceptable to environmental groups or the regulating community, an extension of three to four years after issuance could be a useful compromise. The present enormous banks could be converted to a new system by some discounting of existing banks. The business community is unlikely to complain about the loss of ATUs that will probably expire anyway.

The new cap, baselines, and banking horizon would be essential features of a more effective market. Tighter caps should appeal to the environmental community, as it would help to continue to curb temporal spikes and neighborhood hot spots. These hot spots have not materialized during the current episode, as documented by the agency and studied by a research group (Illinois EPA 2000-2003; Kosobud, Stokes, and Tallarico 2004). This market would take its rightful place among other cap-and-trade programs (Ellerman 2003). It could even participate in other areas of traditional regulation, as once envisioned, by stationary source emitters receiving tradable permit credits for reductions among mobile and small area sources. No such credits have yet been achieved.

There are other aspects of the market design that should be considered. More prompt and timely price information ought to be made available by the Illinois EPA. The electronic bulletin board was a good idea that was little used by buyers. More frequent summary price data could be supplied. Private brokers and others, including speculators, could be invited to publish their own data once a reinvigorated market was underway.

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