ET in LA: Looking Back to the Future

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Executive Summary

With the passage of the 1990 Clean Air Act, there has been a virtual explosion of potential applications for the use of economic instruments for environmental protection. The economics community has moved from the point of doing simulations on hypothetical problems to providing guidance on real-world applications. Examples include the use of credit systems to encourage the scrappage of high-polluting vehicles, reduce acid rain, restore the Everglades, limit greenhouse gas emissions and achieve air quality standards in Los Angeles.

The empirical literature on market-based approaches has attempted to keep pace with the heightened interest by providing an ongoing analysis and assessment of different policy experiments. Previous studies of market-based approaches for environmental protection have been hampered by a paucity of data, particularly at the level of individual firm response. Most available information has been highly aggregated. With the exception of case studies, there have been no details of the functioning of specific markets or of the nature of individual trades. A particularly serious problem has been the almost complete absence of price data.

This paper attempts to fill in critical gaps in our understanding of the performance of environmental markets by constructing and analyzing the most detailed information base to date on emissions trading (ET) in Los Angeles. Los Angeles was chosen for two reasons: first, because it is the area characterized by the greatest level of trading activity under emissions trading; and, second, because Los Angeles is implementing a more extensive marketable credits program called "RECLAIM." RECLAIM is being designed as this research is undertaken, and we are hopeful that insights developed here could be used in RECLAIM and other similar programs.

The analysis suggests that trading activity has been shaped by the detailed regulations governing the market. It also suggests that the various ERC markets

were not likely to be in a classical equilibrium state with a set of well-defined prices. A key factor that limits the efficiency of the ERC markets is the relatively high level of transaction costs associated with trading.

The move towards adopting market-based approaches for environmental protection needs to be accompanied by a vigorous effort to ascertain the properties of these systems as they are actually implemented. There is a great deal more that needs to be learned about environmental markets and taxes -- particularly the conditions under which they are likely to be successful. The introduction of policy experiments throughout the world could aid our understanding immensely.

In short, the good news is that the world is beginning to take the ideas of ivory-towered economists seriously in resolving environmental issues. The bad news is that the stock of usable knowledge in this area is a lot lower than we might like. The path to enlightenment is clear: further study of how such market-based approaches actually perform in practice.

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1. Introduction

Tradeable permits and pollution taxes have received widespread support from economists as ways for promoting environmental protection (Dales, 1968; Kneese and Schultze, 1975). Both of these tools represent ways to encourage businesses, governments and individuals to search for lower cost methods of achieving environmental standards. They stand in stark contrast to the more widely used "command-and-control" approach in which a regulator specifies the technology a firm must use to comply with regulations. Under highly restrictive conditions, it can be shown that both of the economic approaches share the desirable feature that any gains in environmental quality will be obtained at the lowest possible cost (Baumol and Oates, 1975).

Until recently, there has not been a great deal of interest in the use of economic instruments for environmental protection outside of academia. The 1990 Clean Air Act, which contained provisions for reducing acid rain using a tradeable permit approach, heightened general public awareness of market-based approaches. In this particular market, the Environmental Protection Agency (EPA) issues credits that would cut sulfur dioxide (SO_2) emissions in half by the turn of the century. A firm can only emit a ton of SO_2 if it has a credit. Thus, the total amount of pollution is limited by the number of credits. By allowing firms to trade these credits, this approach could save about $1 billion annually compared to more conventional technology-driven standards.

With the passage of the Act, there has been a virtual explosion of potential applications for the use of economic instruments for environmental protection

(Stavins, 1988; U.S. EPA, 1991; Repetto et al., 1992). The economics community has moved from the point of doing simulations on hypothetical problems to providing guidance on real-world applications. Examples include the use of credit systems to encourage the scrappage of high-polluting vehicles, reduce acid rain, restore the Everglades, limit greenhouse gas emissions and help achieve air quality standards in Los Angeles.

The empirical literature on market-based approaches has attempted to keep pace with the heightened interest by providing an ongoing analysis and assessment of different policy experiments. Perhaps the most noteworthy of the tradeable permits experiments prior to the implementation of the acid rain trading scheme was the EPA's emissions trading (ET) policy. This policy was designed to allow greater flexibility in achieving environmental standards. As several authors have noted, its performance has fallen far short of the economist's ideal (Dudek and Palmisano, 1988; Hahn and Hester, 1987).

Previous studies of market-based approaches for environmental protection have been hampered by a paucity of data, particularly at the level of individual firm response. Most available information has been highly aggregated. With the exception of case studies (Liroff, 1986), there have been no details of the functioning of specific markets or of the nature of individual trades. A particularly serious problem has been the almost complete absence of price data.

This paper attempts to fill in critical gaps in our understanding of the performance of environmental markets by constructing and analyzing the most detailed information base to date on the emissions trading market in Los Angeles. The analysis provides new findings on the nature of how rules affect market behavior and how transaction costs affect trading patterns. It is the first information base that includes micro-level data on firm prices.

Los Angeles was chosen for two reasons: first, because it is the area characterized by the greatest level of trading activity under emissions trading; and, second, because Los Angeles is implementing a more extensive marketable credits program called "RECLAIM."[1] RECLAIM is being designed as this research is undertaken, and we are hopeful that insights developed here could be used in RECLAIM and other similar programs.

The remainder of this paper is structured as follows: Section 2 briefly reviews the literature and provides the institutional context for the market under study. Section 3 presents the main empirical findings. Broader implications of the analysis for market design are examined in Section 4. Section 5 highlights the main findings of the study and suggests areas for future research.

2. Environmental Markets and Emissions Trading in Los Angeles

The virtues of environmental markets and pollution taxes are well understood in theory (Pigou, 1932; Montgomery, 1972; Tietenberg, 1985). Compared with a centralized solution, markets or taxes have the potential to achieve a given environmental outcome at lower cost. An understanding of how these instruments perform in actual practice is just beginning to emerge (Opschoor and Vos, 1989; Moore et al., 1989; Anderson et al., 1990). There are three general insights from this literature. First, the rules governing trading can have a dramatic impact on transaction costs and, hence, the efficiency and equity characteristics of the market (Hahn and Noll, 1982; Franciosi et al., 1993). Second, politics plays an important role in determining the structure and performance of markets and taxes (Hahn, 1989). Third, the support of the bureaucracy charged with implementing the program is

[1]RECLAIM stands for Regional Clean Air Incentives Market (SCAQMD, 1992).

frequently crucial for the success of the program (Hahn and Noll, 1990).

EPA's emissions trading policy, which this study examines, represents the oldest and most far-reaching attempt to implement a marketable permit system. The program operates nationwide and covers all significant stationary sources of pollution for five principal air pollutants -- hydrocarbons (ROG)[2], nitrogen oxides (NO_x), particulate matter (PM), sulfur oxides (SO_x) and carbon monoxide (CO).

The commodity that is exchanged under emissions trading is referred to as an "emission reduction credit" (ERC). Credits can be created by lowering emissions below the regulatory standard as a result of a process change, such as burning a cleaner fuel. Credits can also be created as a result of a shutdown either when a plant closes or a particular piece of equipment is no longer operated. ERCs are typically issued in terms of quantity of pollutant reduced per unit time. An ERC could give the holder the right to emit 1 ton per year of the stated pollutant, so long as the ERC is valid.[3] ERC trades typically involve "stationary" sources, such as utilities and refineries, but trading credits with "mobile sources," such as cars, is permitted.[4]

Emissions trading has four distinct elements. Netting, the first program element, was introduced in 1974. Netting allows a firm that creates a new source of emissions in a plant to avoid the stringent emission limits which would normally

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[2]ROG stands for reactive organic gases, which is the acronym currently used in Los Angeles for reactive hydrocarbons.

[3]Note that this does not give the buyer the right to do so in perpetuity as rules can change.

[4]This is covered in Rule 1306 (h), Regulation XIII, SCAQMD (1991). However, the scope is limited to ships and in-plant vehicles. The California Air Resources Board (1993) provides guidelines for the generation of mobile source ERCs through activities such as scrappage and low-emission bus programs.

apply by reducing emissions from another source in the plant. Thus, net emissions from the plant do not increase significantly. A firm using netting is only allowed to obtain the necessary emission reduction credits from its own sources. This is called "internal trading" because the transaction involves only one firm.

Offsets, the second element of emissions trading, are used by new emission sources in "non-attainment areas." A non-attainment area is a region that has not met a specified ambient standard. The Clean Air Act specified that no new emission sources would be allowed in non-attainment areas after the original 1975 deadlines for meeting air quality standards passed. Concern that this prohibition would stifle economic growth in these areas prompted EPA to institute the offset rule. This rule specified that new sources would be allowed to locate in non-attainment areas, but only if they "offset" their new emissions by reducing emissions from existing sources by even larger amounts. The offsets, or ERCs, could be obtained through internal trading, just as with netting. However, they could also be obtained from other firms directly, which is called "external trading."

Bubbles allow existing sources to trade emission reduction credits. The name derives from the placing of an imaginary bubble over a plant, with all emissions exiting at a single point from the bubble. A bubble allows a firm to sum the emission limits from individual sources of a pollutant in a plant, and to adjust the levels of control applied to different sources so long as this aggregate limit is not exceeded.

Banking, the fourth element of emissions trading, allows firms to save emission reduction credits. While EPA action was initially required to allow banking, the development of banking rules and the administration of banking programs has been left to the states.

The emissions trading program has afforded many firms greater flexibility in meeting emission limits, resulting in substantial cost savings. Based on available data, $1 billion would be a lower bound estimate for cost savings, but a more reasonable estimate would be in the range of $5 to $10 billion. Interestingly, these cost savings have been realized primarily from trading emission reduction credits within particular firms, such as between two generation plants owned by the same utility. Far greater savings could have been realized if there had been more trading between firms.

EPA's program allowing lead trading stands in stark contrast to the emissions trading program for air pollution. It comes much closer to the economist's ideal of a freely functioning market. The purpose of the lead trading program was to allow gasoline refiners greater flexibility during a period when the amount of lead in gasoline was being significantly reduced. The success of the program is difficult to measure directly. It appears to have been quite successful in meeting its environmental targets. Moreover, EPA estimated that savings resulting from the lead trading program would be approximately $200 million annually.

3. Results

Table 1 provides an overview of emissions trading activity in the Los Angeles basin since 1974. It includes offset and netting activity.[5] From the early 1980s the netting program has involved between 200 to 500 transactions annually. Offsetting activity began in the mid-1980s. Although the annual number of transactions is small in comparison with netting, the total volume of pollutants exchanged under the offset program exceeds that under the netting program, which has been in

[5]Offset activity includes trading from the bank. There is no precise estimate for bubbles, but one estimate suggests that there were on the order of 200 bubbles over the last decade (SCAQMD, 1993).

Table 1

Overview of Emissions Trading Activity (Number of Transactions)

Year	Offsets	Netting	Total
pre-1977	-	2	2
1977	-	40	40
1978	-	33	33
1979	-	72	72
1980	-	129	129
1981	-	238	238
1982	-	210	210
1983	-	258	258
1984	-	256	256
1985	7	236	243
1986	27	432	459
1987	24	330	354
1988	55	358	413
1989	29	352	381
1990	27	394	421
1991	2,234	155	2,389
Total	2,403	3,495	5,898

Source: SCAQMD (1993)

operation for much longer. In both cases the total volume of pollutants exchanged since the beginning of each program is on the order of 10,000 tons per year. The most commonly exchanged pollutants are NO_x (in the case of netting) and ROG (in the case of offsets). In each case, these pollutants account for over half of the volume traded.

The vast majority of external trades of ERCs under the emissions trading program have been in offsets. We focus on the offset program because it most closely resembles the economist's notion of a market in which there are arm's length transactions. The availability of detailed, disaggregated data on a relatively large number of external transactions in pollution permits makes it possible to examine how markets for these kinds of assets operate in practice, and to link changes in specific rules and institutions to market outcomes.

The offset market exists primarily to facilitate the transfer of pollution rights between new sources and sources which are closing down or reducing their emissions. It has evolved from, and continues to be embedded in, a traditional command-and-control regulatory framework. This framework requires firms to hold operating permits for each source of emissions that define rules of operation for equipment. In addition, the level of permitted emissions for each source category is determined by a comprehensive body of source-specific technology-forcing rules. In the case of new sources, the prescribed level is that of Best Available Control Technology.[6]

The Los Angeles basin has had the most active offset market under the EPA's emissions trading program. This degree of activity can be attributed to a combination of factors. First, the rapid economic growth experienced in the South Coast basin, where gross regional product growth has exceeded gross domestic

[6]See Rule 1303, Regulation XIII, New Source Review, SCAQMD (1991).

product growth every year in the relevant period means that there has been a relatively high level of demand for offsets. Second, the emission thresholds for offsetting have consistently been set significantly lower than those in the rest of the country due to the region's failure to meet the National Ambient Air Quality Standards required by the Clean Air Act. The high level of growth combined with the lower thresholds has resulted in a relatively large number of new sources that each require a relatively large number of ERCs.

This section uses the data from the Los Angeles market to analyze the pattern of trades that took place. As well as uncovering new insights on the functioning of the market, the discussion attempts to test conjectures made in earlier work on this subject before the data required to test them were available. The findings are grouped thematically according to whether they are primarily concerned with the rules governing trade, the determination of prices, or the impact of transaction costs on trading.

3.1 The Data

Trading data are derived from two sources: AER*X, the principal broker in the Los Angeles market, and the South Coast Air Quality Management District, the regulatory body for the Los Angeles basin (AER*X, 1992; SCAQMD, 1993). AER*X (1992) provides information on the year of the trade, the amount traded of the particular pollutant, whether AER*X acted as an intermediary, and in some cases the price of the trade. SCAQMD (1993) records ERCs deposited in and traded from the SCAQMD bank. In each case, information is provided on the amount of the particular pollutant, the method by which it was produced, and the dates on which it was deposited and subsequently traded. Previous studies have only used information up to 1986 (Hahn and Hester, 1987; Dudek and Palmisano, 1988). This

analysis focuses on the period 1985-91, which follows the Los Angeles market through its most active years.[7]

Table 2 provides a breakdown of offset transactions between trades and withdrawals from two special funds created by the SCAQMD. In the six-year period 1985-91, 11,583 tons of pollutants per year have been traded in the offset program, and total expenditure on ERCs is estimated at $1.7 billion. There have been 200 trades involving 129 firms. Most of the trades involve firms that have engaged in at least two exchanges. The two special funds established in 1991 are the Community Bank, which caters to small sources producing less than 2 tons per year, and the Priority Reserve, which secures a source of credits for essential public services. Both funds allocate credits on a monthly basis. In the Community Bank the allocation of credits is in inverse order to the volume of credits requested, whereas the Priority Reserve rations on the basis of how essential the public service is deemed to be. In the first year of their operation, the volume of pollutants offset from these two special funds exceeded the volume traded in the offset market. Because these special funds do not involve exchanges of credits between firms, they are not a central focus of this analysis. The funds do affect the offset market, however, by providing an incentive for some small firms not to participate in the offset market.

Trading activity for 1985 through 1991 is summarized in Table 3 for each of the five pollutants. The first part of the table summarizes trading in terms of the number of trades, and the second part summarizes trades in terms of the number of tons of a pollutant that are traded per year. The table shows that from 1986 onwards, most of the trades involved ROG. Over three-fourths of the trades in these years involve ROG. In terms of the quantity of ERCs traded per year, this same pattern

[7]Although some information is available for 1992 and 1993, it is incomplete, and thus not included here. The information relates only to trades conducted through the SCAQMD bank, and therefore does not provide a comprehensive picture of trading activity in those years.

Table 2

Offset Activity by Number and Volume of Transactions

Number of Transactions

Year	Trades	Community Bank	Priority Reserve	Total
1985	7	-	-	7
1986	27	-	-	27
1987	24	-	-	24
1988	56	-	-	56
1989	30	-	-	30
1990	26	-	-	26
1991	30	2,139	64	2,233
Total	200	2,139	64	2,403

Volume of Transactions[1]

Year	Trades	Community Bank	Priority Reserve	Total
1985	839	-	-	839
1986	946	-	-	946
1987	2,621	-	-	2,621
1988	2,821	-	-	2,821
1989	1,292	-	-	1,292
1990	649	-	-	649
1991	994	1,188	42	2,224
Total	10,162	1,188	42	11,392

[1]In tons per year.

Source: SCAQMD (1993)

Table 3

Composition of Pollutants Traded
1985-1991

Number of Trades

Year	CO	NO_x	PM	ROG	SOX	Total
1985	-	5	-	2	-	7
1986	2	5	2	15	3	27
1987	-	2	1	21	-	24
1988	2	2	5	46	1	56
1989	-	5	-	25	-	30
1990	-	4	1	21	-	26
1991	3	6	2	17	2	30
Total	7	29	11	147	6	200

Volume of Trades[1]

Year	CO	NO_x	PM	ROG	SOX	Total
1985	-	776	-	63	-	839
1986	2	236	11	582	115	946
1987	-	43	52	2,526	-	2,621
1988	203	896	28	1,692	2	2,821
1989	-	258	-	1,034	-	1,292
1990	-	51	6	592	-	649
1991	36	58	14	877	9	994
Total	241	2,318	111	7,366	126	10,162

[1]In tons per year.

Source: AER*X (1992), SCAQMD (1993)

emerges. ROG and NO_x are the only pollutants that are traded in every year of the period.

Trading prices are known for 48 of the trades. Over 90% of all trades for which prices are available were intermediated by AER*X.[8] Price data are available for 27 ROG trades and 14 NO_x trades. The ROG transactions for which prices are known represent 18% of all external trades in this pollutant. The subsequent analysis focuses primarily on ROG because of the available data on prices and because ROG trades represent three quarters of all offset trades in Los Angeles.

Average price information is summarized in Table 4 for ROG and NO_x, the two most frequently traded pollutants. Prices are stated in terms of dollars per ton per year. The going price represents the price to emit one ton per year of the pollutant for as long as the regulations are relevant.[9] Two methods are used to compute average prices -- the first weighted by trades and the second weighted by the amount traded.[10] All subsequent price averages used here are weighted by trade as opposed to the quantity traded at a particular price.

The table shows that prices range from less than $100 to over $700 per ton per year for ROG, with a slightly smaller range for NO_x. Prices exhibit wide variation within and across years. For example, the lowest price for ROG in 1991 was $43

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[8]It is possible that this might, in itself, introduce some bias into the price data, particularly since AER*X represents sellers of ERCs almost exclusively. The cost of intermediation might serve to raise the price of AER*X trades. In addition, if buyers were less informed than the intermediary, who presumably knew previous trading prices, this could raise the price, since the intermediary represented sellers.

[9]In actuality, many permits place daily limits on emissions, typically in pounds per day. Tons per year are used here because this is a common unit used in the literature.

[10]Statistical tests use the first measure of average price, since this is the more appropriate unit of observation.

Table 4

Summary of Real Trading Prices for ROG and NO_x
($ per ton per year in 1992 dollars)

Year	Priced Trades[1]	Average Price (1)[2]	Average Price (2)[3]	Standard Deviation	Range
ROG					
1985	1 of 2	80	80	-	-
1986	4 of 15	85	100	31	45-133
1987	3 of 21	115	146	37	69-160
1988	5 of 46	90	93	24	51-116
1989	6 of 25	220	232	74	67-304
1990	2 of 21	165	145	117	68-262
1991	6 of 17	318	111	214	43-712
Total	27 of 147				
NO_x					
1985	4 of 5	195	195	80	118-318
1986	3 of 5	183	169	88	115-308
1987	0 of 2	-	-	-	-
1988	1 of 2	105	105	-	-
1989	1 of 5	111	111	-	-
1990	2 of 4	427	424	10	416-437
1991	3 of 6	446	468	195	183-655
Total	14 of 29				

[1]Trades for which price data were available.
[2]Average Price (1) = Sum of unit prices of each trade per number of trades.
[3]Average Price (2) = Sum of total value of each trade per total volume traded.

Source: AER*X (1992)

while the highest price was $712.

Data on banking activity were obtained from the SCAQMD (1993). Table 5 summarizes banking activity. As the table shows, 66 ERCs had been deposited in the bank by 1990, amounting to about 8,100 tons per year. Of these, 28 had been used in subsequent trades, amounting to about 2,600 tons per year. Banked trades represent 15% of the total number of trades carried out over this period.

The subsequent analysis uses the data on offset trades to examine a number of conjectures about the operation of a tradeable permits market. These conjectures draw extensively on existing literature. The number of available observations in this dataset is small in absolute terms, particularly where prices are concerned. This placed significant restrictions on the type of statistical analysis that could be performed. Accordingly, two parallel methodological approaches are adopted in the subsequent discussion.

Initially, the emphasis is on discerning relationships that are visible in the data. The fact that the dataset is comprehensive, with the exception of price data, lends some legitimacy to this approach. Where possible, these relationships are analyzed more rigorously using a variety of non-parametric hypothesis tests. Non-parametric tests are chosen because of the relatively undemanding nature of the maintained assumptions (Daniel, 1990). The results of these tests are summarized in Table 6. A 5% significance level is used to accept or reject the various hypotheses. The reader is advised to interpret the results of these tests with caution. In some cases, the small number of observations puts considerable strain on their statistical validity. A further objection is that the sample of trades for which prices are available was not obtained in a truly random fashion.

Table 5

Summary of Activity in the SCAQMD Bank

	ERCs Banked		Banked ERCs Traded	
Year	Number	Quantity (tons/year)	Number	Quantity (tons/year)
pre-1985	14	1,070	0	0
1985	7	213	1	27
1986	9	1,808	1	53
1987	5	579	6	1,679
1988	8	1,001	7	398
1989	15	1,319	10	422
1990	8	2,129	3	48
Total	66	8,119	28	2,627

Source: SCAQMD (1991)

Table 6

Summary of Results of Non-Parametric Hypothesis Tests

Number	Hypothesis	Test	N	DF	Result[1]
H1	The majority of trades involving shutdown-created credits were unbanked.	Palmisano (1992) estimate	-	-	Accept
H2	Once banked, shutdown-created credits were less likely to be traded than those created by process change.	Chi-squared test for homogeneity	74	1	Accept
H3	When traded, banked shutdown-created credits had been deposited for a shorter period than those created by process change.	Mann-Whitney test	30	22, 8	Reject
H4	The number of trades making use of banked credits was lower prior to 1991, when the contemporaneous requirement was in force.	Chi-squared test for homogeneity	200	1	Accept
H5	Price dispersion of ROG credits increased after 1990 as a result of the geographical segmentation of the market.	Moses test	28	4, 2	Accept
H6	The level of prices increased after 1990.	Mann-Whitney test	28	21, 7	Accept
H7	The dispersion of prices decreases with time as the market evolves.	Spearman rank correlation test	6	6	Reject
H8	The dispersion of prices is lower in years when the market is relatively active.	Spearman rank correlation test	6	6	Reject
H9	Annual minimum prices are uncorrelated with average prices.	Spearman rank correlation test	6	6	Accept
H10	Annual maximum prices are correlated with average prices.	Spearman rank correlation test	6	6	Accept
H11	Average ROG prices are correlated with regional per capita income.	Spearman rank correlation test	6	6	Reject
H12	Thinly traded pollutants are more likely to be traded internally.	Chi-squared test for homogeneity	177	4	Accept
H13	Thinly traded pollutants are more likely to be traded from the bank.	Chi-squared test for homogeneity	129	4	Reject
H14	Exchanges of thinly traded pollutants are more likely to involve AER*X.	Chi-squared test for homogeneity	129	4	Reject
H15	Thinly traded pollutants are more likely to be traded in multi-pollutant clusters.	Chi-squared test for homogeneity	153	4	Accept
H16	Small trades are more likely to be traded internally.	Chi-squared test for homogeneity	201	7	Reject
H17	Small trades are more likely to be traded through the bank.	Chi-squared test for homogeneity	153	7	Reject
H18	Small trades are more likely to involve AER*X.	Chi-squared test for homogeneity	153	7	Reject
H19	Small trades are more likely to be in a "multi-pollutant cluster."	Chi-squared test for homogeneity	153	7	Accept

[1]A 5% significance level for formal hypotheses is used to determine "accept" or "reject." "N" stands for number of observations and "DF" stands for degrees of freedom.

3.2 The Impact of Rules on Trading Activity

Trading activity in the Los Angeles offset market is heavily regulated by the SCAQMD. The regulatory environment affecting ERCs in Los Angeles is a dynamic one with frequent rule amendments. For example, Regulation XIII, which governs the exchange of ERCs in the offset market, has seen 59 rule changes over twelve years, with the longest amendment-free period lasting no more than two years and three months (SCAQMD, 1991). Undoubtedly, the most significant reform episode experienced in the Los Angeles market took place in June 1990, and came into effect in September of that year. This episode, which saw the abolition of some rules and the introduction of others, provides an opportunity to examine how rule changes affect market activity by comparing the trading data before and after this date.

The Contemporaneous Requirement

The contemporaneous requirement confined exchange of shutdown-created credits to those firms that had filed applications to trade within 90 days of the shutdown having taken place.[11] This effectively ruled out the possibility of trade once a shutdown-created credit had been banked for a few months. The contemporaneous requirement was abolished as part of the June 1990 reforms. At the same time all banked ERCs that had resulted from an earlier shutdown were reduced to 20% of their face value. As a result, firms were left with 20% of a saleable ERC as opposed to 100% of one which had been rendered virtually unsalable due to the contemporaneous requirement. The devaluation of the banked ERCs illustrates the uncertain nature of the property right they embody.

The contemporaneous requirement could be expected to have any of four effects on market activity. They are listed below as formal hypotheses, designated

[11]Rule 1308, Regulation XIII, New Source Review, SCAQMD (1991).

using the letter "H."

H1 The majority of trades involving shutdown-created credits were unbanked.

H2 Once banked, shutdown-created credits were less likely to be traded than those created by process change.

H3 When traded, banked shutdown-created credits had been deposited for a shorter period than those created by process change.

H4 The number of trades making use of banked credits was lower prior to 1991, when the contemporaneous requirement was in force.

H1 cannot be formally tested, since the dataset does not comprehensively record the method by which individual credits were created. However, a key market participant indicated that the vast majority of unbanked trades involved shutdown-created credits.[12]

The second hypothesis (H2) is confirmed by the data from the SCAQMD bank. Of 65 ERCs banked over the period 1983-90, 34 were the result of shutdown and 31 the result of process change. That is to say that about half were of each type. However, of the 26 exchanges of banked credits that took place prior to the abolition of the contemporaneous requirement, only 6 involved shutdown-created credits. The other 20 were from process change. Thus 18% of all banked ERCs created from shutdown were traded, as against 65% of all banked ERCs created from process change. The statistical significance of this difference is confirmed by the chi-squared

[12]John Palmisano (1992) estimated that at least 95% of unbanked trades involved shutdown-created credits.

test for homogeneity (see Table 6).

One explanation for this pattern is that the contemporaneous requirement made it harder to trade shutdown-created credits once they had been banked. If that was indeed the case, one would expect all trades of shutdown-created credits to occur within a comparatively brief period of their deposit in the bank. Process change credits on the other hand might be deposited for longer periods before a trade took place (H3). The dataset indicates that shutdown-created credits were deposited on average for 179 days prior to trade. The corresponding figure for process change-created credits was 409 days. Although the raw data appears persuasive, the Mann-Whitney test did not confirm the statistical significance of this difference.

The fourth hypothesis (H4) is strongly supported both by observation, and by the corresponding hypothesis test. At the time of the June 1990 reforms, over 11,500 tons per year of shutdown-created ROG credits were lying "dormant" in the SCAQMD as a result of the contemporaneous requirement. Although the June 1990 reforms reduced the size of shutdown-created banked ERCs to 80% of their face value, they brought the remaining 20% back into supply by simultaneously abolishing the contemporaneous requirement. For example, in the case of ROG, over 2,700 tons per year of credits became available. The data show that, both in absolute and percentage terms, 1991 is the year with the highest level of trades involving banked ERCs. The statistical significance of this difference is confirmed by the result of the chi-squared test for homogeneity.

In summary, the evidence indicates that shutdown-created credits were less likely to be banked than process change-created ones, and once banked they were less likely to be traded. This seems partly attributable to the shorter time period available for the identification of a trading partner. As a result, the SCAQMD bank made a smaller contribution to market activity during the years when this

regulation was in force. The contemporaneous requirement meant that 4,000 tons per year of shutdown-created-credits were left in the bank during the life of the requirement.[13]

The Geographical Segmentation of Markets

The June 1990 reforms had the effect of removing the segmentation of the market between shutdown-created credits, which were subject to the contemporaneous requirement, and process change-created credits, which were not. However, in its place the reforms introduced a more formal geographic segmentation of the market. Up to 1990, trades between geographically distant partners had been permitted, but penalized by means of a trading ratio that varied between 1.2:1 and 1.6:1. After June 1990, the basin was divided into 38 distinct zones and firms were only allowed to sell ERCs to downwind trading partners; hence, the direction of transactions has been restricted from west to east.[14] This reform was motivated by the desire to prevent any trade from leading to a deterioration in air quality in the zone from which it was carried out.

It is hypothesized that this reform had the following effect on the market:

H5 Price dispersion of ROG credits increased after 1990 as a result of the geographical segmentation of the market.

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[13]The contemporaneous requirement also could be expected to affect the price of credits, though the predicted direction of this change is ambiguous. On the one hand, the reduced availability of credits could be expected to put upward pressure on price. On the other hand, the time limit imposed by the contemporaneous requirement probably made holders of shutdown-created credits more willing to trade at a lower price. Unfortunately, the overall impact on price could not be tested because the data for priced trades did not record the means by which the credit was created.

[14]Rule 1303(b) and Appendix B of Rule 1303, Regulation XIII, SCAQMD (1991).

This hypothesis is confirmed by the Moses test and a casual inspection of Figure 1, which plots average, minimum and maximum ROG price through time. Between 1990 and 1991 there was over a three-fold increase in the difference between the maximum and minimum price. It is likely that this increase was due at least in part to the geographical segmentation of the market.[15]

There are at least two reasons why such a reform could increase the range of prices observed in the market. First, by creating a large number of segmented markets, the reform created a large number of different supply and demand conditions in each one. Second, the reform converted an already thin market into a set of thinner markets, thus making it less likely that a stable set of prices would emerge for ERCs. The move towards geographical segmentation can be justified in environmental terms, for the case of pollutants whose environmental impacts are location-specific. However, the consequent impact on price dispersion illustrates the problems that such segmentation can place on the operation of a tradeable permits market.

Lowering Offset Thresholds and the Abolition of the Contemporaneous Requirement

The regulatory reforms of June 1990 included measures that would increase both the supply of and the demand for ERCs. The availability of credits, which had previously been removed from circulation owing to the operation of the contemporaneous requirement, had the effect of increasing the supply of credits. Acting against this was the new requirement that subsequent emissions reduction would have to undergo adjustment to the Best Available Control Technology before certification would be possible. This change made it harder for firms to produce

[15]The paucity of data along with the limited degrees of freedom make it difficult to draw categorical conclusions here.

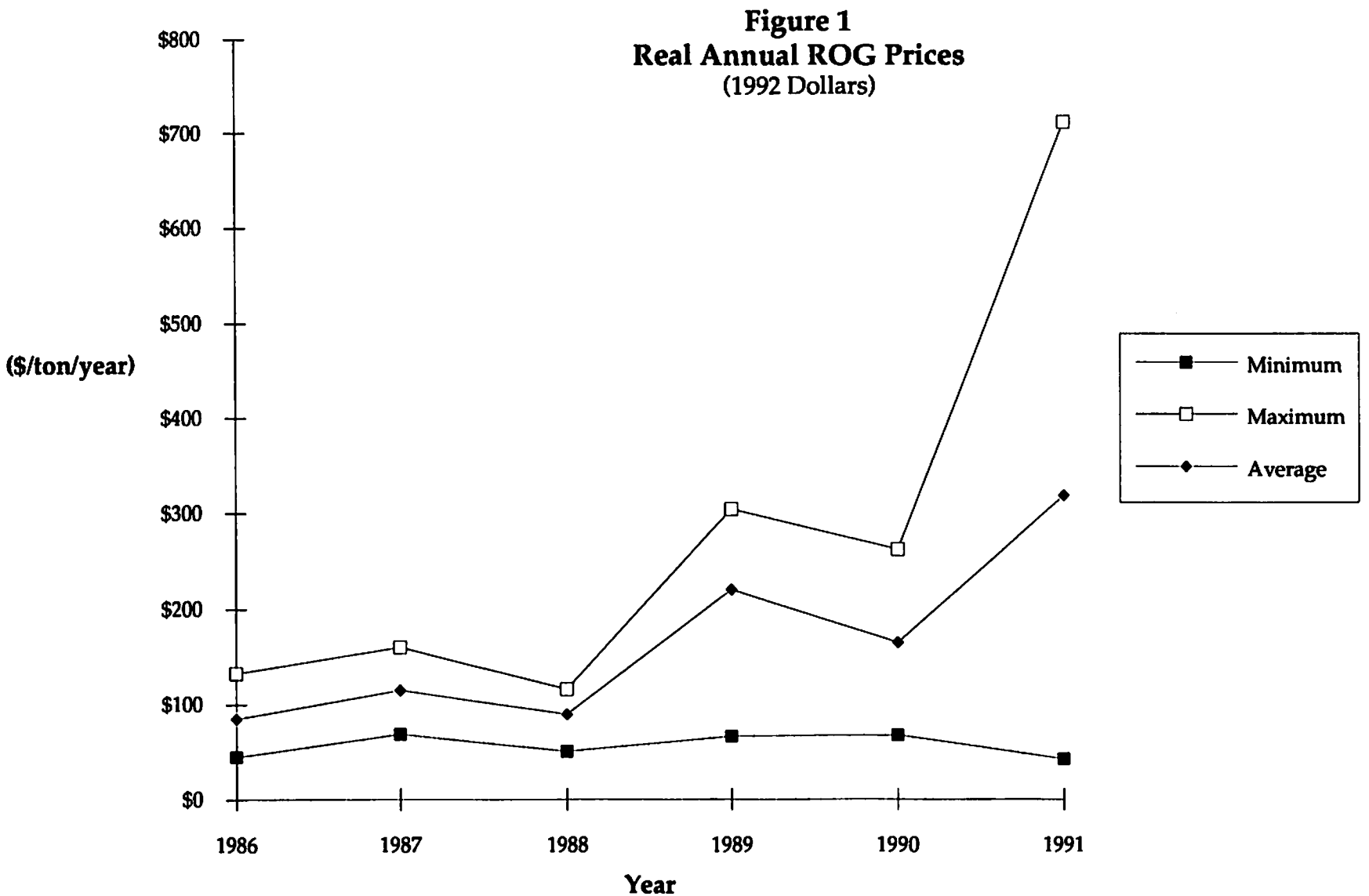
Figure 1
Real Annual ROG Prices
(1992 Dollars)
($/ton/year)
$800
$700
$600
$500
$400
$300
$200
$100
$0
1986
1987
1988
1989
1990
1991
Year
Minimum
Maximum
Average

ERCs by means of overcontrol. On the demand side, the principal effect was brought about by reducing the threshold level of emissions to which the offset regulations apply to zero. Previously, smaller sources had been exempted from the offset requirement altogether. This new rule was to be applied retroactively as well as prospectively, so that whenever a source engages in any new offset transaction, it will be required to offset any past emissions that had previously been exempted under the higher offset threshold.[16]

The price data provide a way of distinguishing which of these two effects was the most significant. If demand increased by more than supply, one would expect to see a rise in the market price, and conversely. This observation gives rise to the following hypothesis:

H6 The level of prices increased after 1990.

Once again, this hypothesis can be confirmed both visually, by the plot of average prices in Figure 1, and statistically, using the Mann-Whitney test. The real average price of ROG credits nearly doubled between 1990 and 1991, while the real maximum price observed in the market almost tripled over the same period. In the case of NO_x, the jump in real average price comes somewhat earlier, with a fourfold increase in price between 1989 and 1990. The higher price level is sustained in 1991. For the other pollutants the very small number of price observations make the overall picture far more sketchy. Broadly speaking, however, the same pattern can be observed. In 1991, PM traded at nine times its average price in 1986 while CO prices increased by about 45% from 1986 to 1991. Although this result provides some evidence for a net increase in demand resulting from the reduction of the offset threshold in the June 1990 reforms, it could also be explained in terms of the geographical segmentation of the marketplace.

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[16]See Rules 1303(b) and 1306(g), Regulation XIII, SCAQMD (1991).

3.3 Price Behavior of ERCs

The availability of price data on individual trades offers a unique opportunity to study the pattern and behavior of prices. Here, we highlight interesting patterns in the data and offer explanations for some of the observed patterns.

Price Dispersion

One of the problems with implementing a market in tradeable permits is establishing early price signals (Hahn and Noll, 1982). Where such a market is not established as the outcome of some kind of auctioning process, there is likely to be considerable uncertainty among firms as to the price at which assets should be traded. The absence of a formal centralized exchange mechanism gives rise to two related hypotheses:

H7 The dispersion of prices decreases with time as the market evolves.

H8 The dispersion of prices is lower in years when the market is relatively active.

H7 states that price dispersion decreases over time; however, using standard deviation as a measure of dispersion, the Spearman rank correlation coefficient does not support this hypothesis. This result can also be seen by inspection of Figure 1. Leaving aside 1991, when dispersion was increased by the geographical segmentation of markets, the span of real ROG prices has increased and decreased over the years 1986 to 1990. The difference between minimum and maximum price between 1986 and 1990 averages about $135 per ton per year, with the minimum

price being as low as 20% of the maximum price. One explanation for this pattern is that price dispersion may be more closely connected to the number of trades taking place in any given year, rather than to the passage of time (H8). However, the Spearman rank correlation coefficient does not support this hypothesis either.

The pattern of price dispersion up to 1990 cannot therefore be explained either by learning effects related to the passage of time, or by the volume of transactions in the market in any given year. The existence of a wide range of prices for the same commodity at any one time probably owes much to the heterogeneity of ERCs as commodities. Credits differ in a number of important respects. First, there is the issue of whether they have been created by shutdown or process change. Second, there is the issue of whether or not they have been deposited in the bank. Third, there is the degree of geographical separation between trading partners which affected the trading ratio up to 1990. Fourth, there is the variety in the details of the contract governing the trade. In particular, these differ as to the manner in which risk is allocated between the two trading parties.[17]

Minimum Price Levels

The most puzzling feature of the price data illustrated in Figure 1 is the fact that the minimum observed market price for ROG stays virtually constant in real terms over the entire period. In spite of credit heterogeneity and regulatory reform, the minimum price falls in the range \$40-\$70 per ton per year, irrespective of the movements in the maximum price, which ranges from \$115 to over \$700 per ton

[17]For example, consider a situation where two trading partners initially agree on a price of \$100 for 100 tons per year of NO_x, but where the regulator decides that only 80 tons per year of emissions in fact qualify as having been reduced for the purposes of issuing an ERC. A number of contractual arrangements are possible. If the buyer continues to pay \$100, but receives only 80 tons per year of ERC, then he has effectively borne the risk involved in the transaction. If on the other hand, the price were scaled down to \$80 for the 80 tons per year exchange, then the seller would be bearing the full risk. Clearly a number of intermediate arrangements are possible, where the risk is shared differently between the two parties.

per year.[18] This pattern gives rise to the following hypotheses, which are confirmed by the Spearman rank correlation coefficient:

H9 Annual minimum prices are uncorrelated with average prices.

H10 Annual maximum prices are correlated with average prices.

H9 suggests a reservation price that is invariant to market conditions. This could represent the minimum price that covers the transaction cost associated with creating and trading an ERC.

Price and Local Economic Conditions

It seems plausible that the price at which ERCs trade could be affected by the conditions of the local economy. Good economic conditions will create both a high demand for ERCs and a low supply of ERCs. More new sources are likely to open and fewer firms will be reducing output or shutting down. Both of these effects would put upward pressure on price. The greater reliance on process change-created credits during periods of high economic activity might also be expected to raise price, due to the operation of the contemporaneous requirement. This gives rise to the following hypothesis:

H11 Average ROG prices are correlated with regional per capita income.

While the hypothesis is plausible, it is not supported using a Spearman rank correlation coefficient. This absence of a relationship may be attributable to the paucity of data.

[18]Unfortunately there is insufficient price data to detect whether the same is true for other pollutants.

3.4 The Impact of Transaction Costs

Earlier literature suggests that the transaction costs of engaging in a trade will be high, and may therefore act as a disincentive for participating in the market (Hahn and Hester, 1989). High transaction costs are likely to reduce the number of mutually beneficial transactions, and thereby reduce the number of trades that take place.

An analysis of offset exchanges under emissions trading reveals that there are two distinct stages involved in completing a trade. The first stage involves identifying a suitable trading partner, and can take anywhere from a day to a year and a half. The process is marked by considerable uncertainty. Half of all proposed trades fall through during the negotiation process. Under emissions trading the problem of identifying a trading partner is compounded by the large number of potential traders relative to the number of trades taking place each year, and by the wide range of industries involved. Hahn and Hester (1989) attribute part of the success of the lead rights scheme to the fact that all the firms came from the same industry and were therefore accustomed to doing business with each other.

There are, however, a number of devices that firms can use to speed up the process of identifying a trading partner, and reduce the risks of the negotiations falling through at an early stage. First, a firm may circumvent the search process altogether by trading internally. About a quarter of all trades in the dataset were of this kind. Second, a firm may obtain a list of the credits deposited in the SCAQMD bank and identify a suitable trading partner there. Third, a firm may approach an intermediary. The principal intermediary in the market is the brokering firm AER*X, which was established in 1984 and has dealt with over 40% of all trades. In

80% of cases, AER*X represents sellers of ERCs (Palmisano, 1992). In addition to AER*X, there are a few attorneys in Los Angeles who act as intermediaries. While reducing search costs, the use of an intermediary will increase the financial costs of trading. Brokerage fees are levied in proportion to the value of the trade at a rate that can vary between 4% and 25%, depending on the complexity of the transaction. Where firms are seeking to exchange a number of different pollutants, a fourth method of reducing search costs is to identify a trading partner with a similar range of needs so that a "multi-pollutant cluster" of credits may be exchanged. "Multi-pollutant clusters" are defined as a series of trades between two firms in the same year (or two contiguous years) involving more than one pollutant. Such "clustering" avoids the need to find a number of different trading partners, one for each of the pollutants concerned.

Once a suitable trading partner has been identified, the second stage in the exchange process is to obtain bureaucratic approval from the SCAQMD, which usually takes between five and twelve months. This stage in the process can entail significant financial costs, which tend to be fixed with respect to the size of the trade. Administrative fees to the regulatory body can amount to $2,900 per trade. Additional administrative fees are levied for certifying ERCs ($1,700), banking them ($900), and reissuing them in smaller units ($900). In addition firms can incur between $7,500 to $15,000 for the preparation of the substantial supporting documentation required for a trade.[19] Above all the process of administrative approval introduces a further element of uncertainty into the transaction. Only about 20% of all trades that reach this stage are fully approved as proposed. Of the 80% of trades not receiving complete regulatory approval, half will be rejected out of hand, and the other half will be subject to a variety of downward revisions. The reason for the large number of unapproved proposed trades is the difficulty

[19]A typical value for the joint financial transaction costs of both partners required to bring about an exchange would be $25,000, with $10,000 as a lower bound (Margolis, 1991). These costs are in 1991 dollars.

associated with certifying the claimed emissions reduction and agreeing on the benchmark against which the reduction is measured. For example, up to 90% of the value of the emissions reduction may be discounted to reach compliance with BACT and other source-specific rules (Margolis, 1991). It is this feature of the bureaucratic approval process that necessitates a variety of risk-sharing features to be incorporated into the trading contracts.

Some types of trades may be less vulnerable to these problems than others. First, trading a credit from the SCAQMD bank considerably reduces the duration and uncertainty associated with the approval process from the buyer's perspective because the magnitude of the credit has already been certified. On the other hand, the seller will have already incurred the cost and delay associated with banking the credit in the first place, and in addition bears the risk that the value of the credits deposited in the bank will be subsequently devalued by the regulatory authority, as was the case in the June 1990 reforms. The banking of credits thus reduces transaction costs for the buyer. For this reason, one might expect such credits to be exchanged at a higher unit price. There is some evidence that this was indeed the case; however, the small number of observations does not make it possible to draw a very strong conclusion. Second, the trading of credits in "multi-pollutant clusters" is likely to reduce the duration of the approval process by permitting a number of trades in different pollutants to be approved simultaneously.

A comparison of potential transaction costs with observed credit prices leads to an important finding: the transaction cost of trades may frequently exceed the market value of credits themselves. For example, a typical trade of 50 tons per year of ROG trading for $150 per ton has an exchange value of $7,500. The total transaction costs of such a trade could easily exceed $10,000. If transaction costs were lower, many more trades would have taken place at prices that probably would have been substiantially higher than the average observed price.

Evidence on High Transaction Costs Trades

On the basis of the preceding analysis, it is possible to identify two types of trades that would be expected to have relatively high transaction costs. The two types are exchanges involving thinly traded pollutants and exchanges involving very small volumes of credits. Exchanges of thinly traded pollutants could be expected to involve higher transaction costs because it would be harder to find a suitable trading partner. One would expect exchanges involving very small volumes of credits to be adversely affected by the fixed nature of the transaction costs that are imposed by the bureaucratic approval process, and possibly also by the difficulty of finding suitable trading partners.

It is hypothesized that exchanges involving thinly traded pollutants are more likely to involve the search cost reducing devices identified in the preceding section. Thus:

H12 Thinly traded pollutants are more likely to be traded internally.

H13 Thinly traded pollutants are more likely to be traded from the bank.

H14 Exchanges of thinly traded pollutants are more likely to involve AER*X.

H15 Thinly traded pollutants are more likely to be traded in multi-pollutant clusters.

For the purposes of testing these hypotheses, CO, PM and SO_x are all designated as being "thinly traded" as there are less than 12 trades recorded for each. ROG, with

close to 150 trades, is clearly not "thinly traded." NO_x, with about 30 trades, falls somewhere in between.

The evidence is presented in Table 7, which breaks down the trades in each pollutant according to each of these four characteristics. Both the table and the related hypothesis tests lend considerable support to the hypotheses relating to internal trading (H12) and "multi-pollutant clusters" (H15). Both of these types of trades are more likely for thinly traded pollutants.[20] For banked trades, the pattern is not so clear (H13). This may in part be attributable to the fact that there are fewer deposits of thinly traded pollutants in the bank from which to choose. In the case of AER*X involvement (H14), the supporting evidence is stronger than it was in the case of banked trades, but not strong enough to generate a statistically significant result in the hypothesis test.

A particularly striking result emerges if all of these devices for reducing transaction costs are considered simultaneously – there are only a small fraction of trades in the thinly traded pollutants that did not make use of at least one of these four devices. ROG was the only pollutant for which there were many trades that did not make use of any of these devices.

A second set of hypotheses is concerned with determining whether the high fixed transaction costs associated with small trades makes it more likely that these will make use of transaction cost reducing devices. For the purposes of analysis a small trade is defined (somewhat arbitrarily) as one below 5 tons per year (or 25 lbs.

[20]It is interesting to note that in the case of internal trades NO_x behaves as a "thinly traded" pollutant; however, in the case of "multi-pollutant clusters," it does not.

Table 7

Breakdown of Trades for Each Pollutant
(Number of trades and percentage of total for each pollutant)[1]

Pollutant	Internal	Clustered	Banked	AER*X	Total
CO	3 (43%)	2 (29%)	2 (29%)	2 (29%)	7
NO_x	4 (14%)	10 (34%)	10 (34%)	13 (45%)	29
PM	6 (55%)	4 (36%)	1 (9%)	1 (9%)	11
ROG	31 (21%)	6 (4%)	34 (23%)	29 (20%)	147
SO_x	3 (50%)	2 (33%)	1 (17%)	2 (33%)	6
Total	47	24	48	47	200

[1]Percentages do not sum to 100 because the different types of trades are not mutually exclusive.

per day) in volume.[21] Thus:

H16 Small trades are more likely to be traded internally.

H17 Small trades are more likely to be traded through the bank.

H18 Small trades are more likely to involve AER*X.

H19 Small trades are more likely to be in a "multi-pollutant cluster."

The evidence is presented in Table 8, which breaks down each size-class of trade according to each of these four characteristics. As might be anticipated from the preceding discussion, there is a statistically significant finding that "multi-pollutant clusters" are not evenly spread across size classes of trades (H19). The table indicates that these clusters are more common for small trades, although there is also one very large trade that was part of a multi-pollutant cluster. The evidence on banked trades (H17) and AER*X involvement (H18) is not particularly convincing, whereas the pattern of internal trading (H16) does appear to offer some support for the hypothesis, although the effect is not found to be statistically significant. Once again, considering all of the devices for reducing transaction costs simultaneously gives a much stronger result. For the smallest size class (under 25 lbs. per day), there was only one ROG trade that did not make use of one or more of these four devices.

The introduction of the Community Bank in 1991 means that the smallest trades (those less than 2 tons per year in volume) no longer need go through the open trading process. Examining the volume of trades in the Community Bank in 1991 makes it possible to draw some inference as to the dampening effect of fixed

[21]This is probably a rather generous definition of a small trade. For the purposes of the SCAQMD Community Bank a small trade is defined as one below the 2 tons per year threshold.

Table 8

Breakdown of Trades for Each Size Class
(Number of trades and percentage of total for each size class)[1]

Lbs./Day	Internal	Clustered	Banked	AER*X	Total
<25	7 (41%)	8 (47%)	5 (29%)	3 (18%)	17
26-50	4 (21%)	0 (0%)	6 (32%)	2 (11%)	19
51-100	8 (19%)	3 (7%)	9 (21%)	10 (23%)	43
101-250	14 (24%)	4 (7%)	13 (22%)	14 (24%)	58
251-500	7 (16%)	8 (19%)	8 (19%)	14 (33%)	43
501-1,000	6 (55%)	0 (0%)	2 (18%)	1 (9%)	11
1,001-5,000	1 (13%)	0 (0%)	4 (50%)	3 (38%)	8
>5,000	0 (0%)	1 (100%)	1 (100%)	0 (0%)	1
Total	47	24	48	47	200

[1]Percentages do not sum to 100 and rows do not sum to total because the different types of trades are not mutually exclusive.

transaction costs on the volume of small trades. The activity in the Community Bank is summarized in Table 2. The Community Bank accounted for 2,139 transactions in 1991 alone. This dramatic increase in the number of small transactions cannot be solely attributed to the low transaction costs associated with using the Community Bank because the credits obtained from the bank are free whereas those obtained in the market have a positive price associated with them. (The allocation of credits from the Community Bank is allocated on the basis of volume demanded, rather than on the basis of price.) However, for a small trade, the cost of purchasing the ERCs would be small relative to the transaction costs. It therefore seems likely that transaction costs were a significant impediment to small trades prior to 1991.

In summary, there is some evidence that both internal trading and "multi-pollutant clusters" may be capable of reducing the transaction costs associated with thinly traded pollutants and small trades.[22] Using the SCAQMD bank and AER*X, on the other hand, seems to be more helpful where larger trades of less thinly traded pollutants are concerned. The advent of the Community Bank has led to a huge escalation in the number of small transactions.

4. Lessons and Challenges

Market-based approaches for environmental protection are beginning to take root across the globe. There are ongoing projects in Eastern Europe, the USSR, Australia, Europe and the United States. The federal program for controlling acid rain and the RECLAIM program for Los Angeles are probably the two programs closest to fruition. The national program for regulating SO_2 must develop rules for

[22]There is some correlation between these two categories, since thinly traded pollutants tend to be traded on average in smaller volumes.

exchange in the context of public utility regulation, a very difficult problem. The RECLAIM program just recently defined the pollutants to be traded -- SO_2 and NO_x -- but the trading rules have not been defined in any detail (Cohen, 1993).

There has been no dearth of advice from economists on how such programs should be designed (Noll, 1990; Harrison and Nichols, 1990; Oates and McGartland, 1985). Yet, the design suggestions have tended to rely more on a general understanding of political economy rather than a deeper understanding of the workings of specific environmental markets.

This paper takes a step toward providing that deeper understanding. The principal message for policy makers is that transaction costs can have a big impact on the structure of the market. Lots of red tape in getting a trade approved discourages trading. It also encourages firms to search for ways to economize on transaction costs, such as by using clustered trades. Difficulty in finding interested buyers and sellers diminishes the incentive to engage in external trades. Uncertainty about the future status of a traded property right can also diminish trading.

Politics has an important impact on transaction costs. In Los Angeles, for example, there are very high stakes, both in terms of direct costs, employment impacts and environmental quality. We have spoken with environmentalists who said they would not sign on to a market-based system unless the system demonstrated beyond any reasonable doubt that it will deliver environmental gains that exceed those that allegedly would be achieved under a command-and-control regime. At the same time, some members of industry voice concern because they believe that the RECLAIM program would be more onerous than command-and-control, achieving more rapid environmental gains and imposing higher economic

costs.[23] With such divergent views about the underlying distribution of property rights, it becomes difficult for programs such as RECLAIM to work effectively.

The SCAQMD finds itself caught between these competing interests. In addition, it must satisfy a federal EPA, whose regional office appears more interested in applying the letter of the law than in insuring environmental progress and innovation. In this highly contentious political environment, it would be a minor miracle if we see unfettered markets for environmental protection in Los Angeles.

Yet, there is hope. Officials at the SCAQMD will encourage the introduction of new and improved environmental markets if they believe such behavior will be rewarded. And such behavior is likely to be rewarded, both internally through cues taken from the head of the agency, James Lents, and externally, through the potential to be a recognized international leader in environmental regulation. Whether these positive incentives are sufficient to overcome bureaucratic inertia and interest group politics remains to be seen.

Perhaps the greatest challenge facing the advocates of market-based environmental protection is to have the government make a "credible" commitment to such markets. This requires, among other things, a clear definition of the property right and the conditions under which such rights may be weakened (or strengthened). Governments have great difficulties making credible commitments in this area for two reasons: first, in general, it is difficult for elected officials to prevent their successors from undoing new policies if they wish to; second, environmental markets are likely to remain politically contentious for the foreseeable future. Politicians have only recently embraced these markets as a means for meeting the growing demand for environmental quality.

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[23]Some industry officials are supportive of RECLAIM, believing that costs will go down for the business community relative to the command-and-control system. For more detail on interest group perspectives see Cohen (1993) and the references cited therein.

5. Conclusions and Areas for Future Research

Environmental markets are likely to be more widely used in future. They hold out the promise of providing more rapid environmental progress at a lower cost than conventional regulatory approaches. In order to gain a greater appreciation for the limits and potential of these markets, it is instructive to examine past applications. This paper examined the performance of the emissions trading market in Los Angeles. We were particularly interested in examining the effects of rules and rule changes on observable market variables.

The analysis showed that geographical segmentation of the market had a marked impact on prices; it highlighted how transaction costs affect trading activity; and it pointed out that the various ERC markets were not likely to be in a classical equilibrium state with a set of well-defined prices.

The analysis, while based on the most extensive economic dataset to date, still suffers from a marked absence of information. We are concerned that policy makers may not see a payoff to generating the kind of information that would be most needed to improve our understanding of market performance. For example, the office at EPA responsible for implementing the SO_2 marketable permit program has shown remarkably little interest in developing the data necessary to evaluate the efficacy of this program. Those in academia interested in lobbying either for efficiency or for data for publications should take note. The message is simple. Regulators need to spend more resources on gathering appropriate data so the academic community can better assess how programs actually work.

The same point about economic data should be made about environmental

data in this context. Information on changes in the aggregate level emissions as well as the regional and temporal pattern of emissions is critical for assessing the environmental effectiveness of market-based programs.

The move towards adopting market-based approaches for environmental protection needs to be accompanied by a vigorous effort to ascertain the properties of these systems as they are actually implemented. There is a great deal more that needs to be learned about environmental markets and taxes -- particularly the conditions under which they are likely to be successful. The introduction of policy experiments throughout the world could aid our understanding immensely.

In short, the good news is that the world is beginning to take the ideas of ivory-towered economists seriously in resolving environmental issues. The bad news is that the stock of usable knowledge in this area is a lot lower than we might like. The path to enlightenment is clear: further study of how such market-based approaches actually perform in practice.

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