An Analysis and Recommendation for the Terms of the RECLAIM Trading Credit

Report Submitted to South Coast Air Quality Management District
(Contract No. R-C93074)

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EXECUTIVE SUMMARY

INTRODUCTION

The South Coast Air Quality Management District (AQMD) has proposed an annual RECLAIM Trading Credit (RTC) with uniform issue and compliance dates as the trading instrument for its market-based regulatory program. The proposed design for this instrument carries potential problems for both RECLAIM facilities and AQMD, including market imbalances, price volatility, economic inefficiencies, and an increase in ambient emission peaks. These problems result directly from the design of the instrument, and they can be alleviated through the selection of alternate design variables and a change in the allocation of RTCs to RECLAIM facilities. Both the problems and the effectiveness of the solutions have been tested and documented in experiments conducted in the Laboratory for Experimental Economics and Political Science at the California Institute of Technology.

CRITICAL VARIABLES

There are four sets of critical issues in the design of RECLAIM instruments and the trading markets for them:

1. Issue and expiration dates of RTCs;
2. Compliance and certification dates;
3. The provision of a market during the reconciliation period, which occurs at the end of each compliance period; and
4. The method of allocating RTCs to facilities.

These issues should be resolved consistent with AQMD's overall program objectives for RECLAIM:

> Achieve an aggregate level of pollution abatement at minimum cost to facilities in the L.A. Basin.
>
> Promote economic efficiency.

The RTC instrument design terms are interactive and integral to achieving these goals. Their variability offers many possible structural alternatives for the instrument.

DESIGN ALTERNATIVE 1: UNIFORM RTCs

In this alternative, all RTCs are valid for emissions in a single (calendar or fiscal) year. All expire on the same date, which coincides with the end of the annual compliance period. This alternative was presented in the RECLAIM Proposed Rules issued in November 1992.

Potential Problems

1. With all facilities submitting annual reports simultaneously, AQMD faces an overly burdensome administrative responsibility.

2. With all RTCs expiring simultaneously, either of two equally undesirable situations is likely:

   A. As the compliance year ends, facilities are likely to see a shortage of RTCs available in the market, with those offered commanding extremely high prices; or

   B. Anticipating a shortage of credits at year-end, facilities may hold RTCs substantially above their emissions levels. If they turn to the market to sell excess credits at yearend, the market may be glutted with RTCs and prices will fall to zero. Unused or unsold RTCs represent a loss of economic opportunity for the facilities and the Basin as a whole.

3. The inability to sell "excess" RTCs at yearend may prompt facilities to increase production in order to capture (some portion of) the remaining economic value of the instrument. This action increases the potential for emission peaks and violations of air quality standards. In essence, the design of the RTC can artificially synchronize facilities' emissions at yearend.

DESIGN ALTERNATIVE 2: STAGGERED COMPLIANCE

If RECLAIM facilities are divided into two groups with annual compliance deadlines six months apart, AQMD would not face such a heavy administrative burden. The remaining problems of Uniform RTCs, however, are not resolved by this alternative.

DESIGN ALTERNATIVE 3: STAGGERED ISSUE DATES, STAGGERED COMPLIANCE DATES

This alternative addresses both the problems of AQMD's administrative task and the absence of market liquidity at yearend. It provides for two sets of instruments, each valid in a different, overlapping, 12-month period. Half the RTCs are issued in January (with a December expiration date), half in July (with a June expiration date in the following year). Either instrument can be used by *any* RECLAIM facility to cover emissions during the time the RTC is valid. The compliance dates are also staggered as in Design Alternative 2.[1]

Advantages

1. Business gains flexibility, particularly as annual compliance dates approach. The availability of two sets of RTCs allows facilities to more easily accommodate unanticipated events.

2. There is less likelihood of artificial synchronization of emissions.

3. Price volatility induced by the Uniform RTC is eliminated, and market prices will more accurately reflect the marginal costs of pollution abatement, an indication of, and requirement for, economic efficiency.

4. Staggered RTCs enhance the effectiveness of a reconciliation period.

Drawbacks

In order to implement the Staggered RTC program, the AQMD must distribute the allocations with a slightly more complicated procedure. As the program continues, the AQMD must maintain records on more than one instrument.

ALLOCATING STAGGERED RTCs

Facilities are divided into two groups. Each facility can receive its entire allocation in one type of RTC (e.g., January to December credits), or it can receive a "mixed" allocation, where half the RTCs are valid from January to December, half from July to June. Either allocation method avoids the problems of Uniform RTCs. A mixed allocation distributes the benefits of staggering directly to facilities, avoiding forced use of the market -- and

1For simplicity, we have set compliance dates to coincide with the expiration dates of the RTCs facilities are initially issued, but this is not necessary.

associated transaction costs -- to obtain the stagger. In addition, a mixed allocation helps the AQMD to provide equitable markets and adds RTCs generated from sources not initially directly in RECLAIM (e.g. RTCs from mobile source retirement).

RECONCILIATION

A reconciliation period offers facilities an opportunity to include more accurate information in emissions reports and to adjust RTC holdings accordingly, provided of course that the RTC market is open and available during reconciliation. Absent reconciliation with an open market, facilities have strong incentives to hold credits in excess of their emissions, or to report emissions above actual levels to avoid noncompliance penalties due to inadequate information and unanticipated events.

Staggered RTCs enhance the efficiency of reconciliation. With Uniform RTCs, facilities are likely to have excess, expired credits during and after reconciliation, having held credits as insurance against non-compliance risk. Staggered RTCs, on the other hand, allow facilities to hold unexpired credits (those with a remaining life of six months) as insurance, reducing the effective cost of the insurance premium to zero.

CONCLUSION

We recommend the following:

1. Stagger RTC compliance dates to reduce AQMD's administrative burden;
2. Stagger RTC issue dates to reduce price volatility and enhance market liquidity;
3. Distribute RTCs to facilities through a mixed allocation method to avoid transaction costs and avoid inequities in distribution; and
4. Provide a reconciliation period with an open market each compliance quarter for all RECLAIM facilities.

INTRODUCTION

The South Coast Air Quality Management District (AQMD) has proposed a market-based regulatory system relying on tradable emission allowances, to achieve an aggregate level of pollution abatement at minimum cost to facilities in the Los Angeles Basin. The program is called "RECLAIM" -- the Regional Clean Air Incentives Market.

AQMD counts as critical, among its program objectives, the efficiency of the market for RECLAIM Trading Credits (RTCs). It is equally important for those credits, once issued, to be used in their most economically efficient manner. In both cases, the terms and allocation method of RTCs will influence the realization of AQMD's objectives and, hence, the success of RECLAIM. This paper reviews the variable terms available to define RTCs and to distribute RTCs to RECLAIM facilities. It also discusses the benefits of providing a reconciliation period with an open market.

ASSUMPTIONS

The consultants make several key assumptions in this discussion.

1. While the length of time RTCs are valid could vary, we assume RTCs are an annual, fixed-term credit governing emissions over a 12-month period.

2. Each RTC carries the right to emit one unit of pollutant, and that unit is a pound. The analyses here are not dependent on this amount, nor would they be affected by a choice of tons, rather than pounds, of pollution. Market liquidity and participation are, of course, dependent on the size of the RTC -- size determines the usefulness of the credit and its accessibility to a range of potential users.

3. Three pollutants -- oxides of nitrogen (NOx), oxides of sulfur (SOx), and reactive organic compounds (ROC) -- are regulated under RECLAIM. Each RTC covers emissions of one, and there are separate markets for each set of RTCs; "inter-pollutant" trading is not allowed. There are also restrictions limiting trading activity between two geographic zones, which are discussed.

4. RTCs cannot be "banked"; facilities cannot carry unused credits forward or backward to cover emissions outside the period for which the RTCs are issued.

5. AQMD reporting requirements will remain largely as proposed: Facilities will certify emissions quarterly (and annually), and are subject to findings of violation any time certified emissions exceed either holdings of RTCs or annual facility emissions caps, or if

reports are found by audit to be inaccurate.

RTCs AS FACTORS OF PRODUCTION

Each RTC represents a factor of production for a facility, with an expiration date and, hence, a time-value. Depending on the terms defining RTCs, the credits may not, as factors of production, have any short-term substitute(s). RECLAIM facilities must hold RTCs to operate if they emit any of the pollutants regulated in the program.

DEFINITIONS

Issue date. The first day a pollutant can be emitted under the authority conveyed by the RTC.

Expiration Date. The last day a pollutant can be emitted under the authority conveyed by the RTC. The RTC may remain eligible for trading or transfer under some limited reconciliation period (see below); however, no emissions can be attributed to a RTC after its expiration date. RTCs expire on a date certain, used or unused. Expiration dates are used to distinguish RTCs in this paper.[2]

Compliance Date. The last day of the compliance period, which is the interval over which a facility sums its emissions of each pollutant for certification and reporting to AQMD.

Certification Date. The date by which facilities must submit emissions reports to AQMD. Certification dates may fall anytime after compliance dates (usually 30 days).

Reconciliation Period. The interval between the compliance and certification dates, when facilities gather the information needed to complete compliance reports and trade RTCs in order to balance emission accounts.

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[2]In financial markets, derivative instruments, including options and futures contracts, are referred to as "June calls" or "December puts," indicating the last (or only) date the rights and obligations conferred by sellers can be exercised by buyers. Derivatives are expected to be available on RTCs, and it would seem appropriate for AQMD to adopt this use of expiration dates to identify RECLAIM instruments.

RTC INSTRUMENT DESIGN VARIABLES

Two variables define the terms of the RTC. A third defines its allocation.

Issue dates. RTCs can have uniform issue dates (e.g., January 1) or staggered issue dates (i.e., half the RTCs could be valid each year beginning January 1, half on July 1).

Compliance dates All facilities can be assigned to the same annual compliance schedule, with certified yearend emissions reports due December 31, for example, or the schedules can vary, with half the facilities reporting on December 31, half on June 30.

Note that, as with issue and compliance dates, RTCs can have uniform expiration dates or staggered expiration dates (June 30 and December 31). The expiration date need not coincide with the compliance date, and is not considered a variable here. This analysis assumes the expiration date will fall 12 months after the issue date of any particular RTC.

Allocation. RTCs will be distributed to facilities consistent with their baseline allocations of emissions, the process for which is under consideration. For this paper, the authors are concerned with the allocation of RTCs, not the determination of baseline emissions. The allocation of RTCs can be uniform, or, if there are several types of RTCs (distinguished by expiration dates), the allocation can vary between facilities (e.g., half the RECLAIM facilities receive one RTC, half another), or within facilities (facilities receive some of each RTC).

ALTERNATIVE INSTRUMENT DESIGNS

There are multiple instrument and allocation alternatives available based on the variables described above, and they are arrayed in Table 1. Four alternatives suggest advantages to AQMD and/or RECLAIM participants:

1. Uniform issue, uniform compliance, uniform allocation.
2. Uniform issue, staggered compliance, uniform allocation.
3. Staggered issue, staggered compliance, divide allocation between facilities.
4. Staggered issue, staggered compliance, divide allocation within facilities.

In this paper, these design alternatives are evaluated for their ability to promote economic efficiency and mitigate market volatility.

Table 1

Alternatives Discussed in Paper

Compliance	*Issue and Allocation Method*		
	Uniform RTC	Staggered RTC allocation across facilities	Staggered RTC allocation within facilities
Uniform	Alt. 1	not discussed (5)	not discussed (5)
Staggered	Alt. 2	Alt. 3	Alt. 4

1. Design Alternative 1, uniform issue of RTCs and uniform compliance period schedules.

2. Design Alternative 2 staggers the schedule of compliance periods while keeping the issue of RTCs uniform.

3. Design Alternative 3 keeps the staggered compliance period schedules and staggers the issue dates of RTCs *across* facilities.

4. Design Alternative 4 is a variation of Design Alternative 3. Issue and compliance dates remain staggered, but RTCs are allocated *within* facilities instead of across facilities.

5. Uniform compliance with staggered RTC allocations is not discussed. The benefits are the same as the other staggered RTC alternatives, except the administrative benefits for the AQMD are absent.

DESIGN ALTERNATIVE 1: UNIFORM ISSUE, UNIFORM COMPLIANCE, UNIFORM ALLOCATION

In the initial draft of RECLAIM rules, AQMD proposed allocating RTCs with uniform start and compliance dates to all RECLAIM facilities (Uniform RTCs). These credits would be valid for emissions released in a calendar (or fiscal) year, beginning on January 1 (or October 1), and expiring 12 months later on December 31 (or September 30). The credits would be valid only for the year issued, and could not be traded after the compliance/expiration date. In addition, AQMD proposed placing all facilities on the same compliance schedule. Figure 1 illustrates this allocation method for two facilities over the course of four years. Note that only one type of RTC is valid at any time.

Potential Problems. While the uniform allocation of Uniform RTCs to all facilities is simple and straightforward, it carries several potential problems, both for economic efficiency and the efficiency of the market. This is particularly the case for facilities facing uncertain demand and/or prices for their products.

As a year ends, facilities find that the flexibility to meet compliance standards declines while compliance costs rise. This, too, is simple and straightforward. At the beginning of the year, facilities have the entire annual allocation of RTCs available to cover emissions. Each quarter, however, RTCs are retired by AQMD, based on emission reports submitted by facilities (Figure 2). As the year progresses, fewer and fewer credits are available, either to trade or to cover emissions, and prices of RTCs offered in the market rise (Figure 3). In addition, with fewer available credits, facilities face greater difficulty and higher costs in responding to unanticipated events, such as a sudden increase in demand for their products or a sudden production outage.

In terms of economic efficiency, facilities should hold credits sufficient to meet their expected emissions and sell the balance, thus maximizing value. But precisely how many RTCs should a facility hold throughout any given year, knowing that the cost of noncompliance is severe? How many should it trade?

Assume, for example, that a RECLAIM facility has been allocated RTCs sufficient to emit 100 pounds of pollution in 1995. Assume, further, that the facility reports emissions of 25 pounds in the first quarter of 1995, 20 pounds in the second, and 20 pounds in the third, or 65 pounds total, leaving 35 pounds of allowable emissions for the fourth quarter.

Figure 1

Example: Allocation of Uniform RTCs

Facility	*RTCs expiring at the end of:* 1994	1995	1996	1997
A	200	180	160	140
B	100	90	80	70

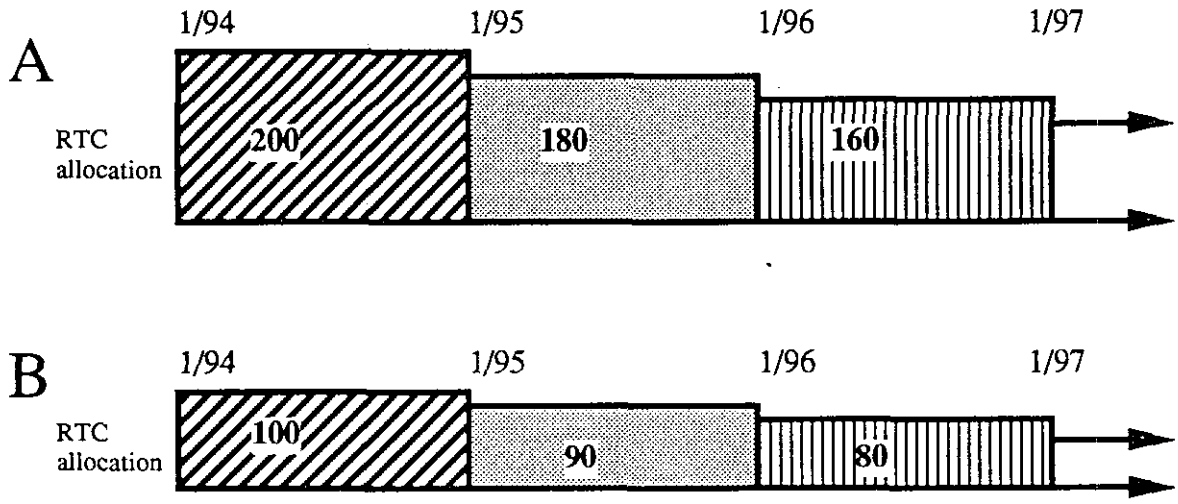


Figure 2

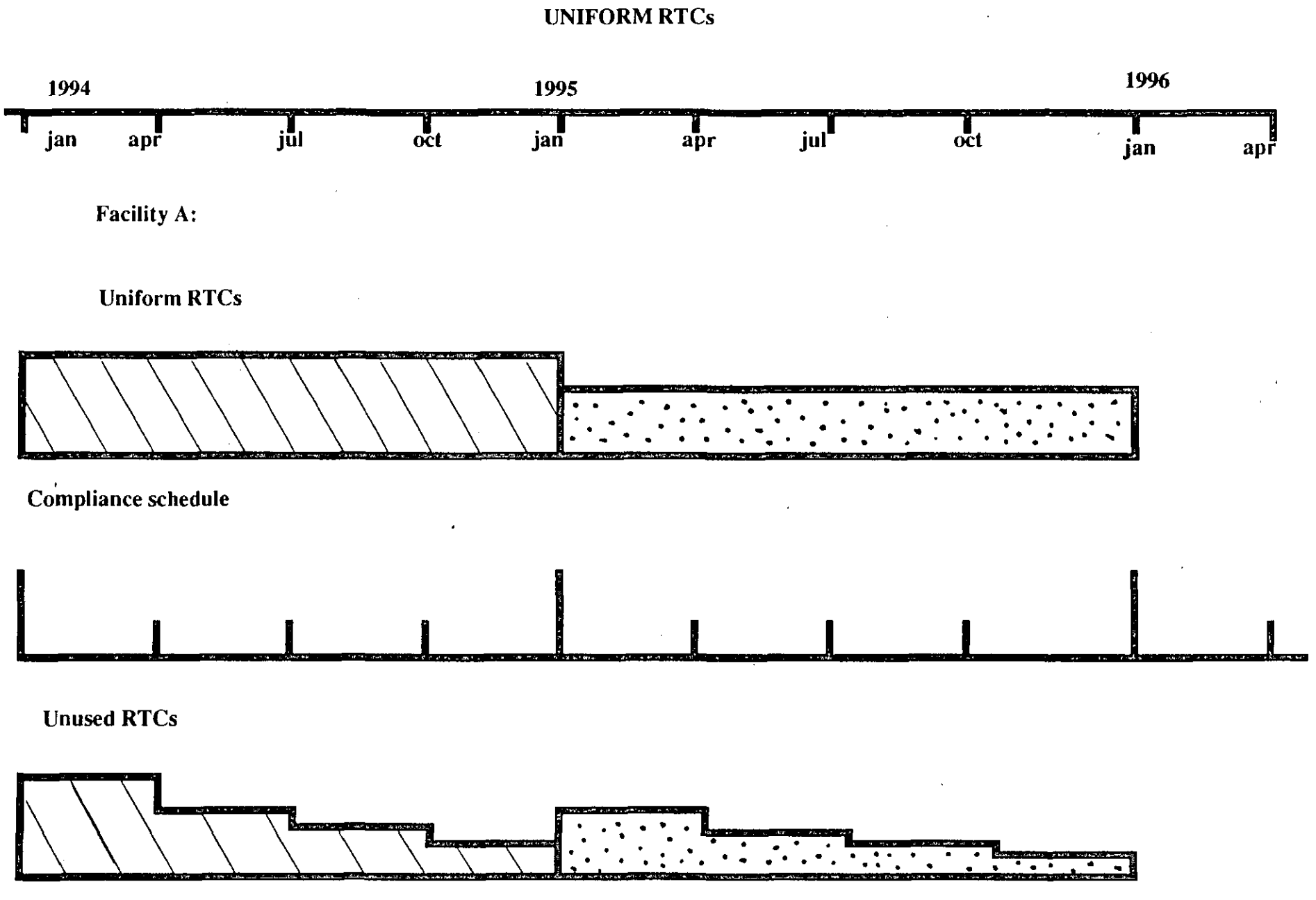
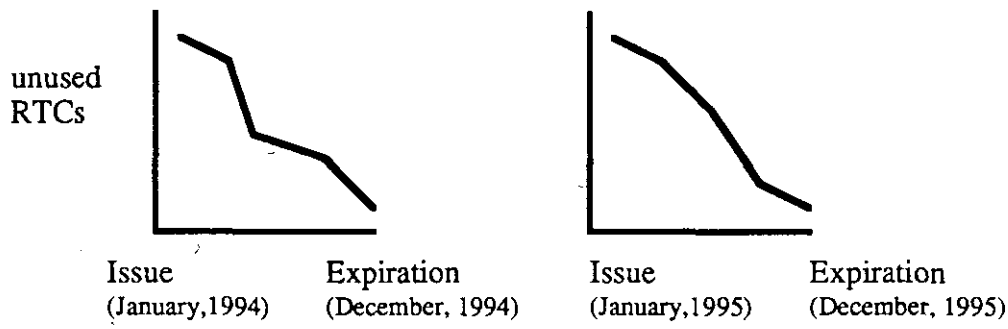

UNIFORM RTCs
1994
1995
1996
jan
apr
jul
oct
jan
apr
jul
oct
jan
apr
Facility A:
Uniform RTCs
Compliance schedule
Unused RTCs

Figure 3

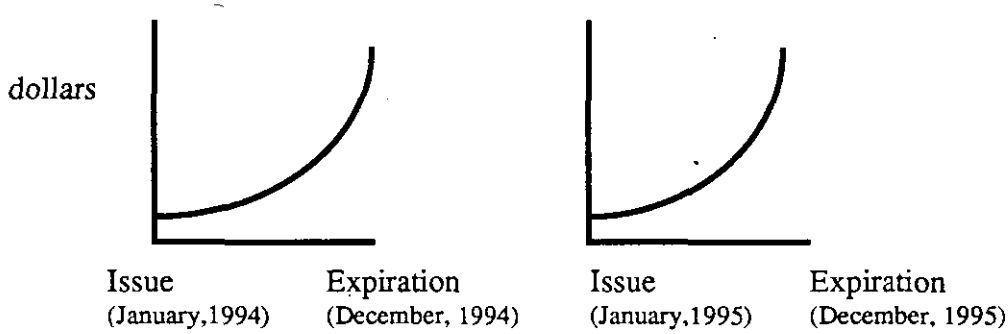
SHORTCOMINGS WITH UNIFORM RTCs

As the compliance year ends:

1. **Flexibility diminishes**: RTCs are retired and the market becomes thinner



2. **Total costs of compliance rise**: prices of RTCs do not reflect the marginal costs of abatement



Facilities find it more costly to respond to unanticipated events caused by:

- measurement uncertainties
- business uncertainties

To this point, the facility has pursued a conservative approach, declining all offers to sell credits in the first three quarters of the year, a reasonable strategy given the threat of substantial penalties for exceeding one's RTC allowance. The facility has essentially held "extra" credits as insurance, despite having a reasonable level of confidence that its emissions for the year will fall within permissible limits. This is a reasonable scenario, given the possibility of error in quarterly reports due to measurement or calibration deficiencies (a potential violation), and lack of experience with RECLAIM.

As yearend approaches, the facility gains confidence in the accuracy of its reported emissions and, perhaps more importantly, the decreasing probability of an unexpected event. The facility determines that fourth-quarter emissions will total 25 pounds, leaving 10 pounds of "extra" credits for the year. This is a "use-it-or-lose-it" proposition: excess credits expire worthless on December 31. They cannot be transferred to another facility after that date, and they cannot be banked for use in any subsequent compliance period.

The facility has two choices for capturing some value from the excess units: increase fourth-quarter production (within allowable limits), or sell the excess credits before yearend. An economically rational facility will try to pursue one, or a combination, (e.g., use five credits and sell the balance) of these alternatives. Any unused credits represent a lost opportunity for the facility, in either unrealized productive activity (economic efficiency) or unrealized market value (trading the credits for cash). Indeed, unused credits are a lost opportunity for the entire Basin: they could have been sold to and used by another RECLAIM facility, maximizing economic efficiency.

Because it is unlikely any facility would knowingly pursue a strategy intended to put it at risk (given AQMD's significant noncompliance penalties), it is likely many facilities will pursue this "insurance strategy." If one facility ends a compliance year with a surplus of credits, other facilities will be in the same position. Consequently, if a facility turns to the market to sell unused credits (because it cannot increase production on short notice) it may very well find there is a surplus of credits offered in the market; that the quantity of credits supplied exceeds the quantity demanded. In such circumstances where the market is "long," bid prices will be low, and the facility may find that the actual price for its RTCs is zero.

In the alternative, despite its best efforts, it is possible a facility could approach yearend holding insufficient credits to cover its emissions. (This shortfall may result from inadequate or inaccurate information generated over the course of the year.) While there is

no reason to correlate reporting errors or deficiencies across facilities, it is possible other facilities will find themselves short, particularly if they have observed low prices for "insurance-induced" excess credits offered in the market at the end of earlier years. In this case, the *market* is short; RTC prices will be extremely high and may reach levels matching noncompliance costs.[3] (An economically rational facility will not buy credits to cover a shortage if credit prices exceed AQMD noncompliance costs. It would, instead, simply pay the penalties.)

In any case, it is highly unlikely that the quantity of RTCs available in the market will exactly match the quantity of RTCs demanded. Both "short" and "long" scenarios are possible, even with all random variables assumed to be independent across facilities. If emissions are correlated, however (due to cyclical fluctuations in general economic activity, for example), there is a greater probability the yearend market will be very short or very long on the expiration date. A facility's knowledge of its emissions increases as the year progresses, but the usable supply of credits available to cover emissions declines. In other words, facilities have their best information about year-to-date emissions in the fourth quarter, but the market may be thinnest (have the fewest credits available) in that quarter, or there may be an abundance of RTCs offered in the market, with each having little useful life remaining. Both situations create the potential for extreme market volatility -- the market is either "squeezed" with prices rising to the level of compliance penalties, or it is glutted with prices declining to zero.

Uniform RTCs pose potential problems for AQMD as well as for business. The introduction of market emission credits artificially "synchronizes" facilities' emissions, carrying a risk of greater peak emission problems. A facility with excess credits at yearend has an incentive to either increase production in the fourth quarter to capture the remaining value of the RTCs, or sell the RTCs to a facility with the flexibility to increase production. If many facilities are in a similar position, there is a potential for unintentional ambient emission peaks in the fourth reporting period.

If facilities are short credits and unable to acquire sufficient RTCs to cover projected fourth quarter emissions, they must either reduce production, or pay AQMD's compliance penalties for exceeding allowable emissions. Lost production represents lost employment, also an unintentional consequence of the terms and allocation of RTCs.

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[3]These costs include AQMD's penalties plus other costs a facility incurs for noncompliance (legal fees, staff time, etc.).

Experimental Analysis and Observations. To determine market behavior under various instrument alternatives, we designed and conducted two pilot experiments, using the resources of Caltech's Laboratory for Experimental Economics and Political Science. Subjects[4] in the experiments traded Uniform "RTCs" in spot and forward markets[5] extending over five time periods ("years"). In other words, the experiments allowed the subjects to buy and sell "Year 1" credits in the first time period, as well as credits valid in Years 2-5. Aggregate levels of allowable emissions were reduced each period, just as AQMD is proposing for RECLAIM. A reconciliation period with an open market was available at the end of each period.

Figure 4 shows a theoretical price path for each period and the actual time-series of contract prices (trades). *The experimental results demonstrate that there is significant volatility with either price spikes or crashes during reconciliation* . Details of the experimental procedures and additional data can be found in the appendix.

RECONCILIATION PERIOD WITH AN OPEN MARKET: A SOLUTION?

A limited reconciliation period (e.g., 30 days) following the end of each compliance quarter has been suggested as a remedy for the potential problems of Uniform RTCs. The suggestion includes an open market during reconciliation, where facilities can buy and sell any unused credits remaining after the compliance date up to the certification date. A reconciliation period can provide some benefits to facilities and other interested parties participating in RECLAIM. If, for example, there is a lag in emissions information (such that the information arrives between the compliance and certification dates), a reconciliation period will provide facilities an opportunity to obtain more precise information and adjust RTC holdings to match current emission calculations.

The Environmental Protection Agency (EPA) has developed a program somewhat similar to RECLAIM for controlling emissions that contribute to the formation of acid rain. EPA is providing a reconciliation period/market (an "extended allowance recordation period") for its program: EPA-regulated units have 30 days beyond the end of the compliance year to

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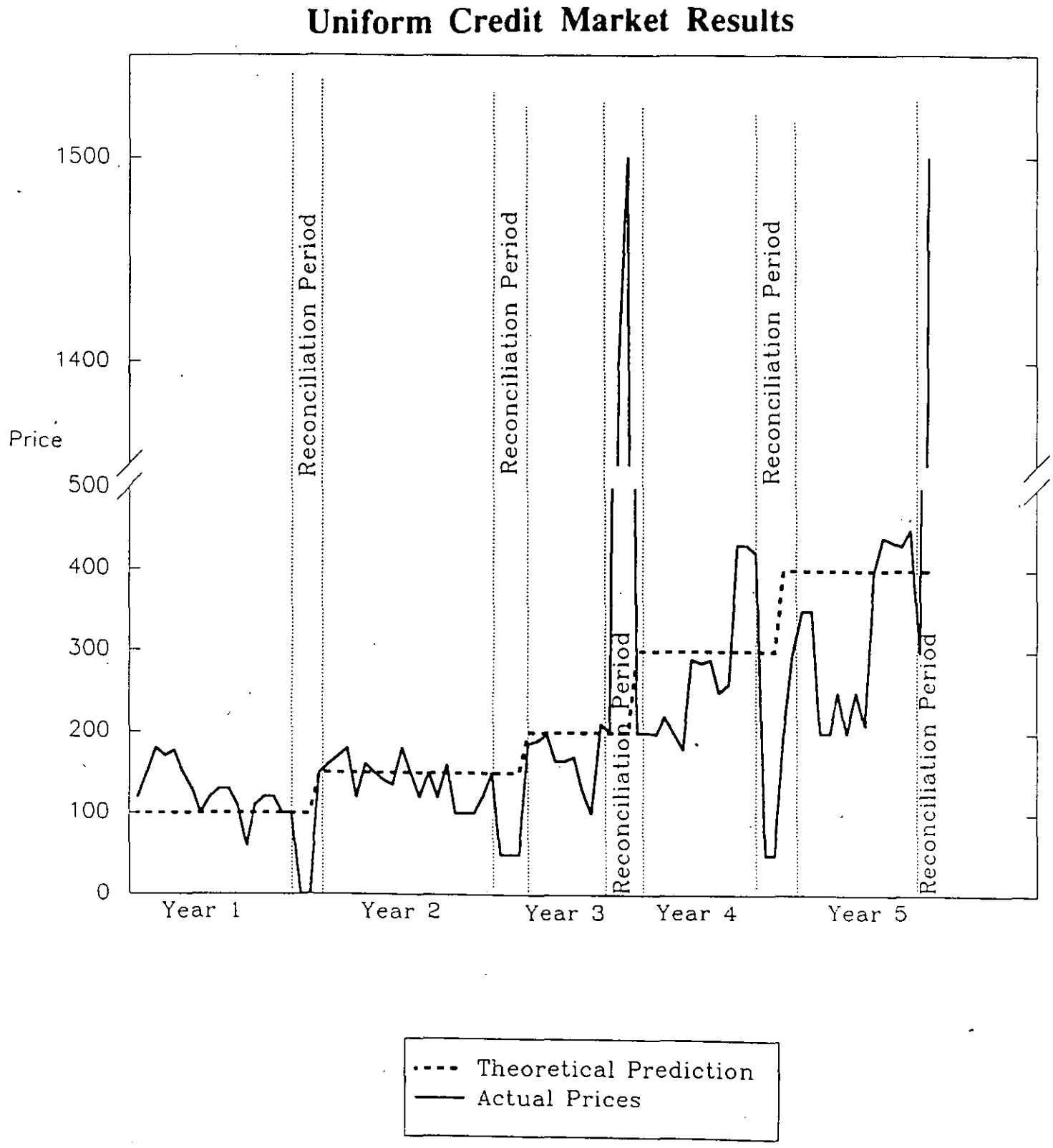
[4]Subjects were recruited from the Caltech undergraduate population.

[5]Spot Market: market where commodity is traded for immediate ("on the spot") payment and delivery. Also called the "cash market."
Forward Market: market where commodity is traded for use and/or delivery at a later date. (Some, but not all, forward market contracts are futures contracts.)

Figure 4


Uniform Credit Market Results
Price
1500
1400
500
400
300
200
100
0
Reconciliation Period
Reconciliation Period
Reconciliation Period
Reconciliation Period
Reconciliation Period
Year 1
Year 2
Year 3
Year 4
Year 5
Theoretical Prediction
Actual Prices

trade allowances (there is no quarterly compliance and credit retirement). In its proposed rules, EPA outlined the value of reconciliation:

> The added time to transfer allowances into a unit's account would not compromise the emissions reductions requirements of the acid rain program, because only those allowances usable for the calendar year during which the emissions occurred would be transferable to the compliance subaccount for the year....The extended transfer period .... does not increase the aggregate balance of allowances available for use for purposes of compliance in any year. The extended allowance transfer period is appropriate for several other reasons as well. The additional time...would allow affected units to avoid violations where allowances are otherwise readily available for purchase to offset emissions,...avoid violations for unforeseen circumstances,...[and] would not dampen incentives for prudent behavior or amplify perverse incentives. [6]

In its final rules for the Acid Rain program, EPA affirmed its opinion of reconciliation:

> As stated in the preamble to the proposed rule, EPA believes the additional flexibility of an extended allowance transfer period is important to the Acid Rain program and is also consistent with Congressional intent. [7]

Reconciliation would not result in emissions exceeding allowable limits, as the only credits available to facilities to cover excess emissions would be other facilities' unused credits valid during the same time period. Annual emission caps would thus remain in force, and any facility exceeding its cap and unable to obtain credits in the market would be subject to enforcement action.

If a reconciliation period is provided, it must be sufficiently long to allow facilities to gather and assess the information necessary to determine whether their RTC accounts are long or short RTCs. If the reconciliation period ends before this information is available to facilities, it will be of little value, and may affect the holding of credits for "insurance" purposes. There are, therefore, two issues to address in designing a reconciliation period/market. First, the market must remain available until the certification date. Second, the certification date must fall after the date facilities obtain more reliable information.

To see the advantages of reconciliation, consider two RECLAIM facilities that reach year-end 1994, one with 210 pounds of emissions (10 pounds above its allocation for the year), the other with 90 pounds of emissions (10 below its annual allocation) (Figure 5). Each has an annual compliance report due to the District by January 31, 1995. In the month of January, Facility A purchases the excess credits of Facility B. Both report to AQMD that

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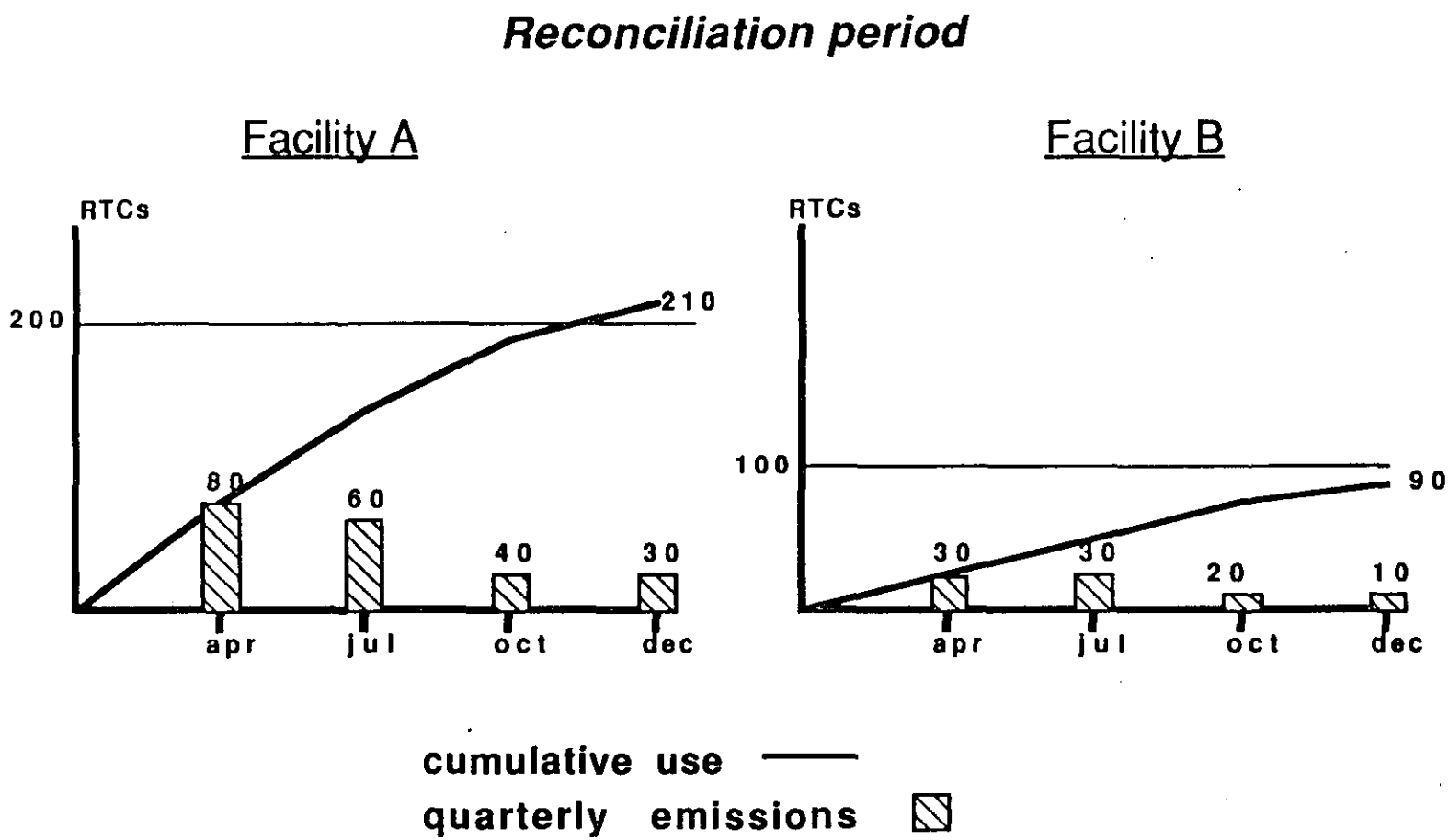
[6]Federal Register, Vol. 56, No. 232, December 3, 1991, p. 63049.
[7]Federal Register, Vol. 58, No. 6, January 11, 1993, p. 3617.

Figure 5



Facility A is "short" 10 RTCs at year-end. It has excess emissions.

Facility B is "long" 10 RTCs. It has excess credits.

they are in compliance for 1994, both realize the full economic value of their allocated RTCs, and emissions in the Basin remain within allowable limits for 1994.

A reconciliation market has merit -- providing additional time to facilities without allowing an increase in emissions -- and it can be adopted for any of the alternatives discussed in this paper, but it does not resolve all market and economic inefficiencies. A reconciliation period would not resolve the potential problems of market imbalances and economic inefficiency inherent in Uniform RTCs. Those problems are not caused by providing insufficient time for facilities to trade imbalances and reconcile long and short positions. They are caused by a lack of market liquidity; by the availability of only a single instrument that has no substitute. A reconciliation market for Uniform RTCs will, in fact, essentially be "a game of chicken." If the market is long in December '94, it will also be long in the January '95 reconciliation market and prices will likely fall dramatically, perhaps to zero. If the market is short in December, it will remain short in January, and prices will rise sharply. If all facilities anticipate market imbalances correctly, the reconciliation period is useless; e.g., if the market is long, there will be significant downward pressure on prices. It is more likely for facilities to be uncertain of the market's direction, in which case they will wait one another out, holding RTCs as long as possible, until the market signals its direction, at which point it will be to late for reconciliation to be of any value to market participants. This behavior was found to be prevalent in the laboratory experiments discussed earlier, where price spikes and crashes occurred during reconciliation.

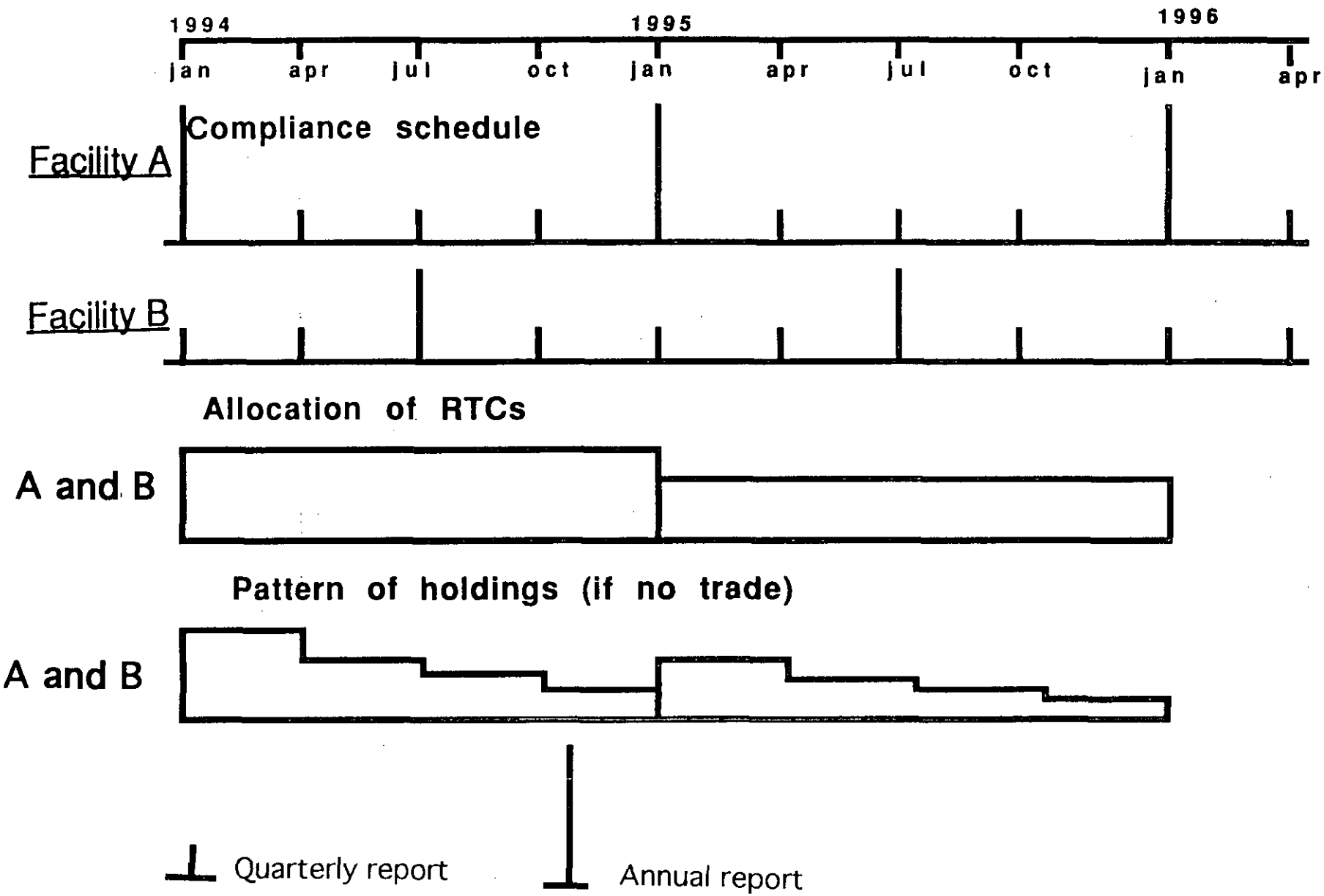
DESIGN ALTERNATIVE 2: UNIFORM ISSUE, STAGGERED COMPLIANCE, UNIFORM ALLOCATION

In this case, AQMD allocates RTCs with uniform distribution dates, but staggers facility compliance dates (Figure 6). All RTCs are valid, for example, from January to December 1994. Half the facilities file annual reports on (or after) December 31, 1994, and every December thereafter (Cycle 1). The other half file their first "annual" reports on June 30, 1994, covering only six months of the year, then their second on June 30, 1995 (Cycle 2).

This alternative is based on the premise that it is neither essential nor necessarily more convenient to tie RTC issue and compliance dates. By staggering compliance dates, AQMD's administrative burden is lessened -- every six months, half the RECLAIM facilities file annual emissions reports. While that benefit is appealing, it is insufficient to justify adoption of this alternative, because it only partially addresses the problems associated with the first alternative (uniform RTCs). In particular, it does not provide the second, substitute

Figure 6

Uniform Issue, Staggered Compliance



instrument needed in the final reporting period to avoid market imbalances and economic inefficiencies.

Potential Problems. This alternative provides Cycle 2 facilities with a second set of instruments they can acquire and use for compliance -- those from Cycle 1 facilities. Cycle 1, however, is clearly at a disadvantage, as there are no suitable RTCs available from Cycle 2. All RTCs expire on the same date. In short, this alternative -- uniform issue, staggered compliance -- resolves the problems of RTCs with uniform issue and compliance dates for only half the RECLAIM facilities -- those assigned to Cycle 2.

There is an important distinction here. AQMD's administrative problem is relieved through staggered compliance dates. Potential market imbalances and price volatility, however, are more difficult and more critical problems, and they are not resolved by staggering compliance. They can, however, be addressed through staggered issue dates, providing two sets of instruments to the market at any given time that can be used by any facility to cover emissions.

DESIGN ALTERNATIVE 3: STAGGERED ISSUE, STAGGERED COMPLIANCE, ALLOCATION BETWEEN FACILITIES

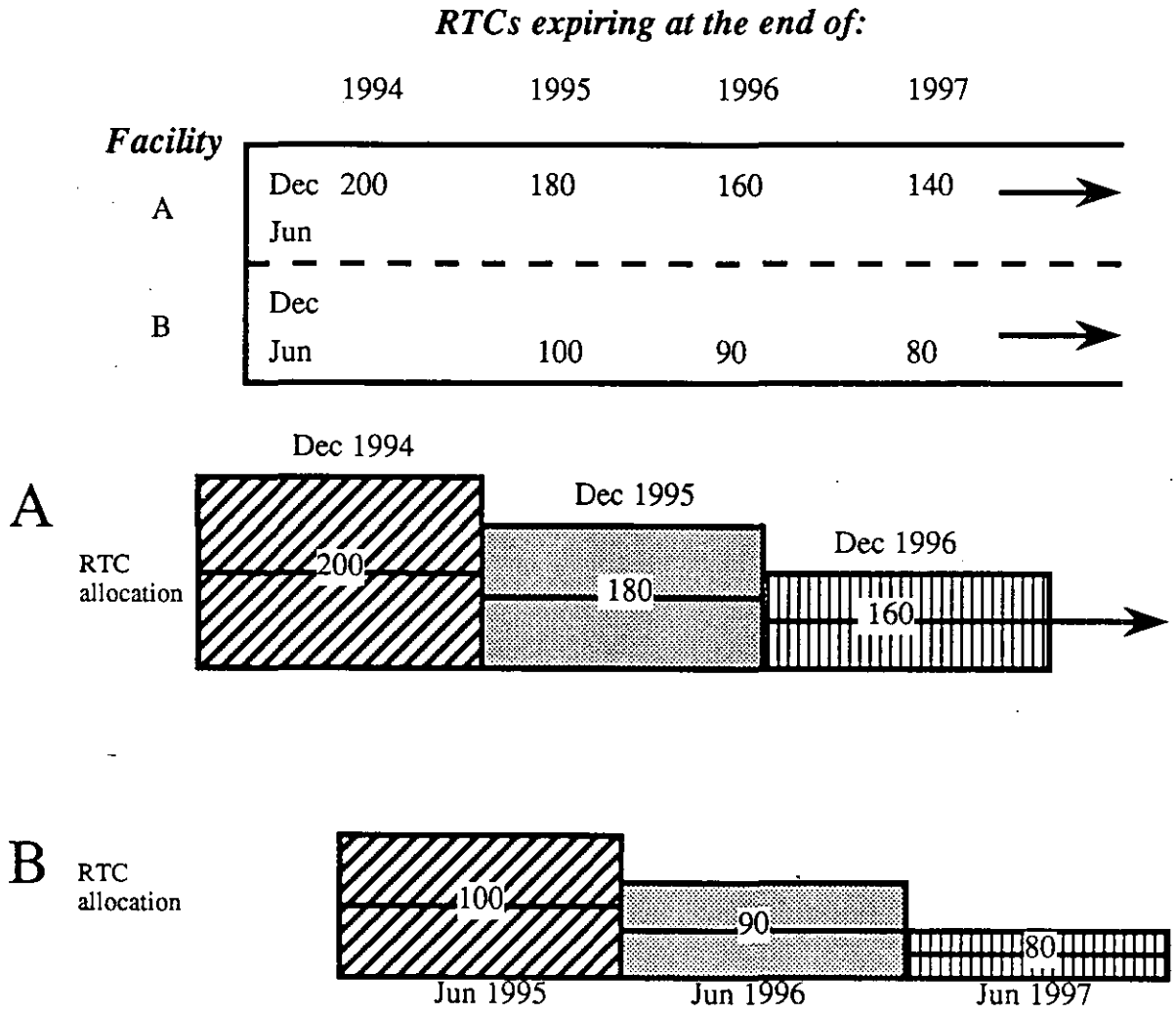
In this alternative, we stagger the issue date, stagger the compliance date (which *only for simplicity* coincides with the expiration date), and allocate RTCs between two groups of facilities identified by their compliance dates. Each RTC carries a one-year life beginning on January 1 or July 1, and expiring on December 31 or June 30. Facilities file annual reports coinciding with the RTC expiration dates: half on December 31 (Cycle 1), half on June 30 (Cycle 2). (Figure 7 illustrates the allocations and reporting requirements for Facilities A and B.) Call the RTCs valid between January and December, "December RTCs," July to June credits, "June RTCs."[8]

Either RTC (December's or June's) can be used by either facility *to cover emissions generated during the 12-month period the RTC is valid.* For example, Facility A may acquire June '95 RTCs from Facility B, and use them to cover emissions generated anytime between July '94 and June '95. Facility A may not use June '95 RTCs to cover pollutants

[8]There is no market or accounting reason for coordinating expiration and compliance dates of RTCs. The cycle designations could as easily and correctly reversed, or annual compliance could fall on one of the quarterly dates. Any mixture that divides baseline emissions equally into two groups for allocation of the December and June instruments is sufficient. In practice, AQMD is likely to find that the facilities assigned to each cycle are unequal in number, since the assignments must equate baseline emissions, not facilities. (See page [Allocating Staggered RTCs].)

Figure 7

Example: Staggered RTCs (unmixed allocation)



emitted before July 1, 1994. Similarly, neither facility may use December '94 credits to cover emissions generated anytime after December 31, 1994.

Advantages Staggered RTCs resolve the central underlying problem of Uniform RTCs as a factor of production, which is the lack of an available short-term substitute at any given time. With staggered credits there are always two instruments available in the market facilities can use to cover emissions. When December credits expire, June credits remain valid for another six months, and eligible for use by all facilities.

Table 2 is an "account" of the allocations, emissions, and trading activity for Facilities A and B for 1994 and 1995. Facility A receives an allocation, on January 1, of 200 December RTCs in 1994, and 180 in 1995, as shown in the first quarter (Q1) columns for each year. On July 1, Facility B is allocated 100 June RTCs in 1994 and 90 in 1995, shown in its third quarter (Q3) columns. (For simplicity, in this example we assume annual compliance.)

At the end of Q1 '94, "A" reports emitting 80 pounds of pollution, and its account is debited. It has 120 December '94 RTCs remaining, which are "carried forward" to Q2 and used to cover Q2 emissions (60 pounds), leaving 60 Dec '94 RTCs for Q3.

Facility B, meanwhile, has received its '94 allocation of 100 June '95 RTCs on July 1, which appear in column Q3. It reports emitting 10 pounds, leaving 90 RTCs to carry forward. In the fourth quarter, "B" sells 20 June '95 RTCs to "A". Its account is debited to reflect the transfer, "A's" account credited, and the trade reported to AQMD. "A" now has 40 RTCs available -- 20 December RTCs and 20 June RTCs -- to cover 30 pounds of pollution emitted in Q4. The December RTCs expire at the end of Q4, consequently, when it files its annual report in December 1994, "A" indicates that 20 pounds of its Q4 emissions are covered by 20 December RTCs, 10 pounds by June RTCs acquired from Facility B. "A" has 10 June RTCs to carry forward to Q1 '95.

'B's' emissions in Q1 '95 jump, to 45 pounds. It holds sufficient credits (50 June RTCs) to cover this level, but has only five June RTCs to carry forward. "A" has credits to sell, which "B" buys -- 60 December '95 RTCs. The trade is executed and reported, the accounts updated, and both facilities remain under their allowable emission levels through the end of 1995. Note that Facility B's June '95 RTCs are retired first in Q2 '95. They hold no value beyond that date. "B" files its annual report on June 30, 1995.

Table 2

UNMIXED ALLOCATION

	1994				1995			
FACILITY A	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Allocation	200				180			
Emissions	-80	-60	-40	-30	-50	-15	-45	-15
RTCs bought (+) or sold (-)				+20		-60		
RTCs carried forward		120	60	20	10	140	65	20
Dec. RTCs available	120	60	20	0	140	65	20	5
June RTCs available				10				
FACILITY B								
Allocation			100				90	
Emissions			-10	-20	-45	-45	-10	-20
RTCs bought (+) or sold (-)				-20		+60		
RTCs carried forward				90	50	5	20	100
Dec. RTCs available				0		20	10	0
June RTCs available			90	50	5		90	80

Advantages. The benefits of staggering RTC issue dates are many. For business, staggering the issue (and expiration dates) of RTCs, along with staggered compliance periods, provides greater flexibility than Uniform RTCs, particularly as each compliance period draws to a close. Because there are two sets of instruments available to cover emissions:

1. The cost of meeting pollution standards is reduced;
2. It is easier and less costly to respond to unanticipated events;
3. The potential for emission peaks and/or negative employment impacts is reduced; and
4. Less price volatility is expected.

Furthermore, because the two RTCs are substitutable, market prices should more accurately reflect the marginal costs of pollution abatement. This will raise the likelihood that marginal abatement costs are equated across facilities, an indication of, and requirement for, economic efficiency.

Staggered RTCs can also enhance the effectiveness of reconciliation periods and decrease the incentives for facilities to hold credits as insurance. Remember that, with reconciliation, facilities had an additional opportunity to reconcile emissions information and trade RTCs to cover unanticipated events. They still held incentives, however, to hold excess RTCs to ensure against a market squeeze that reconciliation would not alleviate. If the market were long, due to many facilities holding excess RTCs, the "insurance premium" would be equal to the lost market value of the unused credits. With reconciliation and Staggered RTCs, this premium is lower, if not zero.

If there is any delay in obtaining accurate emissions information, and no reconciliation period is available, facilities will likely report excess emissions to AQMD in order to avoid noncompliance penalties. Staggering the trading instrument will not relieve this problem. With reconciliation and Uniform RTCs, facilities may not choose to overreport, but the market may be long and facilities will lose the economic value of unused instruments, which is their insurance premium. *Combining reconciliation with staggered instruments eliminates the premium.* Reconciliation removes incentives to overreport; staggering allows unused RTCs to be used in the subsequent two quarters.

Commenters have noted that the "business climate" is changing; that businesses have altered

their operating processes and schedules to "produce to sell."[9] In essence, businesses have determined that it is more inventory cost-effective to produce up to levels of demand, but no higher. They argue that this change is fairly recent and, due to their lack of experience producing to meet stochastic demand, it is difficult for them to accurately project emissions and needed RTC holdings. RECLAIM will add, at least initially, an additional level of uncertainty to business planning, simply because it is a new and innovative approach to regulation. To the extent that production is, indeed, demand driven and more stochastic, the additional flexibility offered by Staggered RTCs should be valuable.

For AQMD, staggered compliance periods smooth reactions in the Basin to unexpected events, which means pollution periods should be more predictable and less likely to yield National Ambient Air Quality Standards (NAAQS) violations; businesses will find the adjustment to tighter standards easier; and the risks inherent in pollution management will be reduced. Additionally, the administrative burden represented by annual reports can be spread, with only half the facilities reporting every six months.

Potential Problems. Facilities must enter the trading market in order to acquire the instruments' staggered features. If transaction costs are to be held down (an objective for RECLAIM), a well-functioning market must be in place and operating for this alternative to be fully effective.

DESIGN ALTERNATIVE 4: STAGGERED ISSUE, STAGGERED COMPLIANCE, ALLOCATION WITHIN FACILITIES

Here, rather than dividing facilities into two groups that each receive one type of Staggered RTC (Alternative 3), we divide each facility's allocation between the two types of Staggered RTCs. In other words, all facilities receive half their allocation in December RTCs, half in June RTCs. They receive what we term, a "mixed" allocation (Figure 8). Their allocation of RTCs has been "translated" into two sets of instruments (Figure 9), equal in number to the "unmixed" allocation provided by Alternative 3.

Advantages. The benefits of this variation over those of Alternative 3 are important. The benefits of Staggered RTCs are allocated *with* the RTCs. Under Alternative 3, a facility

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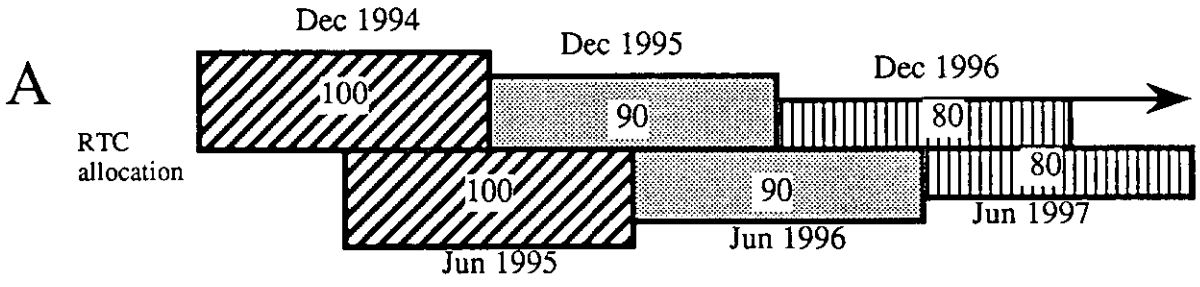
[9]See comments on initial RECLAIM Rules from the California Energy Commission, November 20, 1992; Sharon F. Rubalcava, McClintock, Weston, Benshoof, Rochefort, Rubalcava & MacCuish, December 1, 1992; and Richard S. Zbur, Latham & Watkins, December 11, 1992.

Figure 8

Example: Staggered RTCs with Mixed Allocation

RTCs expiring at the end of:

Facility		1994	1995	1996	1997
A	Dec	100	90	80	70
	Jun		100	90	80
B	Dec	50	45	40	35
	Jun		50	45	40



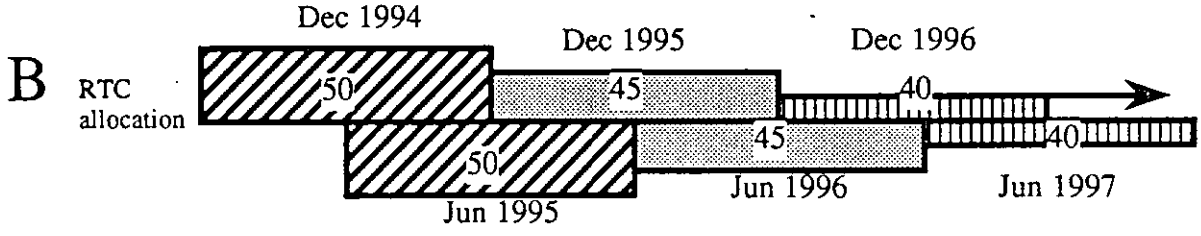
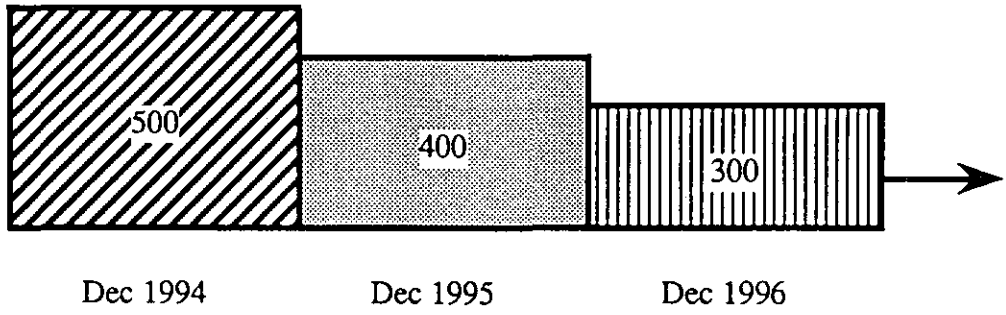


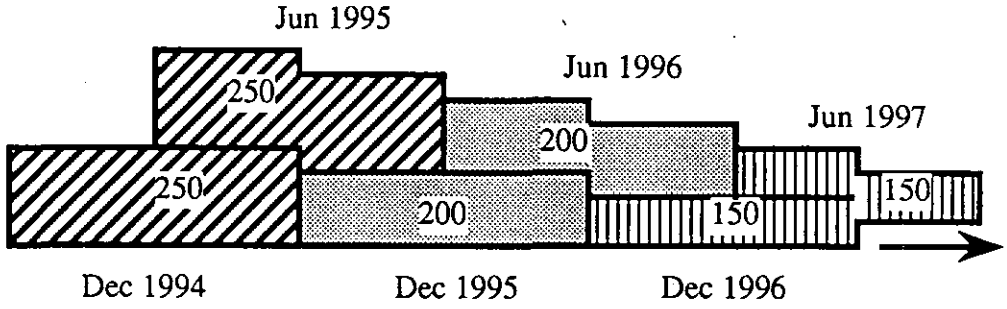
Figure 9

Conversion of Uniform RTC to Staggered RTC Allocation

Allocation of Uniform RTCs



Allocation of Staggered RTCs



RTCs expiring at the end of:

Allocation		1994	1995	1996	1997
Uniform	Dec	500	400	300	
	Jun				
Staggered	Dec	250	200	150	
	Jun		250	200	150

could acquire a mixed allocation only by trading in the market. With Alternative 4, trading to obtain the benefits of the stagger becomes unnecessary, and facilities avoid the associated transaction costs. Finally, by mixing facility allocations, AQMD need not address the issue of what to do with facilities entering the program "six months late." The program can be initiated for all facilities simultaneously, with all receiving RTCs valid in the first six months, and facilities can be easily added to the program without disrupting the balance of instrument types. Those facilities on the June compliance schedule could file an "annual" report after the first six months, or under their normal schedule (after 18 months). Quarterly reporting schedules are unaffected.

Potential Problems. For both Alternatives 3 and 4, the initial allocation of RTCs and assignment of facilities to compliance periods is somewhat more difficult at the outset than with Uniform RTCs. This is discussed below, with suggested approaches for resolving these problems.

Experimental Analysis and Observations. We repeated the pilot experiment outlined on page 15, but distributed a mixed allocation of staggered credits to each subject. Again, subjects traded in spot and forward markets for five "years." A theoretical price path prediction and the actual time-series of contract prices (trades) are illustrated in Figure 10. *Actual prices changed gradually, and there were no spikes or crashes.* In Figure 11, the actual price time-series from the Uniform "RTC" markets is plotted against prices from the Staggered "RTC" experiment. The results are stark and dramatic.

We computed the year-by-year "profits" made by subjects to determine the benefits, *in our experiments*, from each instrument design alternative (Figure 12). In our experiments, subjects earned 12 percent greater profits from staggered credits than uniform credits. We conclude that Staggered RTCs will be more efficient for RECLAIM facilities than Uniform RTCs. Note that these results are valid only for our experiment. They are not intended as an estimate or projection of actual market efficiency.

ALLOCATING STAGGERED RTCs

For the trading market to function efficiently, RTCs must be allocated in roughly equal proportions among compliance schedules or facility groups. Any imbalance in the supply of available credits will create pricing disparities and liquidity problems. Staggered credits will trade in separate, though related, markets. If more RTCs are allocated to and available in one market than the other, prices in that market will probably be lower. There will not be as many credits available in the other and, depending on the number of facilities participating in

that market, prices will probably be higher. It is important to note that the allocation of RTCs is the critical factor in this analysis, not the number of facilities.

Figure 10

Time Path Prices: Staggered Credit

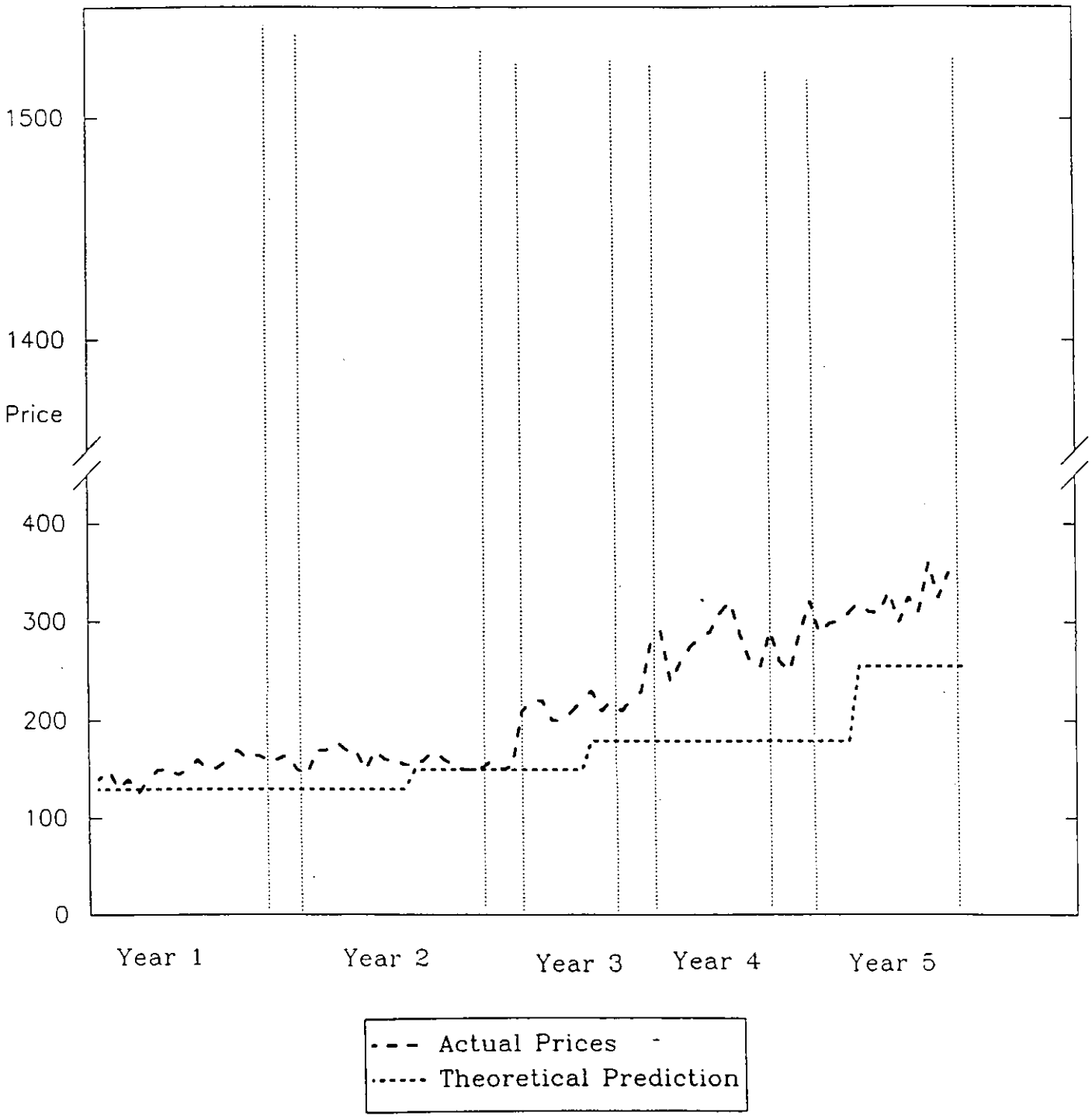


Figure 11

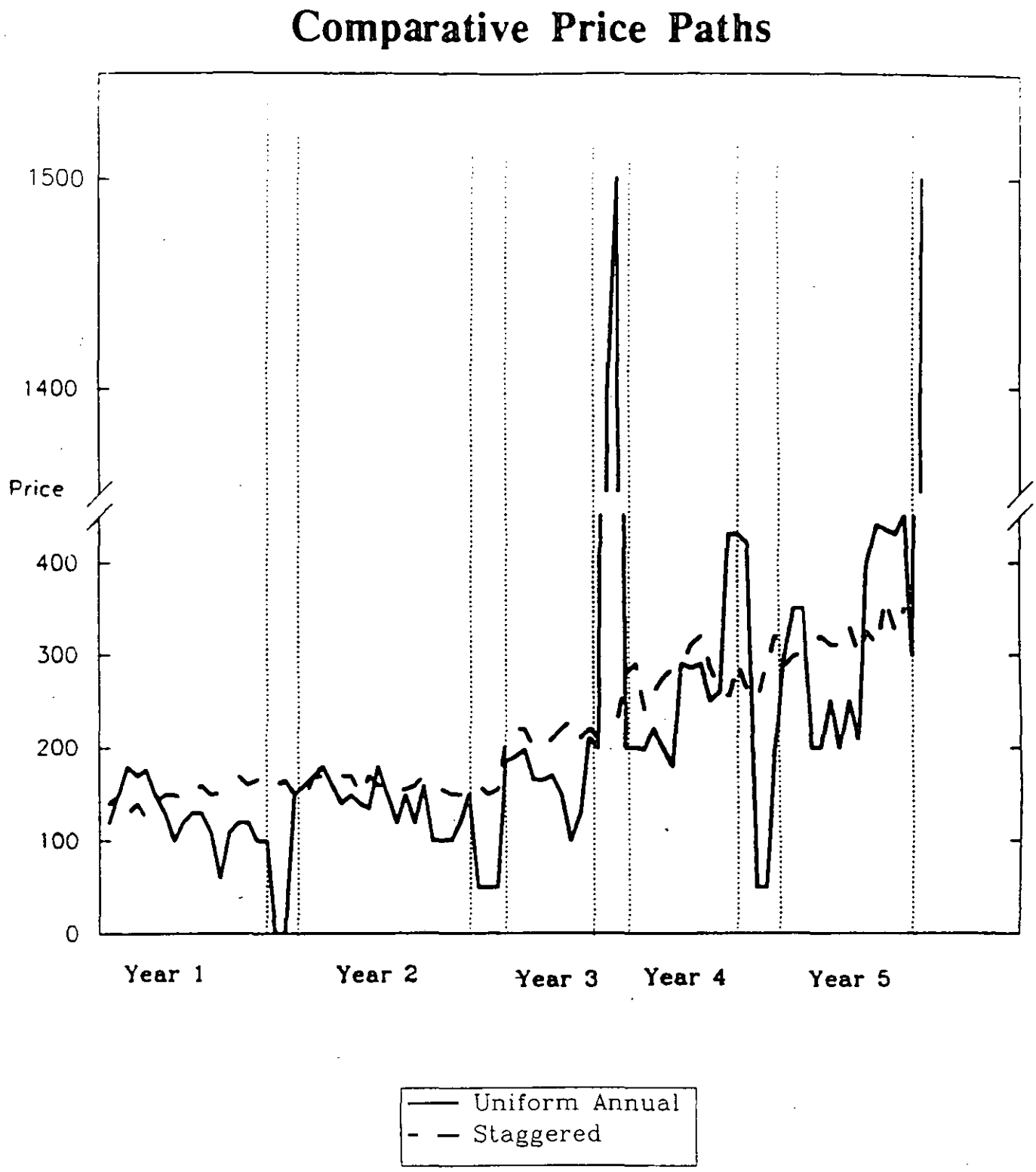
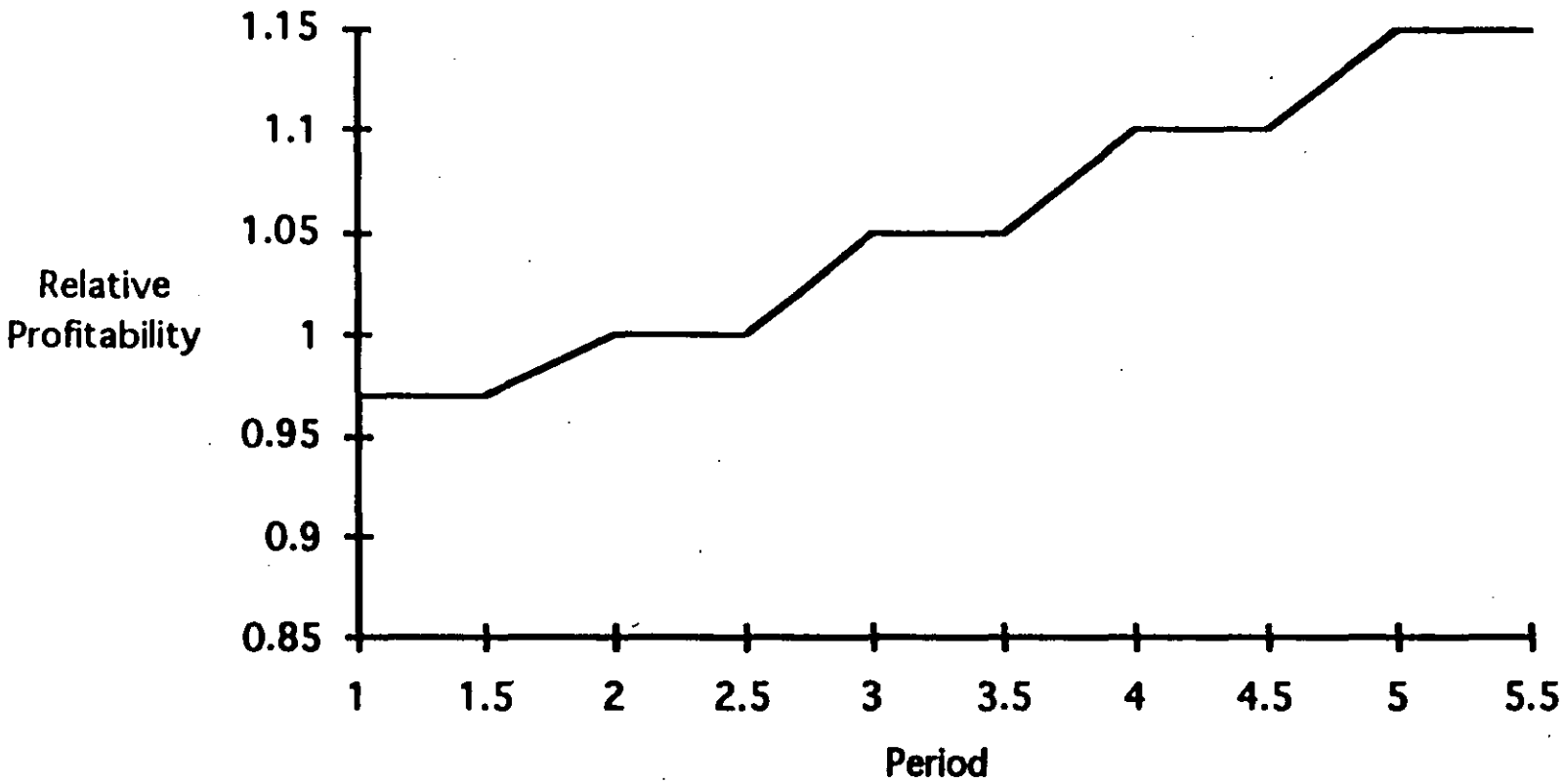

Comparative Price Paths
1500
1400
Price
400
300
200
100
0
Year 1
Year 2
Year 3
Year 4
Year 5
Uniform Annual
Staggered

Figure 12

Cumulative Relative Efficiency: Staggered/Uniform



Half the RTCs for each pollutant regulated in RECLAIM must, in the aggregate, be allocated to each compliance schedule. Facilities that emit a mixture of NOx, SOx, and/or ROC, presumably need to be on the same cycle for each pollutant, and would find it desirable for all their emissions to follow a single cycle. AQMD may find that it is impossible to make such allocations. Consider the RTC allocations for three hypothetical facilities (assumed to be the only facilities in the Basin) illustrated below:

Facility	SOx	NOx	ROC	Cycle
A	10	0	10	1
B	0	10	10	?
C	10	10	0	2

In order to equally divide RTCs for each pollutant between cycles, different cycles must be assigned to Facilities A and C for SOx; A and B for ROC; and B and C for NOx. This is impossible. No feasible cycle assignment provides the necessary division of pollutants and RTCs under a uniform, unmixed allocation of credits.

If the allocation is mixed, however, this problem is entirely eliminated. Consider our three facilities again:

Facility	SOx	NOx	ROC	Cycle
A	5	0	5	1
	5		5	2
B	0	5	5	1
		5	5	2
C	5	5	0	1
	5	5		2

There are equity and administrative issues posed by staggered credits, including:

1. Assigning facilities to a compliance schedule (either January to December or July to June);

2. Accommodating the six-month "delay" between the issue of December RTCs and the issue of June RTCs; and

3. Accommodating RTCs generated by conversion of emission reduction credits (ERCs), area source reductions, and mobile source retirement.

Assigning Compliance Schedules. The AQMD can assign facilities to compliance schedules using several methods. One method would allow facilities to "self-select," choosing their own preferences that best meet business and operating needs. This approach cannot guarantee that the necessary balance between schedules (and markets) will be provided. The assignments could instead be random, or made by lottery, following a predetermined formula aimed at balancing schedules and market allocations.

Accommodating the "Start-Up" of RECLAIM. If the allocation of RTCs is divided between facilities -- i.e., half receive December RTCs, half June RTCs -- what should be done in the first six months of RECLAIM with facilities placed on the July-to-June compliance schedule? There are two basic alternatives: continue to regulate those facilities under "command and control" for six months, or proportionately distribute RTCs after adding six months to the duration of the program. While the latter would marginally reduce initial allocations, over the life of the program the cumulative allocations would be the same. A mixed allocation alleviates this "start-up" problem, and further reduces the marginal impact of spreading allocations over a longer time period.

Accommodating Other Sources of RTCs. Both new facilities and RTCs generated by ERCs, area source reductions, and mobile source retirements can be more easily added to RECLAIM using the mixed allocation alternative. Mixed allocations eliminate the need to make several sensitive decisions. For example, when ERCs are converted into staggered RTCs, into which cycle will they fall? One might assume they would be assigned to the same compliance schedule for the facility holding the ERCs, but that would not necessarily maintain the equilibrium of RTCs on each schedule in each zone (see below). If AQMD chose to randomly assign ERCs -- in each zone, to each cycle -- facilities might argue they are being unfairly forced to turn to the trading market to balance their RTC allocations. A mixed allocation, however, allows AQMD to convert a facility ERCs into half June RTCs and half December RTCs, *automatically* maintaining a balance of RTC-types in each zone and without distorting facility holdings. This also represents a reduction in AQMD's administrative burden. The creation of RTCs from mobile source retirements and area source reductions can be similarly accommodated, by issuing a mixed allocation to their owner(s).

TANNER SENSITIVE ZONE: TRANSFER RESTRICTIONS

In order to comply with the California's Tanner Sensitive Zone legislation, AQMD has proposed dividing the Basin into two zones, and restricting the transfer of RTCs between facilities in each zone. Facilities in the downwind zone would not be allowed to transfer RTCs to upwind facilities; however, upwind facilities could transfer RTCs to facilities in either zone. This is a trading restriction. It is not an additional dimension of the RTC. The distinction is extremely important. In restricting trades, each time an upwind facility sells RTCs to a downwind facility, the supply of upwind RTCs available to all upwind facilities is diminished and can never be replaced. The acquired RTCs, even if never used by the downwind purchaser, cannot be sold back to the upwind zone, to either the seller or another upwind facility, despite having originated in the upwind zone. Simply said, trades from upwind to downwind facilities are irreversible, with real economic inefficiencies the expected result.

Upwind RTCs will command market prices higher than or equal to downwind RTCs, but never lower than downwind prices on a sustained basis. (If upwind RTC prices were lower than downwind, purchases by downwind facilities would quickly bid upwind prices to downwind levels. Lower upwind prices are thus not sustainable. But upwind facilities cannot, under the AQMD proposal, purchase downwind credits; therefore, if downwind RTCs are less expensive than upwind, upwind facilities cannot bid them higher.) Marginal abatement costs may simply be higher for upwind than downwind facilities, perhaps due to the composition of industries in each zone. If that is the case, the proposed trading restrictions preclude the arbitrage activity necessary to equate prices in the two markets, and the higher upwind prices will prevail.

If, on the other hand, prices are equal and upwind facilities sell RTCs to downwind facilities, the number of RTCs eligible for use by upwind facilities will decline; upwind RTC prices will eventually rise as supply diminishes, and with them, compliance costs for upwind facilities. Recognizing this possibility, upwind facilities may elect to hold their RTCs as insurance. With AQMD's proposed trading restrictions, once an upwind RTC is sold to a downwind facility that RTC becomes a downwind credit, ineligible for transfer back to the zone of origin. The "loss" of the upwind RTC is irreversible.[10]

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[10]For the proposed restriction to be effective, AQMD must be able to identify and track the location of sellers, buyers, and RTCs.

The irreversibility of downwind sales is an additional wedge in market forces. Facilities will not hold RTCs simply to cover emissions, but also to avoid the additional risk of having to purchase (upwind) credits at potentially higher prices in the future. While this approach is basic for all facilities, it is particularly acute for those in the upwind zone. Selling upwind RTCs to downwind facilities decreases the available supply of credits to cover upwind emissions, with the expected effect a rise in prices. Cheaper or not, downwind RTCs are not an alternative for upwind facilities. Downwind facilities will not face this problem and, indeed, they may see an apparent increase in the available supply of credits, because upwind facilities' demand has no effect on prices for RTCs transferred to the downwind zone. These price differences represent a divergence in marginal abatement costs across zones -- an economic inefficiency exacerbated by irreversible trades.

Alternatives to the transfer restriction could protect the sensitive zone while minimizing both pricing disparities and the economic inefficiencies induced by irreversible downwind trades. AQMD could allow "netting" of trades between zones, whereby the net number of RTCs transferred to the upwind zone from downwind facilities must be less than or equal to zero. If, for example, cumulative trading from upwind to downwind sources totaled 100 December 1996 RTCs, upwind facilities could be permitted to transfer up to 100 December 1996 RTCs from downwind sources. There would be no net increase in the number of RTCs in the upwind zone, and air quality in the Tanner Sensitive Zone would not be affected; the resulting air quality would be the same as if no trades had occurred. Netting would also improve market liquidity, broadening the utility and applicability of downwind credits.

If improved air quality in the Tanner Sensitive Zone over and above that provided for the entire Basin is desirable, this netting alternative could be modified. Rather than a maximum zero net balance, the RECLAIM rules could provide for a specific net decrease in upwind RTCs. For example, if 100 RTCs are transferred from upwind to downwind facilities, 80 or 90 RTCs could be allowed to transfer from the downwind to the upwind zone. While a lesser number would provide for improved air quality in the upwind zone (since transferred upwind credits cannot be replaced one-for-one), pricing problems would remain, though these, too, would be reduced.

Implementation of a netting alternative requires tracking of trades across zones and providing the means for facilities to determine the benefits of trading across zones before they trade. Before availing themselves of this alternative, upwind facilities would need to be certain any downwind RTCs they purchase can be used to cover emissions. Interzone

trades will also require an ability to track time of execution, so that RTC transfers exceeding the limits of netting can be identified and disallowed. Disputed trades could be resolved in favor of time-priority.

These operating requirements are available in mature, sophisticated markets.[11] They may not be immediately available in the markets offered for RTC trading, though the markets can be relieved of this burden if the terms of the RTC include identification of the zone of origin, and the trading restrictions were applied to RTCs, not trades.

What we have in mind here is a zonal restriction that precludes upwind facilities from using downwind RTCs (so designated by their terms, just as they are by issue and expiration dates) to cover emissions. In this alternative, RTCs sold by an upwind facility to a downwind facility could subsequently be transferred to a facility in the upwind zone. Despite the first trade, the transferred RTCs remain upwind credits; their transfer does not alter their designation. The number of RTCs eligible for use in each zone would not change until credits are retired. By approaching the netting alternative in this fashion, AQMD need not "pre-approve" each trade nor track interzone trading. The necessity of tracking the location of each trader is also obviated: location is included as a dimension of the RTC.

To illustrate both the application and advantage of this alternative, consider two upwind facilities -- U1 and U2 -- and two downwind facilities -- D1 and D2. Assume D1 is bidding for (wants to buy) 10 RTCs. U1 is offering 10 RTCs; it wants to sell 10 of its upwind credits. The two facilities agree on a price and the trade is executed. Subsequently, U2 bids for 5 RTCs and D2 offers 5. Under the AQMD proposal, this transaction cannot be completed, even though the number of upwind RTCs has declined (by 10, thanks to the prior trade). In our alternative (i.e., if the RTCs were designated by zone of origin), this trade could be executed, contingently, after the first trade had been executed and confirmed. Assume the facilities hold their initial allocations in either upwind or downwind RTCs before trading begins.

Again, before U2 and D2 display bids and offers, D1 and U1 trade 10 RTCs. Subsequently, U2 wants to buy five, and D2 sell five, but D2 cannot sell downwind credits

[11]For example, the futures exchanges maintain daily price limits for each underlying commodity and financial instrument that bracket maximum price movements (up or down) permitted in a single day. Once these prices are reached, additional trades can be executed only at or between the limit for the balance of the day. New limits are established for subsequent trading sessions. In addition, the futures and securities exchanges have established "circuit breakers" to curb the velocity of market volatility. A drop of 250 points in the Dow Jones Industrial Average prompts a one-hour trading halt in stocks, stock options, and stock index options and futures. When the markets resume trading, a further 150-point decline in the Dow prompts a second halt, and may result in the markets closing early that day.

(under the AQMD proposal) to U2, an upwind facility, nor can it find a downwind buyer for its instruments. With our proposal, D2 could trade around this problem while still ensuring equivalent protection afforded to the sensitive zone. The necessary trades are illustrated in the following "accounts":

D1 purchases 10 upwind RTCs from U1, a permissible trade under the AQMD proposal. U1's account is debited, D1's credited.

U1	U2	D1	D2
-10U		+10U	

D1 sells five upwind credits to D2; D2 sells five downwind credits to D1. They "swap" upwind and downwind RTCs. D2 has "converted" five of its downwind holdings into upwind RTCs.

U1	U2	D1	D2
-10U		+10U	
		-5U	+5U
		+5D	-5D

D2 sells the five converted upwind credits to U2. The number of RTCs in the upwind zone before any of the trades occurred is reduced by five.

U1	U2	D1	D2
-10U		+10U	
		-5U	+5U
		+5D	-5D
	+5U		-5U

This chain of contingent trades carries transaction costs for the participating facilities, but

they may be lower than those generated by AQMD having to track interzone trades, and the costs of the system are borne by the users who benefit, not AQMD.

If all bids and offers were submitted simultaneously, of course, the contingent trades would be unnecessary. U1 would simply sell five RTCs to U2 and five to D1, which would then buy an additional five from D2. The problem addressed by contingent trades comes from sequential executions, both from the inability to "see" all bids and offers at one time (which could occur with multiple market centers trading RTCs), and from the real time between executions.

In either of the alternatives, the proposed zonal restrictions pose fewer complications for the mixed than the unmixed allocation of staggered RTCs. If credits are allocated between groups of facilities, the groups cannot simply be divided by location. All upwind facilities cannot be on one compliance schedule with one type of RTC while downwind facilities are on the other. The allocations must be geographically balanced if the proposed trading restrictions apply. A mixed allocation within facilities removes this problem: Regardless of the number of facilities in either zone, the proportion of RTC-types will be the same across and within zones. Additionally, facilities not included in RECLAIM initially can be added to the program without disturbing the proportion of June to December RTCs in each zone.

OPTIMAL NUMBER OF STAGGERS

There are demonstrable benefits in providing two instruments for market-based regulatory programs, like RECLAIM. Depending on the number of facilities included in each program, there may be additional benefits generated in offering more than two instruments, though additional instruments also generate additional costs, both to facilities and to the regulator. Identifying and tracking each credit becomes more difficult when the number of different instruments increases. Since each credit trades in a "separate" market, there will be more markets and less overall liquidity, which raises transaction costs to facilities. To a certain extent, there are more advantages to the mixed allocation method than the allocation of credits between firms when multiple instruments are issued by the regulator.

The point at which the costs of multiple instruments exceed the benefits provided has not been addressed, and the authors cannot determine what number of trading credits is optimal, for RECLAIM or any similar program.

Appendix: Experimental Methods, Design and Results

The purpose of this appendix is to provide background information and details of the procedures and parameters utilized in experiments to evaluate uniform credits versus staggered credits in the design of the RECLAIM trading instrument. Since many readers may not be familiar with experimental methods in economics, a brief introduction on the methodology is provided.

Part I. Overview of Experimental Methods

Several approaches to RECLAIM trading instrument design can be proposed; however, it is necessary to develop a method to evaluate each approach. The problem is intensified when there is no operational history of the market in question, and when the market design to be considered is unique and virtually untested. While one can gather data on environments and designs that may be analogous, conclusions reached by such methods cannot be rigorously supported. In the engineering sciences, analysis of new techniques or designs is usually evaluated through laboratory methods, simulations, and "testbed" procedures. This study uses these same methods in analyzing the properties of possible designs for the RECLAIM Trading Credit (RTC).

Laboratory methods for analysis of economic issues have been developed and refined over the past 30 years. Use of these techniques allows for the detailed analysis of RECLAIM trading instrument designs (see Plott [1986,1992] and Smith [1982,1992] for a more comprehensive review of experimental methods in economics). The basic process is to conduct controlled experiments in which live subjects act as market participants. Each subject is provided with a detailed profit function, including uncertainties, costs, benefits, risks, and market procedures.

The main purpose of conducting an experiment in any field is to obtain reliable measurements of the phenomena in question, so that hypotheses can be tested with confidence. The measurements are reliable because the parameters in the experiment are controlled by the experimenter, can be replicated, and the experimental outcomes can be analyzed without confounding factors.

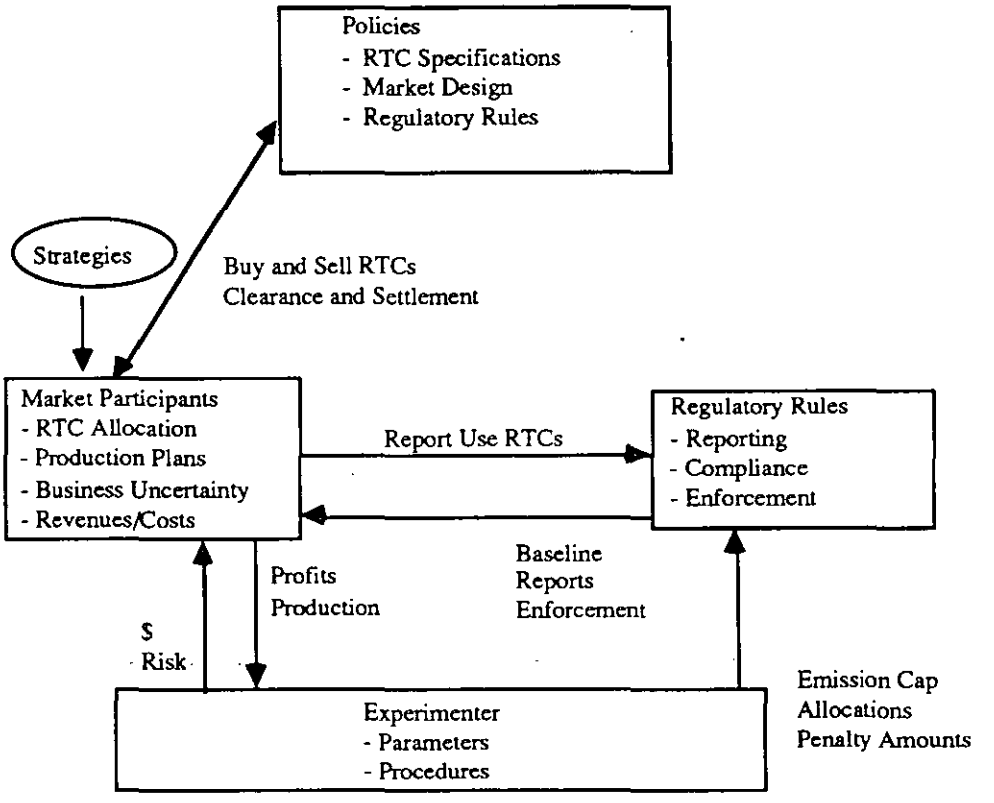
The key parameters in economic experiments are the values participants place on the resources being exchanged. These preferences are induced on individuals using monetary payoffs (see Smith [1976]). That is, control over preferences and exchange opportunities in an experiment is exerted by providing monetary rewards related to the decisions made by subjects in a prespecified manner. As long as the rewards are salient, relative to the subjective cost of participating in the experiment, control can be maintained.

As an example, in an experimental market, subjects engage in the trade of a fictitious commodity. Buyers in the market put value on the "commodity" because they make money by purchasing it from sellers and then reselling it to the experimenter at a predetermined redemption value or schedule.

Sellers profit by capturing the difference between their selling price to buyers and their prespecified cost schedule. In the context of possible RECLAIM trading instrument designs, preferences (revenues minus costs) can be induced that correspond to the derived profits to a firm when emissions are one of the factors of production. It is these parameters that will define the economic environment of an experiment over which the experimenter has control.

The next element to be specified in an economic experiment is the mechanism (institution) through which transactions and information are governed. This element provides the complete description of the policy that operates in the economic environment. For the experiments reported below, this element allows for the testing and analysis of the comparative performance of alternative RECLAIM trading instrument designs. That is, given the parameters specified in the experimental environment, the decisions made by participants can be recorded, and then various aspects of the trading process (prices, allocations, profits, production decisions, etc.) can be compared. Figure 1 is an overview of the experiment testbed.

Figure 1
Experimental Testbed Overview



In general, subjects are recruited to participate in an experiment in which they are told they will earn money -- but the amount they will earn depends on the decisions made during the experiment (typically, undergraduate or graduate students subjects can expect to earn $15 to $20 per hour spent in

the experiment, although with wide variations depending on how well they make decisions). The specifics of the experiment are contained in a set of instructions that describe each subject's payoff function, the trading mechanism, and reporting/accounting rules.

To summarize, the use of experimental methods in evaluating various market designs for RECLAIM allows this study to systematically evaluate policy performance in a controlled environment. The experiments provide a source of experience and data about how various policies might work. The experimental environment created below attempts to discover the efficiency and price behavior in a very simple but detailed environment with features that are likely to be present in the RECLAIM market. Implementation of policies in the testbed environment provides a first-stage evaluation of the instrument design properties.

Part II. Experiments with RTC Instrument Designs

We will now describe the basic parameters of our experiments, the timing of decisions and reporting, and experimental procedures used to implement the market.

1.1 Testbed Parameters

1.1.1 Individual Valuations for Emissions

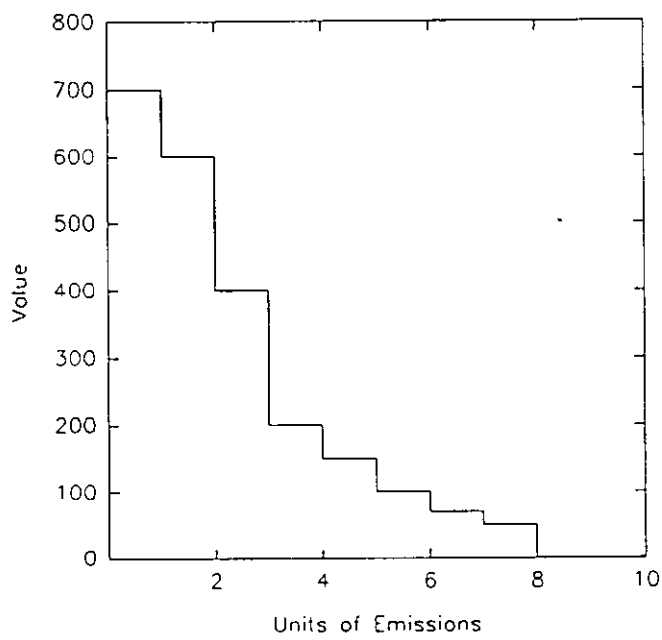
The valuation for units of emission is based on the derived profit for emissions. For each participant, i, the profit function V(·) was induced using monetary payoffs based on the following structure:

$$V_i(x_i) = \max_{X_i} P_i(q_i)q_i - C_i(X_i, Z_i)$$

$$q_i = f_i(X_i, Z_i)$$

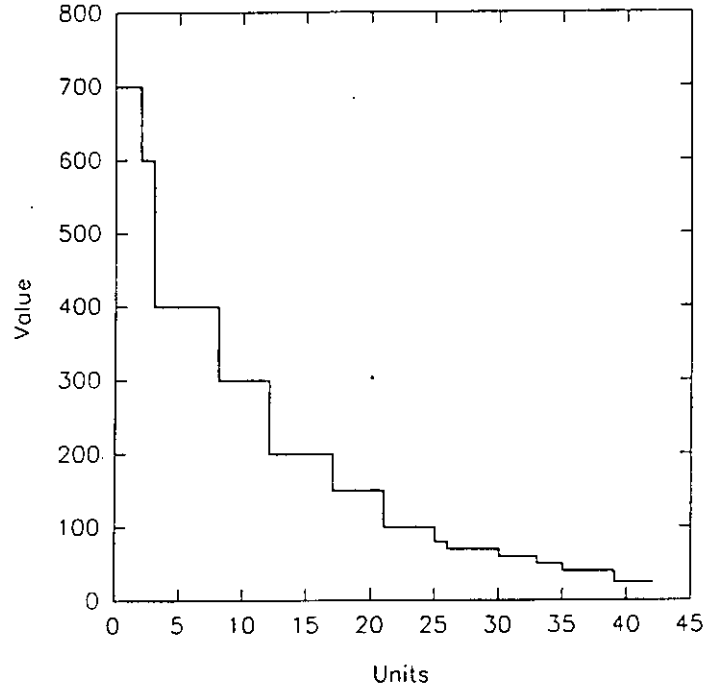
where X_i is the level of emission "used" by firm i, P_i is the price of the product produced using X_i and Z_i through the production function f_i with associated costs C_i. For example, the actual marginal [V'(x)] derived per-period profit function for Subject 1 used in the experiments is provided below:

Figure 2
Marginal Valuation Function for Subject 1



The per-period market demand based on subject marginal valuations is given in Figure 3. These provide the basis for the demand conditions we will use for the calculations in section 3.0.

Figure 3
Underlying Market Demand Function for Emissions



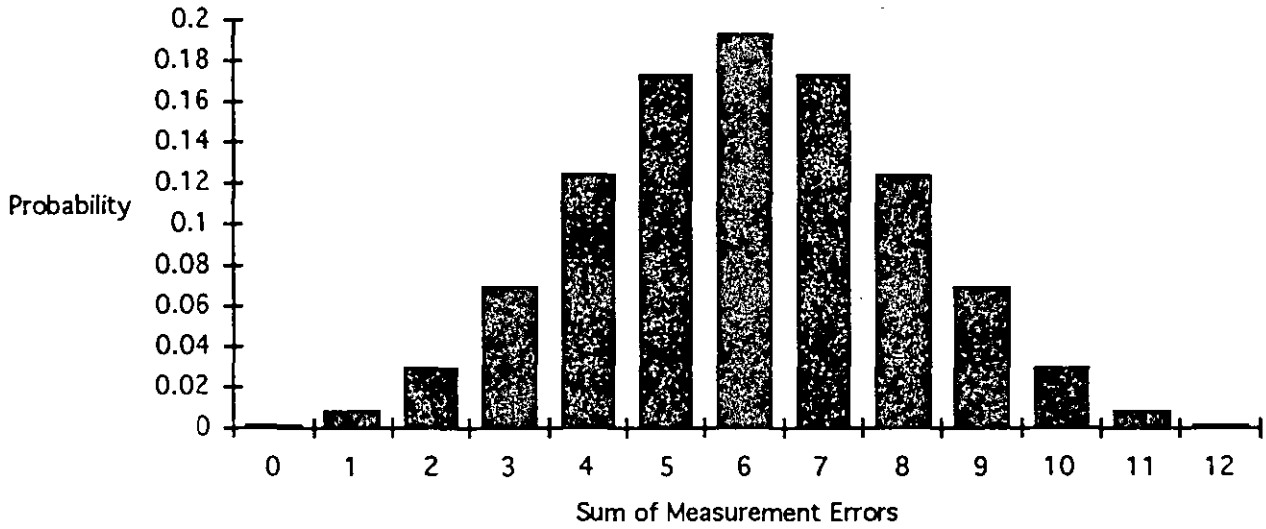
The demand conditions were stationary; i.e., the valuations did not change from year-to-year of the experiment, for the entire experiment.

1.1.2 Business and Measurement Uncertainty

In each experimental production and reporting period, participants, did not know the exact amount of credits needed to be in compliance. The actual number of emission units[1] used was subject to uncertainty. At each reporting period, due to measurement and/or demand uncertainty, the user would first report units used (this amount determined individual value) and then opened a measurement error envelope that contained either a 0,1, or 2. These outcomes were known to all to be equally likely events. This amount was added to the reported amount used to determine the actual number of units to be retired to meet compliance. For example, if Subject 1 reported the use of 4 units of emissions, she would receive the amount V(4) from her redemption value function. She would then open her current reporting measurement envelope and add the amount contained therein to her report. If the measurement error was 1, five units were transferred from her appropriate credit emissions account to comply. Given there are six subjects in the experiment, the probability over the sum of the measurement errors is a triangular distribution that is provided below (we will use this information when we calculate the competitive equilibrium in section 3.0.)

[1] We use the term units as opposed to pounds since such descriptive terms are not appropriate to use in experimental descriptions.

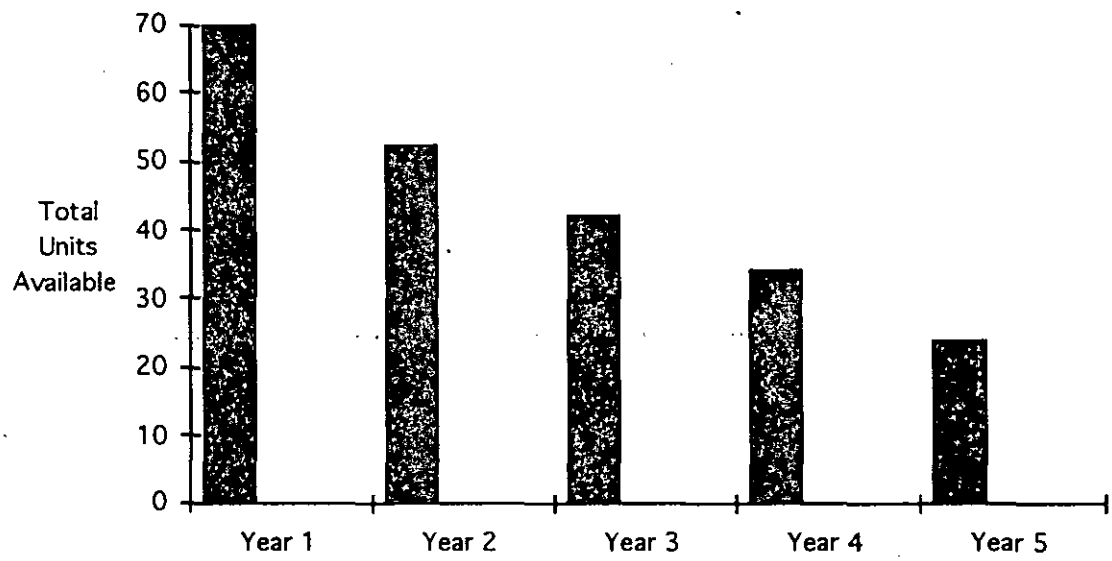
Figure 4
Distribution of the Sum of Measurement Uncertainty



1.1.3 Emission Caps

In the experiments, a constraint on the aggregate amount of emissions that could be assigned for a "year" was set (see Figure 5). The annual caps were then distributed among the participants as emission credits to be used in their production decisions. Notice that the aggregate emission cap falls each year. The terms of the credit are a major design variable in the experiment and we will discuss their implementation in depth in section 1.3.

Figure 5
Aggregate Emissions Cap



1.2 Timing of Decisions, Reporting, and Enforcement

The experiment was divided into five intervals we called years. Each year consisted of two reporting **periods** in which subjects made production plans, reported emissions, and bought and sold emission credits. The figure below shows the timeline of events in our testbed. Notice that each participant first selected the production input and then determined the exact level of emissions used for the period. In the event that a participant does not have enough of the needed emission credits in his account, he was assessed a penalty of 1600 in experimental currency (this is $4.00 when converted into U.S. currency) for each unit over the actual emissions. This amount is subtracted from his earnings.

Figure 6
Experiment Decision and Reporting Timeline

Spot Market Year 1		Reconciliation	Spot Market Year 2		
Forward Markets Years 2-5		Market	Forward Markets Years 3-5		
Open		Year 1 Open	Open		
Trade Units	Trade Units	Trade Units	Trade Units	Trade Units	Trade Units
Year 1	1.1	1.2	Year 2	2.1	2.2
Start	Midyear 1 Report	Year 1-End	Start	Midyear 2	Year 2
	Learn Actual	Report		Report	Report
	Certify Use	Learn Actual		Learn Actual	Learn Actual
	Transfer Units	Reconciliation		Certify Use	Certify Use
		Certify Use		Transfer Units	Transfer Units

Spot Market Year 3		Reconciliation Market	Spot Market Year 4	
Forward Markets Years 4-5		Year 3 Open	Forward Markets Year 5	
Open			Open	
Trade Units	Trade Units	Trade Units	Trade Units	Trade Units
Year 3	3.1	3.2	Year 4	4.1
Start	Midyear 3	Year 3-End	Start	Midyear
	Report	Report		Report
	Learn Actual	Learn Actual		Learn Actual
	Certify Use	Determine over/under		Certify Use
	Transfer Units	Reconciliation		Transfer Units

1.3 Terms of the Emission Credit: The Main Design Variable

In the experiments reported below two different emission credits were designed: a *uniform annual* credit and a *staggered* credit.

1.3.1 Uniform Credit with Reconciliation Market

Under this instrument design, each participant was allocated a portion of the annual cap defined in Figure 5. This allocation provided a participant with a portfolio of emission credits for each of the five years of the experiment that could be used against actual emissions in each year. Participants could only use current year credits in their account to meet actual emissions. Participants could add or subtract units to any of their five annual credit accounts by buying and selling credits in the appropriate market. Thus, at anytime during the experiment, participants could trade in both spot and forward annual credit markets. For example, in Year 1 there were four forward markets (Years 2,3,4, and 5) plus the current year spot market; in Year 3 there were two forward markets (Year 1 and 2 credits are retired).

At the end of each year, a reconciliation period was provided to allow participants (who did not have enough emissions credits in their current year account to meet their actual emissions) to try to purchase credits from those individuals with unused credits in their current year account. It should be noted that any unused credits held by a participant would expire worthless, and the penalty for noncompliance was 1600 per unit. The annual caps were distributed to participants by period as described in Table 1 below:

Table 1

Annual Allocations of Emissions

Participant	Year 1 Allocation	Year 2 Allocation	Year 3 Allocation	Year 4 Allocation	Year 5 Allocation
Subject 1	6	4	4	2	0
Subject 2	16	12	10	10	8
Subject 3	6	4	4	4	4
Subject 4	14	12	10	8	6
Subject 5	18	12	10	8	6
Subject 6	10	8	4	2	0
Total	70	52	42	34	24

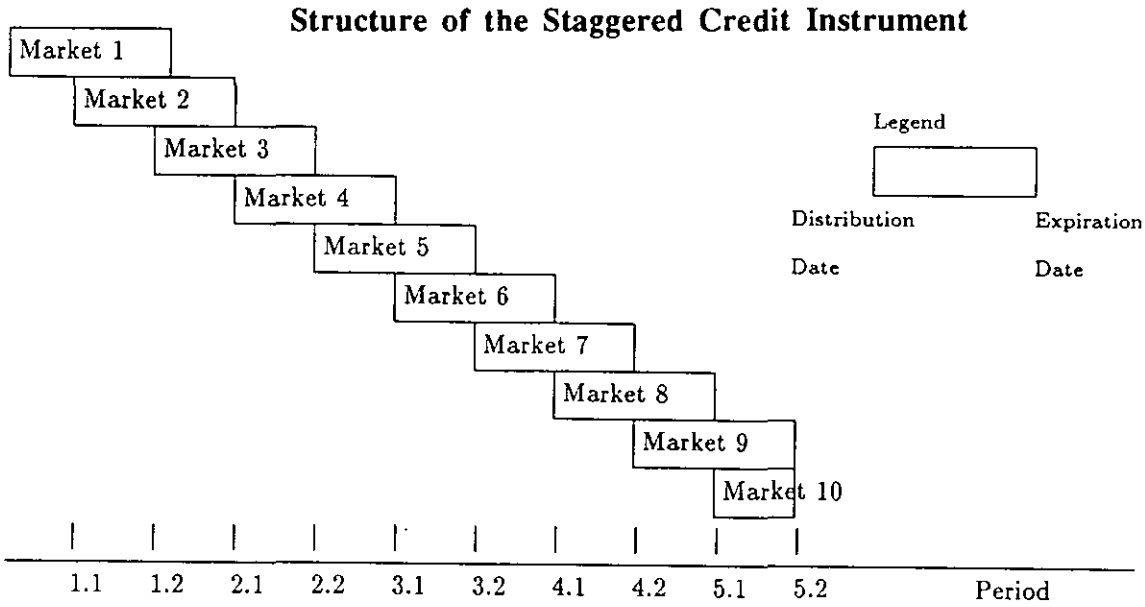
1.3.2 Staggered Credit Design

The annual cap profile in Figure 5 was divided into two allocations per year. Thus, at the beginning of Year 1 there are 10 markets open (one spot market and nine forward markets). The

structure of the staggered credit for compliance purposes is provided in Figure 7. The figure shows that at the first reporting period in Year 1, credits held in either markets 1 and 2 can be used for compliance; i.e., each credit instrument has a two-period life.

Figure 7

Structure of the Staggered Credit Instrument



The annual caps were distributed to participants by period as described in Table 2 below:

Table 2

Staggered Initial Allocation of Emissions Credits

Participant	Market Allocations									
	1	2	3	4	5	6	7	8	9	10
Subject 1	3	3	2	2	2	2	1	1	0	0
Subject 2	10	6	5	7	5	5	7	3	4	4
Subject 3	1	5	2	2	1	3	2	2	2	2
Subject 4	10	4	8	4	5	5	4	4	5	1
Subject 5	10	8	5	7	5	5	6	2	3	3
Subject 6	8	2	5	3	2	2	2	0	0	0
Total	42	28	27	25	20	22	22	12	14	10

1.4 Trading Mechanism

Credits in either the uniform annual credit or the staggered credit design could be traded through an electronic real-time trading market called the multiple unit double auction (see Johnson et al. [1989]). This market uses the same rules found on major stock exchanges in the United States (e.g., New York

Stock Exchange, Pacific Stock Exchange, etc.), where traders submit bids and asks with the bid-ask spread determined by a standard bid-ask improvement rule. Subjects could trade in any markets that were open so that spot and forward contracts could be made. Short-selling was prohibited. The software maintained all of the cash accounts and credit accounts across all markets and participants. Thus, subjects were always aware of their credit holdings in all markets.

2.0 Experimental Procedures

Subjects for the experiments were recruited from the undergraduate population at the California Institute of Technology. A prerequisite to be in the experiment was that the participants needed to be familiar with the electronic double auction software. Thus, each participant had to have participated in a previous unrelated market experiment. Each experiment lasted approximately two hours. The instructions used in the experiments are provided in A.l. Two experiments, one for each of the emission credit designs, were conducted.

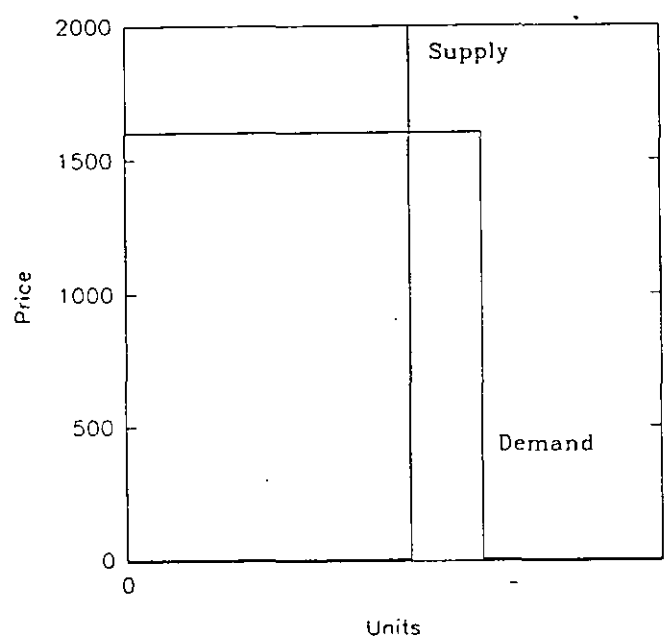
3.0 Competitive Equilibrium Predictions

3.1 Uniform Annual Credit Market

For the annual credit market, the demand for credits requires the calculation of what occurs in the reconciliation market. Since the demand for credits in the reconciliation period is elastic at 1600 per unit, the penalty for noncompliance and the supply of credits is elastic at O, unused credits expire worthless, the market supply and demand is similar to what is depicted in the figure below.

Figure 8

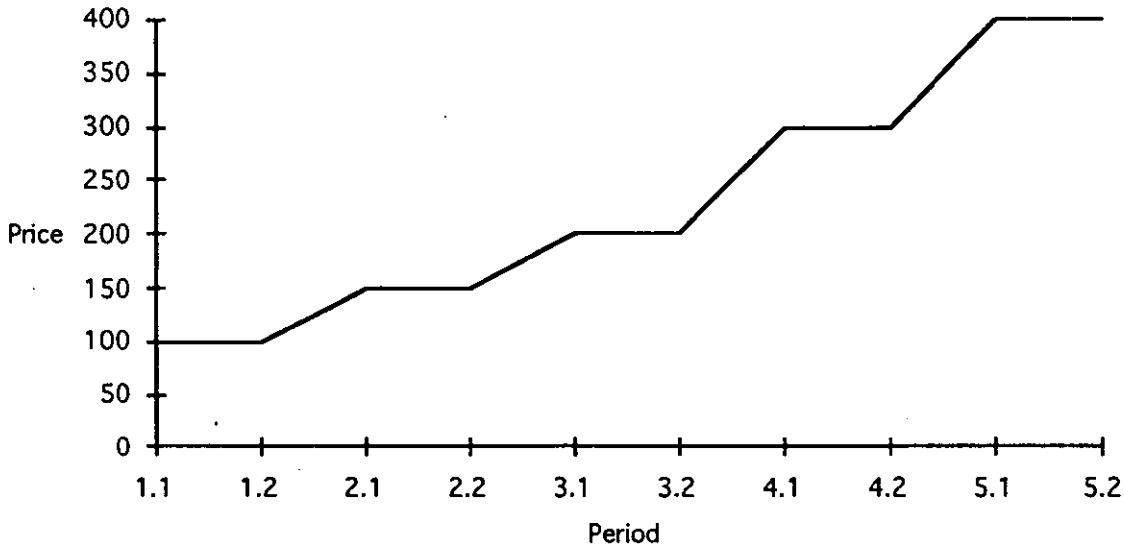
Supply and Demand During Reconciliation



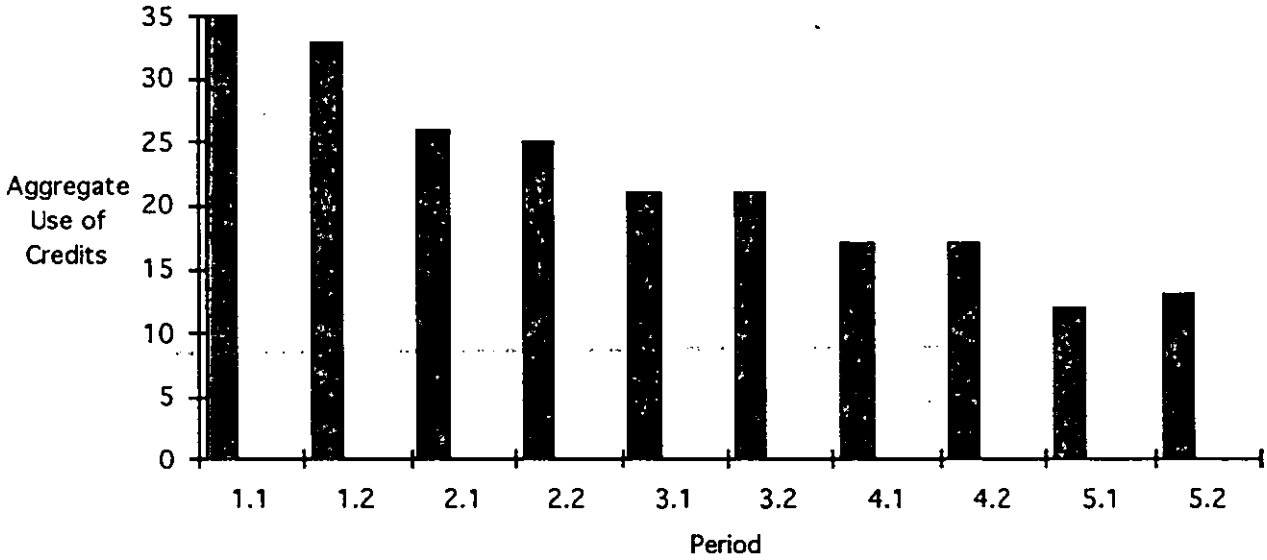
Thus, the predicted competitive price during reconciliation will be O if the market *is long* (supply greater than demand), 1600 if the market is *short*, and the price can be anywhere between O and 1600 if supply and demand match (we use the midpoint of 800 for calculation purposes). Given this outcome during the reconciliation period, for any year the individual demand for each participant is determined by solving a maximization problem based on the probability of the excess demand valued during reconciliation. With this structure we can calculate the *ex ante* price path and production decision for the market. This information is provided in the figure below.

Figure 9

Expected Competitive Equilibrium Price with Annual Uniform Credit



Expected Competitive Use with Uniform Credit

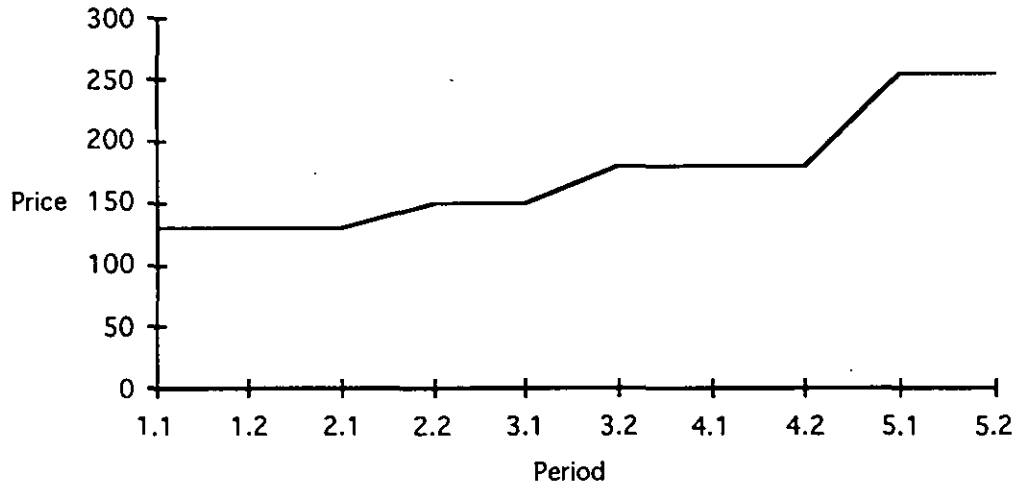


3.2 Staggered Credit Market Predictions

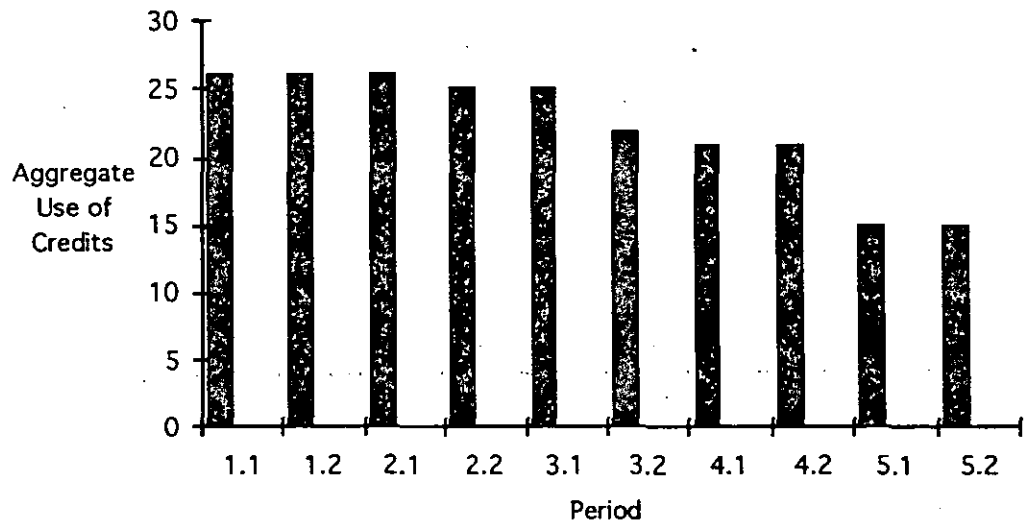
For the staggered credit, under the competitive assumption, each participant would react according to a Kuhn-Tucker maximization problem based on carryover amounts. In general, given that demand is static, individuals would like to smooth production so that use is the same for each period. However, since there are only limited carryforward possibilities, production cannot necessarily be leveled across periods. Indeed, one clear prediction is that participants should report use of the shortest vintage credits in their compliance reports first. The equilibrium price and production paths are given below:

Figure 10

Expected Competitive Equilibrium Price Path with Staggered Credit



Expected Equilibrium Use Path

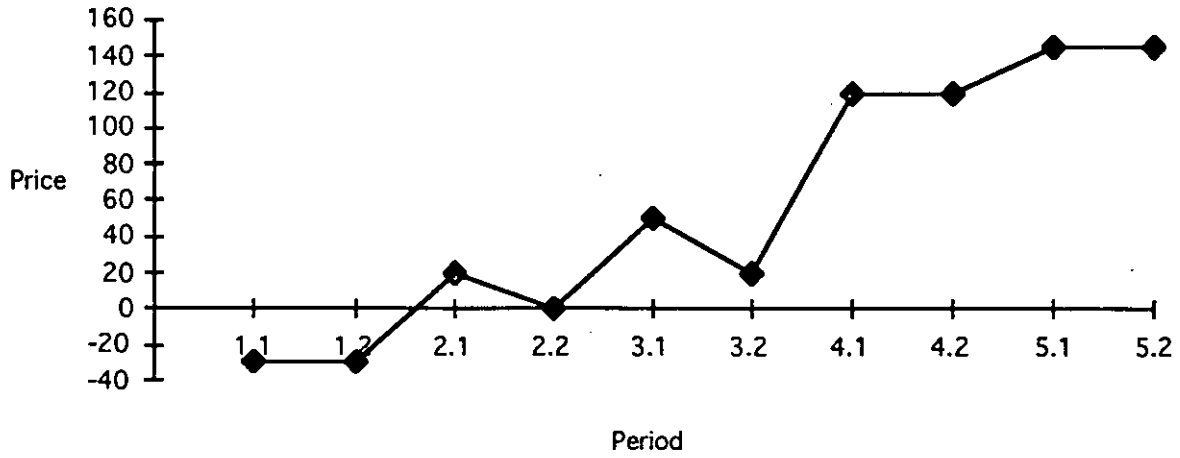


3.3 Comparative Predictions Uniform vs Staggered

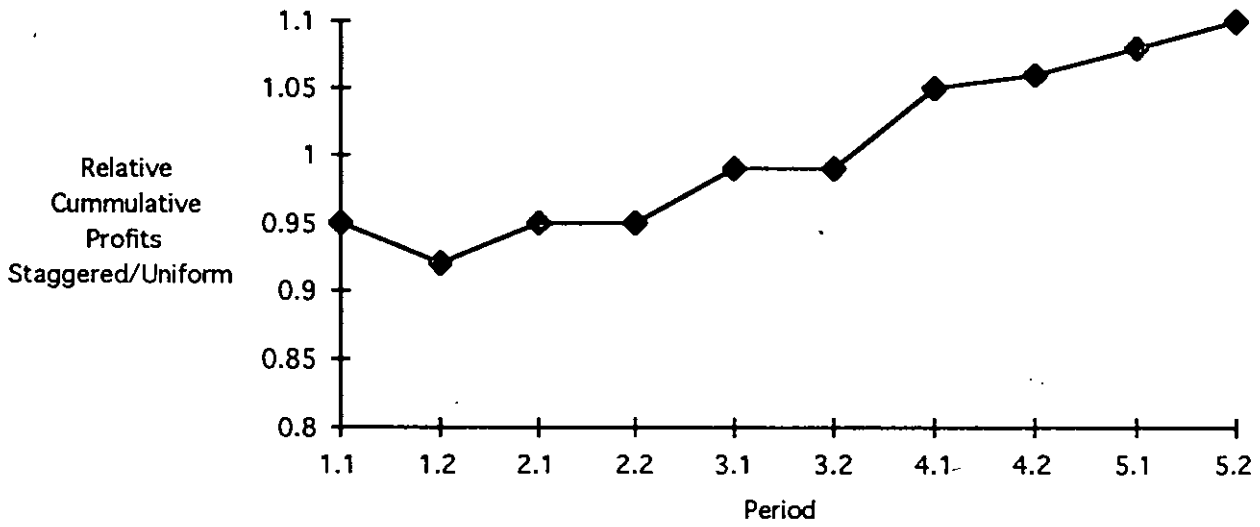
Over the life of the experiment, we can compare the predicted price path and efficiency for the uniform vs staggered credit. The figure below shows the price path differences and the comparative profitability (without discounting) on the participants in this experimental environment.

Figure 11

Comparative Price Path: Uniform Minus Staggered



Relative Cumulative Profits by Year [Staggered/Uniform]



The price and production paths are based on stationary demand and no discounting of profits.

4.0 Experimental Results

In this section we provide the results of the experiments in terms of price formation, credit usage patterns, and comparative performance of the credit designs.

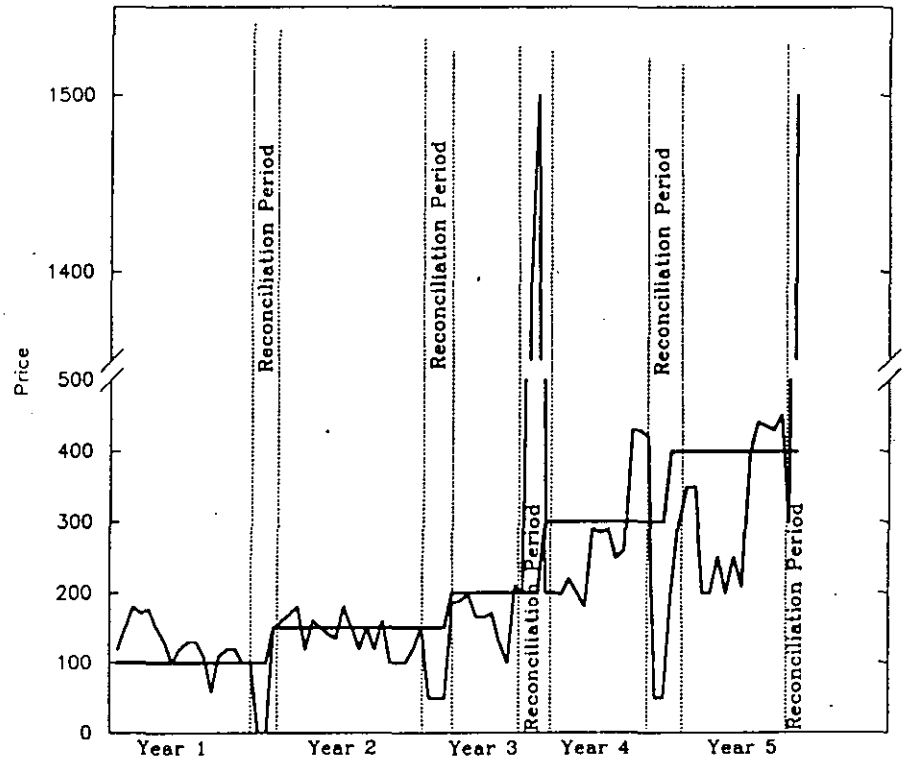
4.1 Price and Production Paths

4.1.1 Uniform Credit

Figure 12 presents the time path of prices under the uniform annual credit instrument design. The figure shows the spot and forward contracts and prices during the reconciliation periods.

Figure 12

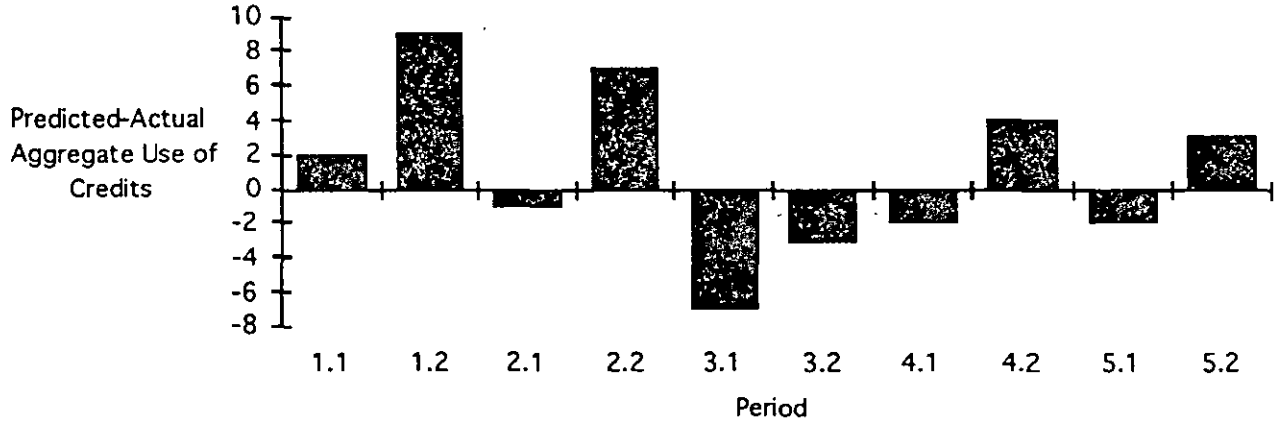
Uniform Credit Market Results



Result 1: The price path exhibits price spikes or deflation during the reconciliation periods. Figure 13 supplies the use of emission credits over time.

Figure 13

Cumulative Use by Year: Predicted-Actual Uniform Annual Credit



Result 2: The use pattern shows that when credits are plentiful during the first half of the year, production is higher than predicted and thus falls in the later half of the year.

Result 3: The short and long conditions in the market result in either penalties or unused credits in the market and thus in lost profit opportunities.

4.1.2 Staggered Credits

Figure 14 presents the time path of prices under the staggered credit instrument design. The figure shows the spot and forward contract prices along with the predicted equilibrium price path.

Result 4: The price path is flat except for a slight increase in the last period from over-use in earlier periods.

Figure 14
Time Path Prices: Staggered Credit

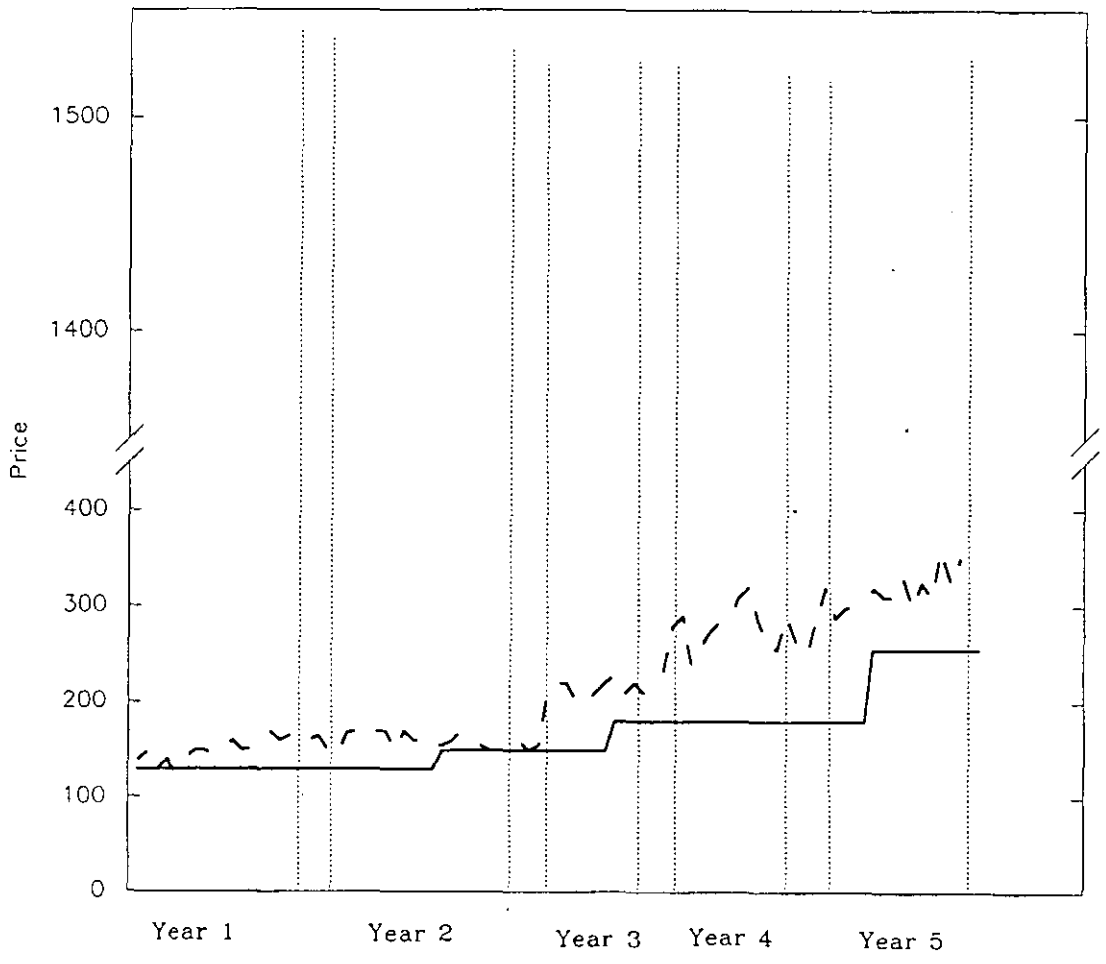
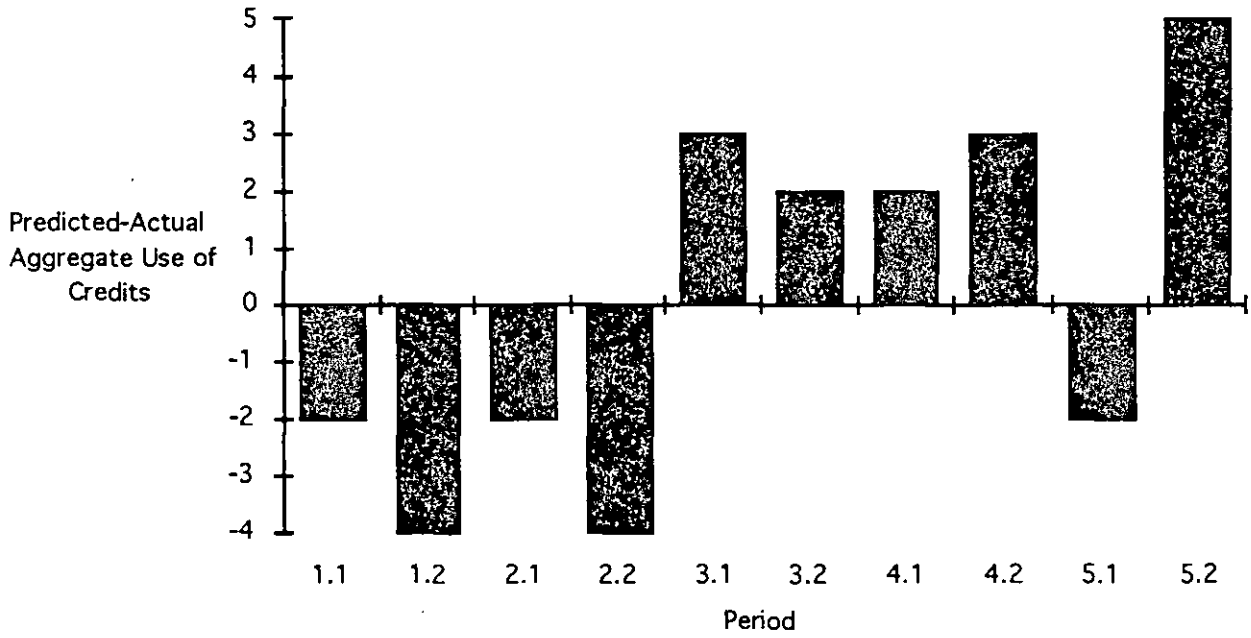


Figure 15
Credit Use by Period: Predicted-Actual Staggered Credit



Result 5: Subjects use more credits in the early years than that predicted from the competitive model.

4.2 Comparative Analysis

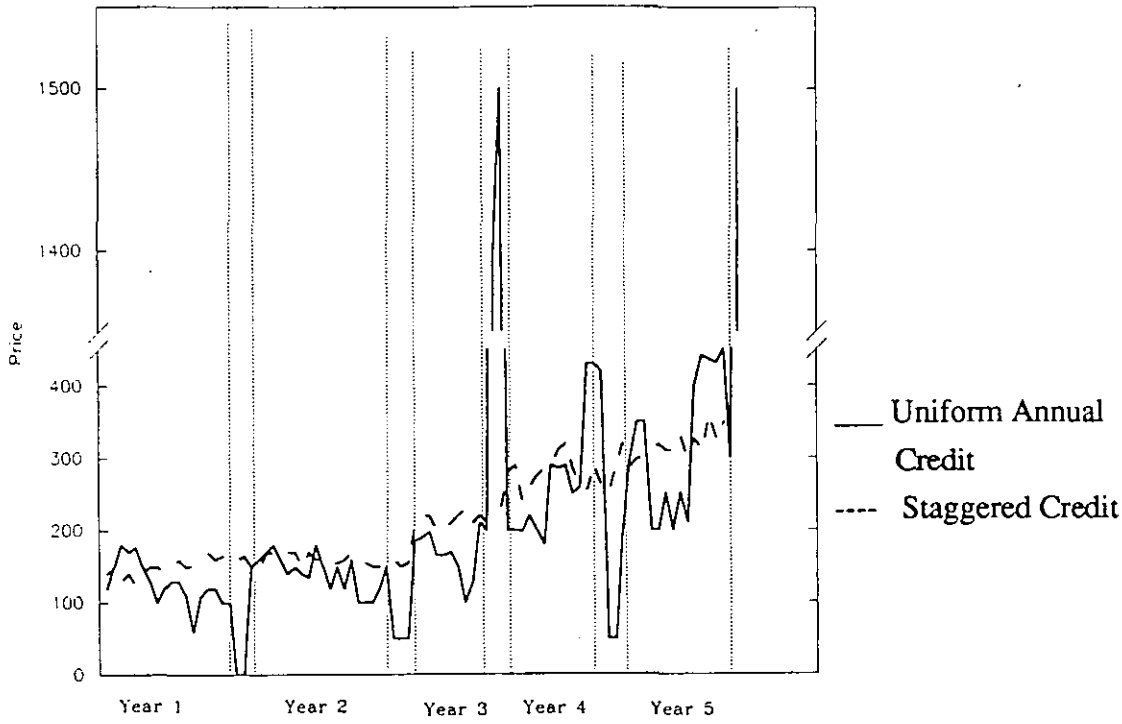
We now turn to the comparative performance of the two credit designs in terms of price volatility and subject profitability.

4.2.1 Price Variation

Figure 16 provides the price paths of the staggered and uniform credits.

Result 6: Prices have significantly less variation in the staggered credit design when compared to the uniform credit.

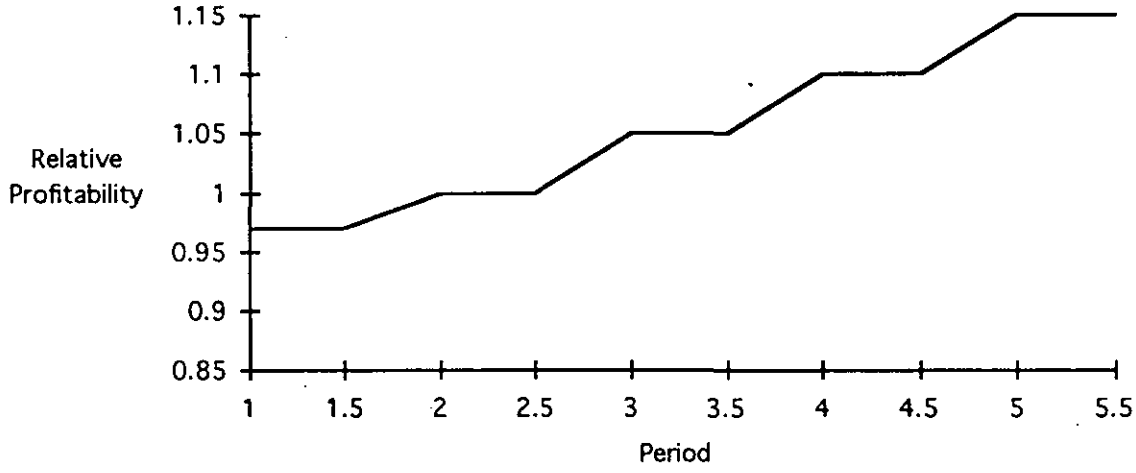
Figure 16
Comparative Price Paths



4.2.2 Efficiency (Profits)

Figure 17 shows the relative profit path of the staggered credit, i.e., total subject profit under staggered credits divided by total subject profit under uniform credits.

Figure 17
Cumulative Relative Efficiency: Staggered/Uniform



Result 7: Profits are significantly higher (12%) with the staggered credits when compared to the uniform credits.

Part III. Instructions to Subjects

Staggered Credit

1. Redemption Values

You are about to participate in an experiment in which you will make decisions in a market. Your profits from the experiment will be in terms of francs, which you can convert into U.S. dollars at a rate of francs to one U.S. dollar. (Thus, the more francs you earn the more U.S. currency you will earn.) Any profits you make in the experiment are yours to keep. You will be paid at the end of the experiment.

The experiment will be divided into a series of *years*. Each year will consist of two *interims* in which you will make decisions. Your packet contains a *Redemption Value Sheet* that describes the value to you of an item we will call X. This is private information and you should not reveal these values to other participants. Below is a sample Redemption Value Sheet.

Redemption Value Sheet

Number of Units of Item X You Own	Additional Value to You	Total Value to You
1	900	900
2	700	1600
3	600	2200
4	300	2500
5	100	2600
6	0	2500
7	0	2500

The Sheet is used to determine the value of units you apply to your *compliance report* at the end of each interim. For example, with the table above, if at an interim in a year you use three units in your compliance report you would receive a value of 2200 francs. If you were to use four units in you compliance report instead of three units you would receive an additional 300 francs in value. The difference between your values from the compliance report and the purchase and sale of units of X will determine your earnings.

2. Initial Allocations of X for Each Year

At the beginning of this experiment you will be given an allocation of X, which you own, for each Year:interim in the experiment. The amounts are listed on your screen under the Inventory Box. For example if you had the screen below you would have an initial allocation of units of X with 7 units in Year 1:interim 1, three units in Year 1:interim 2, four units in Year 2:interim 1 and Year 2:interim 2, three units in Year 3:interim 1 and Year 3:interim 2, etc.

ID: Cash on Hand:

				BID			ASK		
Market	Period	Time	ID	Price	Q	ID	Price	Q	Inventory
Y1 : I1	1	6:00							7
Y1 : I2	1	6:00							3
Y2 : I1	1	6:00							4
Y2 : I2	1	6:00							4
Y3 : I1	1	6:00							3
Y3 : I2	1	6:00							3
Y4 : I1	1	6:00							3
Y4 : I2	1	6:00							2
Y5 : I1	1	6:00							1
Y5 : I2	1	6:00							2

You can add to your inventory of X for a Year:interim by buying units in that market (we will describe how you buy and sell in this market later). If you purchase units the amount you spend will be deducted from the values you receive. You can reduce your inventory by selling units in the market. The amount you receive from sales is added to your values. Thus, at the end of each interim your earnings are determined from the units you apply to compliance for redemption value and the purchases - sales from the market. For example, from the Sample Redemption Value Sheet, if you used four units of X for Year 1:interim 1 compliance, you would obtain 2500 francs. If you spent 1000 francs purchasing units during the interim and sold units in return for 500 francs, your profits for the interim would be:

Redemption

Value	Purchases	Sales	Interim Earnings
2500 -	1000 +	500 =	2000 Francs

3. Compliance Reporting and Inventory Accounting

When the experiment starts, the market for trading units will be open for six minutes. At the end of six minutes you will be asked to fill out a compliance report form for Year 1:interim 1. You can only use units in your Year 1:interim 1 inventory to apply to the report. These will be used to determine your redemption value for the interim. You will then subtract purchases and add sales revenues to find your interim earnings. However, any unused Year 1:interim 1 units can be used for your Year 1:interim 2 compliance. The table below shows the inventory you can use for your interim compliance reports.

Inventory Units and Compliance Report Applications

Compliance Period	Year	Interim
Y1 : I1	1	1
Y1 : I2	1	1
	1	2
Y2 : I1	1	2
	2	1
Y2 : I2	2	1
	2	2
Y3 : I1	2	2
	3	1
Y3 : I2	3	1
	3	2
Y4 : I1	3	2
	4	1
Y4 : I2	4	1
	4	2
Y5 : I1	4	2
	5	1
Y5 : I2	5	1
	5	2

Once you submit your compliance report you will open your Year 1:interim 1 *measurement report,* which contains one of three equally likely numbers {0, 1, 2}. You will add this number to your compliance report number to determine the amount of units that will be *retired* from your Year 1:interim 1 inventory. For example, if you used four units in your compliance report and you open your Year 1:interim 1 measurement report and find a 1, your Year 1:interim 1 inventory will be reduced by five units. In the event you do not have enough units in the appropriate inventories, you will pay a franc penalty out of your current interim earnings. An example of the reporting and retirement of units is provided below:

Compliance and Retirement Report

Year	Interim	Compliance Amount		Measurement Amount		Retirement Amount	Inventory
1	1	4	+	1	=	5	__
1	2	___	+	___	=	___	__+__
2	1	___	+	___	=	___	__+__

4. Accounting

At the end of each interim you will account for your earnings using the following accounting form:

Year:Interim	Value-	Purchases-	Penalty +	Sales +	Capital	=	Profits
1:1	___	___	___	___	___		___
1:2	___	___	___	___	___		___
2:1	___	___	___	___	___		___
2:2	___	___	___	___	___		___

Remember that at each interim you will use the following procedure:

i. Fill-in your compliance amount in the reporting sheet.
ii. Fill-in the total redemption value based on your compliance report in the accounting sheet.
iii. Open your year:interim measurement envelope and place the measurement amount in your reporting sheet.
iv. Retire the units from current year:interim or previous year:interim inventory or pay a per-unit penalty charge of _____ and enter the penalty amount in your accounting sheet.
v. Subtract the cost of the units you purchased and add the revenue from your sales. In addition, add in the capital provided to you and calculate the profits.

5. Timing Review

Year 1		Year 2		Year 3		Year 4	
Trade	Trade	Trade	Trade	Trade	Trade	Trade	
Start	Interim 1	Interim 2	Interim 1	Interim 2	Interim 1	Interim 2	Interim 1
	Report	Report					
	Retire	Retire					
	Y1:I1	Y1:I1 first					
	Account	Y1:I2 next					
		Account					

6. Trading Mechanism

Software Tutorial

Instructions to Subjects

1. Redemption Values [uniform credits]

You are about to participate in an experiment in which you will make decisions in a market. Your profits from the experiment will be in terms of francs, which can convert into U.S. dollars at a rate of francs to one U.S. dollar. Thus, the more francs you earn the more U.S. currency you will earn. Any profits you make in the experiment are yours to keep. You will be paid at the end of the experiment.

The experiment will be divided into a series of *years*. Each year will consist of two *interims* in which you will make decisions. Your packet contains a *Redemption Value Sheet* that describes the value to you of an item we will call X. This is private information and you should not reveal these values to other participants. Below is a sample Redemption Value Sheet.

Redemption Value Sheet

Number of Units of Item X You Own	Additional Value to You	Total Value to You
1	900	900
2	700	1600
3	600	2200
4	300	2500
5	100	2600
6	0	2500
7	0	2500

The sheet is used to determine the value of units you apply to your *compliance report* at the end of each interim. For example, with the table above, if at an interim in a year you use three units in your compliance report, you would receive a value of 2200 francs. If you were to use four units in you compliance report, instead of three units, you would receive an additional 300 francs in value. The difference between your values from the compliance report and the purchase and sale of units of X will determine your earnings.

2. Initial Allocations of X for Each Year

At the beginning of this experiment you will be given an allocation of X, which you own, for each year in the experiment. The amounts are listed on your screen under the Inventory Box. For example, if you had the screen below you would have an initial allocation of units of X with 10 units in Year 1, eight units in Years 2 and 3, and six units in Years 4 and 5.

ID: Cash on Hand:

Market	Period	Time	ID	BID Price Q	ASK ID	Price Q	Inventory
Year 1	1	6:00					10
Year 2	1	6:00					8
Year 3	1	6:00					8
Year 4	1	6:00					6
Year 5	1	6:00					6

You can add to you inventory of X for a year by buying units in that market (we will describe how you buy and sell in this market later). If you purchase units the amount you spend will be deducted from the values you receive. You can reduce your inventory by selling units in the market. The amount you receive from sales is added to your values. Thus, at the end of each interim your earnings are determined from the units you apply to compliance for redemption value and the purchases - sales from the market. For example, from the sample Redemption Value Sheet, if you used four units of X for Year 1:interim 1 compliance you would receive 2500 francs. If you spent 1000 francs purchasing units during the interim and sold units in return for 500 francs your profits for the interim would be:

Redemption Value	Purchases	Sales		Interim Earnings
2500 -	1000 +	500	=	2000 Francs

3. Compliance Reporting and Inventory Accounting

When the experiment starts, the market for trading units will be open for six minutes. At the end of six minutes you will be asked to fill out a compliance report for Year 1:interim 1. You can only use units in your Year 1 inventory to apply to the report. These will be used to determine your redemption value for the interim. You will then subtract purchases and add sales revenues to find your interim earnings.

Once you submit your compliance report, you will open your year:interim *measurement report* which contains one of three equally likely numbers {0, 1, 2}. You will add this number to your compliance report number to determine the amount of units that will be *retired* from your Year 1 inventory. For example, if you used four units in your compliance report and you open your Year 1:interim 1 measurement report and find a 1, your Year 1 inventory will be reduced by five units. In the event you do not have enough units in your current year inventory to meet the retirement amount, you will pay a ___ franc penalty out of your current interim earnings. An example of the reporting and retirement of units is provided below:

Compliance and Retirement Report

Year:Interim	Compliance Amount		Measurement Amount		Retirement Amount	Inventory
1:1	4	+	1	=	5	__
1:2	___	+	____	=	____	__+__
2:1	___	+	____	=	____	__+__

4. Accounting

At the end of each interim you will account for your earnings using the following accounting form:

Year:Interim	Value-	Purchases-	Penalty +	Sales +	Capital	=	Profits
1:1	___	____	____	___	____		____
1:2	___	____	____	___	____		____
2:1	___	____	____	___	____		____
2:2	___	____	____	___	____		____

Remember that at each interim you will use the following procedure: i. Fill in your compliance amount in the reporting sheet ii. Fill in the total redemption value based on your compliance report in the accounting sheet iii. Open your interim:year measurement envelope and place the measurement amount in your reporting sheet iv. Retire the units from your current year inventory or pay a per unit penalty charge of ___ and enter the penalty amount in your accounting sheet v. Subtract the cost of the units you purchased and add the revenue from your sales. In addition, add in the capital provided to you and calculate the profits

5. Timing Review

Year 1		Year 2		Year 3		Year 4	
Trade	Trade	Trade	Trade	Trade	Trade	Trade	
Start	Interim 1	Interim 2	Interim 1	Interim 2	Interim 1	Interim 2	Interim 1

6. Trading Mechanism

Software Tutorial

Participant _____

Compliance and Retirement Report

Year:Interim	Compliance Amount		Measurement Amount		Retirement Amount	Year Inventory
1:1	___	+	____	=	____	____
1:2	___	+	____	=	____	____
2:1	___	+	____	=	____	____
2:2	___	+	____	=	____	____
3:1	___	+	____	=	____	____
3:2	___	+	____	=	____	____
4:1	___	+	____	=	____	____
4:2	___	+	____	=	____	____
5:1	___	+	____	=	____	____
5:2	___	+	____	=	____	____

Participant: _____

Accounting Sheet

Year: Interim	Value-	Purchases-	Penalty +	Sales +	Capital	=	Profits
1:1	___	___	___	___	___		___
1:2	___	___	___	___	___		___
2:1	___	___	___	___	___		___
2:2	___	___	___	___	___		___
3:1	___	___	___	___	___		___
3:2	___	___	___	___	___		___
4:1	___	___	___	___	___		___
4:2	___	___	___	___	___		___
5:1	___	___	___	___	___		___
5:2	___	___	___	___	___		___

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