STUDYING ENVIRONMENTAL REGULATION IN LABORATORY ENVIRONMENTS

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Abstract

Several projects which address issues of environmental regulation and the management of common property resources are in progress in the Experimental Economics Laboratory at McMaster University. The market and non-market decision-making environments which are created in the laboratory setting to study environmental regulation and common property resource management are presented in this paper.

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I. INTRODUCTION

Members of the Department of Economics at McMaster University are participating in a major eco-research programme at the University which is funded by the Government of Canada and which focuses on the restoration of the Hamilton Harbour and the harbour eco-system. The McMaster research programme encompasses researchers from the humanities, social sciences, physical sciences, health sciences, and engineering. While much of the research is discipline oriented (such as engineers studying water flows in the harbour and how this affects the distribution of toxic substances and biologists studying the effects of toxic substances on bird populations), a considerable amount of inter-disciplinary work is being undertaken (such as psychologists, sociologists, and economists joining to prepare surveys to evaluate attitudes toward the environment and to acquire contingent valuations of different environmental projects).

Laboratory methodology is becoming established as an effective tool for evaluating economic theories about individual and market behaviour and for testbedding institutions designed to implement regulatory policies (Plott, 1991). Experimental economics laboratories are established in the United States, Europe, the United Kingdom, and Japan. As part of the eco-research programme, McMaster University has established the first dedicated experimental economics laboratory in Canada. Work is proceeding on the study of a pollution emission permit trading scheme which has been proposed for nitrous oxides and sulphur oxides in

Canada (Godby *et al.*, 1994, 1995; Mestelman *et al.*, 1993; Muller and Mestelman, 1994). Research is directed towards studying the benefits of permit banking, the trading of permit entitlements, market uncertainty, and industry concentration (Brown Kruse *et al.*, 1995). In addition to studying market based regulation schemes, researchers at the McMaster Experimental Economics Laboratory are studying voluntary allocations by individuals of resources to group goods (such as environmental clean-up) and alternative forms of collective decision-making for determining environmental standards (Chan, Godby *et al.*, 1994a, 1994b; Chan, Mestelman *et al.*, 1995a, 1995b).

It is important to note that participants in laboratory markets and collective decision-making environments are not engaged in a simulation exercise. Real markets are created in a controlled environment and real money is paid based on the decisions made by traders in these markets. In collective decision-making environments, the actions of each individual have an impact on the payoffs of all individuals. Unless there is reason to believe that the payoffs to participants are salient, it is unlikely that the outcomes of the laboratory environments will be meaningful.

The laboratory environments in which emission permit trading and voluntary contributions to public goods are studied are presented in the following sections. These environments are flexible and can be easily adapted to study other problems. The three environments described below are the environment in which both permits and entitlements to permits may be traded and the market has a balanced mix of firm types (some small, some large, some with high abatement costs, some with low abatement costs), the environment in which the market for

permits contains a "large" dominant firm and a group of "small" fringe firms, and the environment in which voluntary contributions are made towards the provision of a public good (such as the maintenance of a resource which can be used by all members of a community).

II. PERMIT TRADING WITHOUT A DOMINANT FIRM

2.1. The Setting

The decision-making environment in which agents buy and sell permits to emit pollutants and entitlements to future permits may be complex. In its most complex form in the laboratory, in addition to trading decisions, agents must determine a plan for allocating permits across time and how to deal with the uncertainty that they may find themselves with a surplus or deficit of permits because of events external to the market. Ambient air quality within the vicinity of the firm may be the measure of emissions released by the firm. The firm may plan for a particular ambient air quality, which will require that it relinquish a particular number of emission permits. If an air inversion in the vicinity of the firm results in lower ambient air quality than anticipated, the firm must remit more permits than it planned to use. The alternatives are to pay a large fine, acquire additional permits from the market, or reduce its inventories of permits.

The Canadian permit trading proposals were first considered in a laboratory environment in which no transactions were computer mediated (Mestelman *et al.*, 1993, Muller and Mestelman, 1994). This environment required that traders

manually maintain all of their trading and production records. This made it difficult for traders to concentrate all of their attention on market transactions. The current work on emission permit trading at McMaster's Experimental Economics Laboratory (McEEL) uses a computer-mediated environment which reduces the effort and attention traders must devote to record keeping, which is all maintained via the computer stations into which the subjects enter their trading and production decisions.[1] Sections 2.2, 2.3, and 2.4 are taken and adapted from Godby *et al.* (1995).

2 2 The Trading Environment

In the emission trading environment which is currently being used in McEEL a *session* consists of periods which are divided into 6 sub-periods or *phases* — share market, distribution, primary coupon market, production decision, production result, and reconciliation. Not every phase occurs in every treatment.

During the *share market phase* traders buy and sell shares in a computerized double auction market. This phase only occurs under treatments with tradable shares. The share market phase is followed by the *distribution phase*, in which subjects receive coupons according to their current holdings of shares and the previously announced coupon dividend rate for that period. The distribution phase does not require any intervention from the traders. During the *primary coupon market phase*, traders again buy and sell coupons in a computerized double-

[1] The software is adapted from RNA3, a computer program developed by Shawn LaMaster and colleagues at the University of Arizona.

auction market. During the *production decision phase*, traders choose the number of units of the input to use and consequently the number of coupons they will need. In the *production result phase*, which occurs once all production plans have been submitted, traders are informed of their *actual* input use and of the cash generated from current production. Under the uncertainty treatment, actual input use may differ from planned input use by an amount specified in advance by the investigators. In the present case these errors were drawn from a uniform distribution over the values (-1, 0, +1). This feature models measurement error (as discussed by Carlson *et al.*, 1993) or other errors in determining emissions. Such other errors might include unforeseen changes in output or changes in the availability of a substitute for the rationed input.

During the *reconciliation phase* traders buy and sell coupons in a computerized double-auction market to eliminate any coupon deficit or unwanted coupon surplus. We choose not to allow traders to plan a coupon deficit during the production decision phase. Nevertheless, when uncertainty is present, it may be the case that actual use exceeds coupon holdings. In this case, the trader has a coupon deficit that must be cleared by purchasing more coupons. Similarly, traders may deliberately incur a coupon surplus (in the production decision phase) that they choose to sell rather than to bank. The reconciliation period allows such trades.

In the *coupon-redemption phase*, traders redeem the number of coupons corresponding to their actual input. Traders with a coupon deficit pay a per unit penalty which is greater than any trader's marginal abatement cost. Subsequently, eliminating the deficit becomes a first charge against any coupons

acquired in the following period The coupon-redemption phase does not require any intervention on the trader's part

After the coupon-redemption phase the next period begins with a share market (if enabled) and a new distribution of coupons. There is no share market in the last period of the session. At the end of the session, traders' earnings are converted to Canadian dollars and paid privately in cash.

2.3. The Planner and Wizard

The market institution just described clearly places major cognitive demands on the traders. When banking is allowed, the marginal value of a coupon is not determined directly by the trader's abatement cost schedule for the current trading period, but rather by the place in the schedule that the coupon would occupy if all current coupons and anticipated coupon dividends are allocated optimally over the remaining periods of the session. Similarly, the marginal value of a share is derived from the incremental value of the coupons it bears. These values are the output of simple, deterministic maximization problems. In the field, the operations research department of participating firms could certainly compute these marginal values, given any trial holding of shares and coupons. Accordingly, traders are provided with a *production planner* that simulates an operations research department. The production planner is shown in a window on the computer screen. Traders can enter any trial quantity of coupons and shares. The production planner computes the abatement cost-minimizing allocation of current and anticipated coupons over time and reports both the allocation, the corresponding profit, and the change from the current

holdings.

Even the production planner may be too time-consuming for traders to use in the course of the auction markets Accordingly, traders are also provided with advice from trading and production *wizards*. The trading wizard uses the production planner to compute the marginal value of coupons or shares, depending on the phase of the market, and displays its advice in a window during the primary coupon market, the reconciliation market, and share market phases of the period. The production wizard simply displays the operating profit-maximizing number of input units to use during the production decision phase.

2.4. An Example

Table 1 displays the marginal abatement cost saving schedule (in laboratory dollars, L$) for a trader in an emission permit trading environment. In this abbreviated example, the trader must plan over a three period time horizon If this trader uses five coupons in period 1, the abatement cost saving is the sum of L$200, L$190, L$180, L$170, and L$160, for a total abatement cost saving of L$900. The trader has been given an entitlement of two shares, which each pays a coupon dividend of two coupons in periods 1 and 2 and one coupon in period 3.

Figure 1 displays the information presented to the trader during the share phase. The Status window shows the trader's inventory of shares, coupons and cash at all times. A Market window displays the current Ask and Bid The Clock window displays time remaining in the market. In the top right corner, the Wizard displays its trading advice Traders should be able to infer from this

their maximum willingness-to-pay for a coupon (i.e. their maximum bid) and their minimum willingness-to-accept payment for a coupon (i.e. their minimum ask). The Planner, which can be directly accessed during trading, allows traders to calculate their profits for any trial number of shares or coupons. The trial numbers are adjusted using the arrow keys. The Planner advises this trader to allocate 4 coupons in period 1 and three coupons in each of periods 2 and 3. Table 1 shows that by transferring one coupon from period 2 (during which the 2 shares pay a dividend of 2 coupons each) to period 3 (during which the 2 shares pay a dividend of 1 coupon each), abatement cost savings will increase by L$10 (by giving up abatement cost savings of L$170 in period 2 this trader gains abatement cost savings of L$180 in period 3).

Furthermore, if this trader purchased one more share at the start of period 1, there will be 5 additional coupons to allocate over the three periods. The 15 coupons will be most effectively allocated if 5 coupons were redeemed in each of the three periods This will increase this trader's abatement cost savings by L$160 in period 1, L$330 in period 2, and L$330 in period 3. The total abatement cost saving is L$820 (which is reported by the Wizard in the top right-hand box). This trader could profit by paying up to L$820 for an additional share. The other value reported in the Wizard box is L$900. This is the abatement cost saving which would be lost if one of the two shares was sold in this first round of trading. By selling this share, only five coupons would be available for use over the three periods. Optimal coupon use will fall by two coupons in period 1, by one in period 2, and by two in period 3. The total reduction in abatement cost saving is L$350 in period 1, L$180 in period 2, and L$370 in period 3 The total of these values, L$900, is the minimum price the

trader should accept for the sale of one share if the trader wanted to maximize profit. Once a share is purchased or sold, the Wizard amends its advise to reflect the value of the next transaction.

Figure 2 displays the information presented during the primary coupon market. Note that the Wizard now displays advice about the value of additional coupons rather than shares. Assuming no shares were bought or sold during the share market, this trader could increase abatement cost saving by purchasing one additional coupon and using it in period 2 or period 3. Abatement cost saving will increase by L$170. Similarly, by selling one coupon, the trader will reduce the number of coupons that can be redeemed in period 1 from four to three, and abatement cost saving will fall by L$170 This trader should neither pay more than L$170 for an additional coupon nor accept less than L$170 for the sale of one coupon. This is reported in the Wizard box. Once a coupon has been purchased or sold, the Wizard box is amended to reflect the value of the next transaction. As Figure 2 is presented, there are 31 seconds remaining for trading in Period 1, the outstanding bid is L$90 and the outstanding ask is L$300, both entered by trader 1 (whose screen is displayed). No trades have been made in Period because the List of Trades box is empty.

Figure 3 displays the information presented during the production decision phase. Note that the Production Decision window gives information on coupons owned and coupons intended to be used (Planned Input), together with the implied effect on this period's cash balance. The Planner indicates the profit maximizing allocation of an alternative bundle of shares and coupons. The screen displayed in Figure 3 shows the Wizard recommending the use of 4 coupons in the

first period. The Production Decision box shows the new cash position which would result if only 2 coupons are used. The Planner reflects the optimal allocation of coupons if this trader had two coupons available for the first period and 3 shares available for the remaining two periods. The recommended allocation is correct, but it is not a particularly meaningful scenario to describe, because this trader has 4 coupons available for the current period 1, not 2 coupons. Although the Planner is a useful planning tool, it is only as effective as the trader who asks the questions. If you ask inappropriate questions, you will get inappropriate answers!

Figure 4 displays the information given the trader during the reconciliation market. This trader chose to use 4 coupons in period 1 (as recommended by the Wizard). This trader's cash position has increased to L$1540 (L$500 is the Cash endowment shown in Figure 1, L$300 is the net sales revenue received by this trader for sales of output, which is fixed each period, and L$740 is the abatement cost saving realized by the use of 4 coupons in period 1). This trader, however, was unfortunate. Notice that the Status box in Figure 4 indicates a coupon deficit. Conditions were such that this trader must deliver an additional coupon to the regulator. If this coupon is not delivered, the trader will have to pay a L$200 penalty and give up a coupon in the next period. If the trader can purchase an additional coupon during the reconciliation market, the trader saves both the fine (L$200 in this case) and the coupon's value when used optimally in future periods (L$180 in period 3, given optimal banking). Therefore, the value of a coupon to this trader is up to L$380 in the period 1 reconciliation market. This is reported by the Wizard in Figure 4.

2.5. Closing Comments

This environment is complex. Although traders are provided with a tool to assist them to make sale, purchase, and coupon-use decisions, traders are free to speculate on the decisions that others will make. The outcomes of these market interactions are very dependent upon the behaviour of the traders in the markets. An important question is "Does the trading environment provide sufficient incentives to traders to use the information available in such a way as to lead to efficient outcomes?" In this context an efficient outcome is one which minimizes the cost of achieving the level of emission prescribed by the regulator. The outcome is not predetermined by the valued induced by the experimenters, in the manner that the outcome of a numerical simulation is predetermined by the parameterization of the model.

III. PERMIT TRADING WITH A DOMINANT FIRM

3.1. The Setting

In some ways this environment is not as complex as the previous environment. This environment, however, does not present a transparent problem to the traders in these markets. The environment contains one large trader, who would produce 10 units of output in the absence of any regulation. There are ten small firms, who would each produce 1 unit of output in the absence of any regulation. One research question is "Can the dominant firm exercise monopoly or monopsony power in the emission permit market if given the opportunity?" A second research question is "Can the dominant firm manipulate the price in the

product market by exercising monopoly or monopsony power in the emission permit market?"

The market for permits (the access to a regulated input) is a double-auction market in which some agents are sellers and some agents are buyers. None of the agents are able to trade on both sides of the market. The market price for the final product is the price which will clear the units supplied by the eleven producers. All producers know what market demand is, but not what others will produce. The dominant firm knows the production costs and abatement costs of all of the fringe firms. The double-auction market for permits is a computer-mediated trading institution.

3.2. The Double-Auction Trading Environment

The double-auction trading institution with a dominant firm and ten fringe firms is implemented using the multiple-unit double-auction (MUDA) software developed at the California Institute of Technology. This software does not provide the record keeping functions described in the previous section. The buyers and sellers must keep manual records of sales and purchases and the profits on all transactions. The MUDA software facilitates the market interactions, and records all bids, asks, and contracts. The abatement cost savings associated with the use of a permit, and the profits gained by selling or buying permits must be computed from the records kept by buyers and sellers.

Figure 5 displays the trading screen and the Contract History screen for MUDA At the top of Figure 5 are a series of boxes which display the Market in

which the buyer or seller is participating (under MUDA it is possible for traders to participate simultaneously in many markets for many different products), the Period, and the Time remaining in the period. A second and third series of boxes display the outstanding BID PRICE and the outstanding ASK PRICE, along with the quantity demanded (bid for) and supplied, QNTY and the identification number (ID) of the trader who has entered the outstanding bid or ask. The INVNTRY box reports the buyer's or seller's inventory of units bought or available for sale. Finally, the PRICE and QNTY boxes at the right of the top row will contain the buyer's or seller's bid price or ask price and the quantity demanded or offered for sale (one unit in all cases for this experiment).

The second row provides prompts to the buyers and sellers to aid them in entering bids and asks, accepting outstanding asks or bids, and cancelling bids or asks which they previously entered. To enter a bid, a buyer must type the bid price in the right-hand PRICE box, type 1 in the QNTY box, and then press the F1 function key on the computer keyboard. If a seller wishes to accept the outstanding bid, the seller presses the Ctrl key on the computer keyboard. In this environment, only a bid or an ask which improves on the outstanding bid or ask is accepted and displayed on the screen. All traders see the same ID, BID PRICE, and ASK PRICE boxes. The F3 key calls up a CONTRACTS HISTORY screen which permits the trader to see the list of all previous contracts, the period in which they were made, the time in the period, who the buyer and seller were, the price, the quantity traded, and the total value of the transaction. This assists the traders in maintaining their record sheets. This also permits the experimenters to reconstruct the record sheets of all subjects and check their calculations of earnings.

3.3 The Product Market

When output decisions can affect the price of the product, the eleven producers privately transmit an output decision to the experimenter. The experimenter determines the total output produced by the eleven producers and announces the price which will clear the market. Each producer then determines the profit earned that period. Cost is determined by the number of units of output produced and the number of permits which are used.

3.4. Closing Comments

While this environment appears to be much less complex than the environment in which traders could carry permits (called coupons) from period to period and in which they could trade entitlements to permits, the variable product price treatment in this environment introduces a degree of complexity which makes the ultimate permit use and output less than transparent. Because the price of the product is not determined when decisions must be made about the purchase or sale of permits, the realization of any particular allocation of permits, use of permits, and distribution of output across the dominant and fringe firms is dependent on the expectations of the agents. Whether a particular solution prevails will depend on the behaviour of the traders in these environments. Whether the double-auction institution supports a competitive outcome or an imperfectly competitive (monopolistic or monopsonistic) outcome is not a prediction of the theoretical models underlying this environment (see Brown Kruse *et al.*, 1995).

IV. THE VOLUNTARY CONTRIBUTION ENVIRONMENT

4.1. The Setting

The computer-mediated voluntary contribution (or public goods) environment used in McEEL was first used for the experiment reported in Chan, Godby, *et al* (1994a). The software was developed by R. Andrew Muller and Mary-Anne Sillamaa for use on a UNIX base, and has proven to be versatile.

Participants in the voluntary contribution environments are told that they must allocate an endowment of resources or income across two markets. Each participant's payoff depends upon the amount of resources the participant allocates to Market 1 and the amount of resources the participant and all other participants allocate to Market 2. The participant's payoff can be represented by a payoff table which summarizes all possible outcomes based upon the amount the participant allocates to Market 2 and the amount that all of the other participants allocate to Market 2 Given the endowment of each participant, anything not allocated to Market 2 is automatically allocated to Market 1. The payoff tables for a three-person group in which everyone has the same endowment, but one person receives a greater return from allocations to Market 2, are presented as Tables 2 and 3.

4 2. The Computer-Mediated Environment

Table 2 shows the payoffs for a person who has an endowment of 20 tokens (see the number at the extreme right of the first row). This person knows that

the combined endowments of the other two people in the group is 40 tokens (see the number at the bottom of the first column) If this person thinks that the others in the group will allot nothing to Market 2, the best this person can do is to allot 12 or 13 tokens to Market 2 If this person's expectations are fulfilled, this person's payoff will be 176 tokens. On the other hand, if this person thought that the others would each allot 13 tokens to Market 2, or 26 tokens in total, this person's best response would be to allot nothing to Market 2 and earn a payoff of 696 tokens.

Once a session begins, each subject's computer screen displays the information on the upper portion of Figure 6 (excluding the second set of Input/Status lines). Each subject is presented with a message with information about the number of tokens which can be allotted to Market 2, and an instruction line which repeats that information for the current period. When an allotment is made, it appears in the square brackets in the Yours column under Allotments. As soon as all of the people in all of the groups participating in a session make their decisions, the computer collects everyone's allotment and provides this information plus payoff information to the participants. At this point numbers would appear in the Others' column and the Your Payoff column. A new line will appear on the screen with a 2 in the Period column, and the participant will be cued with (perhaps) a new message and instructions for the next period.

The second set of Input/Status lines would appear if it was possible to monitor the behaviour of other members of the group. If monitoring was costless, instead of receiving information about Others' contributions, each participant would receive information about the other two members of the group, who will be

identified throughout the session as participants 1 and 2.

4.3. Closing Comments

This is a versatile environment. By the appropriate choice of payoff function environments can be created in which people are contributing to the provision of a public good or in which people are exercising entitlements to appropriate resources from a common pool. In the former case we can study the factors which lead to cooperative behaviour in the provision of public goods or which lead to free-riding. New institutions can be introduced, and their success at facilitating cooperative behaviour can be assessed. In the latter case we can study issues related to environmental management. We can study the factors which lead to cooperative behaviour in the exploitation of scarce resources when congestion externalities are present. More complex environments can be introduced in which the exploitation of the common pool can lead to its extinction. In this situation, institutions which lead to cooperative behaviour would be important to identify, for not only would exploitation lead to low social benefits over time, but to the elimination of all benefits.

V. *CONCLUSIONS*

Three different computer-mediated environments were presented. These are all currently being used to study issues which have some relationship to the problems of the Hamilton Harbour Watershed at the western end of Lake Ontario. Any use of emission permit trading to allocate emissions across those firms and individuals who use the Hamilton Harbour as a depository for waste materials will

require some regulating body to determine the size and distribution of entitlements to produce. Institutions by which the entitlements and their distribution are determined and through which permits and entitlements are traded must be selected. The laboratory methods described here offer relatively inexpensive ways to evaluate market and non-market institutions designed to facilitate cooperative behaviour for the management of common property resources.

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Table 1

Sample Marginal Abatement Cost Saving Schedule

	Period 1	Period 2	Period 3
Coupon 1	200	200	200
Coupon 2	190	190	190
Coupon 3	180	180	180
Coupon 4	170	170	170
Coupon 5	160	160	160
Coupon 6	150	150	150
Coupon 7	140	140	140

Table 2

Payoff Table for Low Preference People

OTHERS' ALLOTMENT TO MARKET 2 \ YOUR ALLOTMENT TO MARKET 2	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	20	44	66	86	104	120	134	146	156	164	170	174	176	176	174	170	164	156	146	134	120
1	46	69	90	109	126	141	154	165	174	181	186	189	190	189	186	181	174	165	154	141	126
2	72	94	114	132	148	162	174	184	192	198	202	204	204	202	198	192	184	174	162	148	132
3	98	119	138	155	170	183	194	203	210	215	218	219	218	215	210	203	194	183	170	155	138
4	124	144	162	178	192	204	214	222	228	232	234	234	232	228	222	214	204	192	178	162	144
5	150	169	186	201	214	225	234	241	246	249	250	249	246	241	234	225	214	201	186	169	150
6	176	194	210	224	236	246	254	260	264	266	266	264	260	254	246	236	224	210	194	176	156
7	202	219	234	247	258	267	274	279	282	283	282	279	274	267	258	247	234	219	202	183	162
8	228	244	258	270	280	288	294	298	300	300	298	294	288	280	270	258	244	228	210	190	168
9	254	269	282	293	302	309	314	317	318	317	314	309	302	293	282	269	254	237	218	197	174
10	280	294	306	316	324	330	334	336	336	334	330	324	316	306	294	280	264	246	226	204	180
11	306	319	330	339	346	351	354	355	354	351	346	339	330	319	306	291	274	255	234	211	186
12	332	344	354	362	368	372	374	374	372	368	362	354	344	332	318	302	284	264	242	218	192
13	358	369	378	385	390	393	394	393	390	385	378	369	358	345	330	313	294	273	250	225	198
14	384	394	402	408	412	414	414	412	408	402	394	384	372	358	342	324	304	282	258	232	204
15	410	419	426	431	434	435	434	431	426	419	410	399	386	371	354	335	314	291	266	239	210
16	436	444	450	454	456	455	454	450	444	436	426	414	400	384	366	346	324	300	274	246	216
17	462	469	474	477	478	477	474	469	462	453	442	429	414	397	378	357	334	309	282	253	222
18	488	494	498	499	500	498	494	488	480	470	458	444	428	410	390	368	344	318	290	260	228
19	514	519	522	523	522	519	514	507	498	487	474	459	442	423	402	379	354	327	298	267	234
20	540	544	546	546	544	540	534	526	516	504	490	474	456	436	414	390	364	336	306	274	240
21	566	569	570	569	566	561	554	545	534	521	506	489	470	449	426	401	374	345	314	281	246
22	592	594	594	592	588	582	574	564	552	538	522	504	484	462	438	412	384	354	322	288	252
23	618	619	618	615	610	603	594	583	570	555	538	519	498	475	450	423	394	363	330	295	258
24	644	644	642	638	632	624	614	602	588	572	554	534	512	488	462	434	404	372	338	302	264
25	670	669	666	661	654	645	634	621	606	589	570	549	526	501	474	445	414	381	346	309	270
26	696	694	690	684	676	666	654	640	624	606	586	564	540	514	486	456	424	390	354	316	276
27	722	719	714	707	698	687	674	659	642	623	602	579	554	527	498	467	434	399	362	323	282
28	748	744	738	730	720	708	694	678	660	640	618	594	568	540	510	478	444	408	370	330	288
29	774	769	762	753	742	729	714	697	678	657	634	609	582	553	522	489	454	417	378	337	294
30	800	794	786	776	764	750	734	716	696	674	650	624	596	566	534	500	464	426	386	344	300
31	826	819	810	799	786	771	754	735	714	691	666	639	610	579	546	511	474	435	394	351	306
32	852	844	834	822	808	792	774	754	732	708	682	654	624	592	558	522	484	444	402	358	312
33	878	869	858	845	830	813	794	773	750	725	698	669	638	605	570	533	494	453	410	365	318
34	904	894	882	868	852	834	814	792	768	742	714	684	652	618	582	544	504	462	418	372	324
35	930	919	906	891	874	855	834	811	786	759	730	699	666	631	594	555	514	471	426	379	330
36	956	944	930	914	896	876	854	830	804	776	746	714	680	644	606	566	524	480	434	386	336
37	982	969	954	937	918	897	874	849	822	793	762	729	694	657	618	577	534	489	442	393	342
38	1008	994	978	960	940	918	894	868	840	810	778	744	708	670	630	588	544	498	450	400	348
39	1034	1019	1002	983	962	939	914	887	858	827	794	759	722	683	642	599	554	507	458	407	354
40	1060	1044	1026	1006	984	960	934	906	876	844	810	774	738	698	654	610	564	516	466	414	360

Table 3

Payoff Table for High Preference Person

OTHERS' ALLOTMENT TO MARKET 2 \ YOUR ALLOTMENT TO MARKET 2	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	20	53	84	113	140	165	188	209	228	245	260	273	284	293	300	305	308	309	308	305	300
1	55	87	117	145	171	195	217	237	255	271	285	297	307	315	321	325	327	327	325	321	315
2	90	121	150	177	202	225	246	265	282	297	310	321	330	337	342	345	346	345	342	337	330
3	125	155	183	209	233	255	275	293	309	323	335	345	353	359	363	365	365	363	359	353	345
4	160	189	216	241	264	285	304	321	336	349	360	369	376	381	384	385	384	381	376	369	360
5	195	223	249	273	295	315	333	349	363	375	385	393	399	403	405	405	403	399	393	385	375
6	230	257	282	305	326	345	362	377	390	401	410	417	422	425	426	425	422	417	410	401	390
7	265	291	315	337	357	375	391	405	417	427	435	441	445	447	446	445	441	435	427	417	405
8	300	325	348	369	388	405	420	433	444	453	460	465	468	469	468	465	460	453	444	433	420
9	335	359	381	401	419	435	449	461	471	479	485	489	490	491	489	485	479	471	461	449	435
10	370	393	414	433	450	465	478	489	498	505	510	513	514	513	510	505	498	489	478	465	450
11	405	427	447	465	481	495	507	517	525	531	535	537	537	535	531	525	517	507	495	481	465
12	440	461	480	497	512	525	536	545	552	557	560	561	560	557	552	545	536	525	512	497	480
13	475	495	513	529	543	555	565	573	579	583	585	585	583	579	573	565	555	543	529	513	495
14	510	529	546	561	574	585	594	601	606	609	610	609	606	601	594	585	574	561	546	529	510
15	545	563	579	593	605	615	623	629	633	635	635	633	629	623	615	605	593	579	563	545	525
16	580	597	612	625	636	645	652	657	660	661	660	657	652	645	636	625	612	597	580	561	540
17	615	631	645	657	667	675	681	685	687	687	685	681	675	667	657	645	631	615	597	577	555
18	650	665	678	689	698	705	710	713	714	713	710	705	698	689	678	665	650	633	614	593	570
19	685	699	711	721	729	735	739	741	741	739	735	729	721	711	699	685	669	651	631	609	585
20	720	733	744	753	760	765	768	769	768	765	760	753	744	733	720	705	688	669	648	625	600
21	755	767	777	785	791	795	797	797	795	791	785	777	767	755	741	725	707	687	665	641	615
22	790	801	810	817	822	825	826	825	822	817	810	801	790	777	762	745	726	705	682	657	630
23	825	835	843	849	853	855	855	853	849	843	835	825	813	799	783	765	745	723	699	673	645
24	860	869	876	881	884	885	884	881	876	869	860	849	836	821	804	785	764	741	716	689	660
25	895	903	909	913	915	915	913	909	903	895	885	873	859	843	825	805	783	759	733	705	675
26	930	937	942	945	946	945	942	937	930	921	910	897	882	865	846	825	802	777	750	721	690
27	965	971	975	977	977	975	971	965	957	947	935	921	905	887	867	845	821	795	767	737	705
28	1000	1005	1008	1009	1008	1005	1000	993	984	973	960	945	928	909	888	865	840	813	784	753	720
29	1035	1039	1041	1041	1039	1035	1029	1021	1011	999	985	969	951	931	909	885	859	831	801	769	735
30	1070	1073	1074	1073	1070	1065	1058	1049	1038	1025	1010	993	974	953	930	905	878	849	818	785	750
31	1105	1107	1107	1105	1101	1095	1087	1077	1065	1051	1035	1017	997	975	951	925	897	867	835	801	765
32	1140	1141	1140	1137	1132	1125	1116	1105	1092	1077	1060	1041	1020	997	972	945	916	885	852	817	780
33	1175	1175	1173	1169	1163	1155	1145	1133	1119	1103	1085	1065	1043	1019	993	965	935	903	869	833	795
34	1210	1209	1206	1201	1194	1185	1174	1161	1146	1129	1110	1089	1066	1041	1014	985	954	921	886	849	810
35	1245	1243	1239	1233	1225	1215	1203	1189	1173	1155	1135	1113	1089	1063	1035	1005	973	939	903	865	825
36	1280	1277	1272	1265	1256	1245	1232	1217	1200	1181	1160	1137	1112	1085	1056	1025	992	957	920	881	840
37	1315	1311	1305	1297	1287	1275	1261	1245	1227	1207	1185	1161	1135	1107	1077	1045	1011	975	937	897	855
38	1350	1345	1338	1329	1318	1305	1290	1273	1254	1233	1210	1185	1158	1129	1098	1065	1030	993	954	913	870
39	1385	1379	1371	1361	1349	1335	1319	1301	1281	1259	1235	1209	1181	1151	1119	1085	1049	1011	971	929	885
40	1420	1413	1404	1393	1380	1365	1348	1329	1308	1285	1260	1233	1204	1173	1140	1105	1068	1029	988	945	900

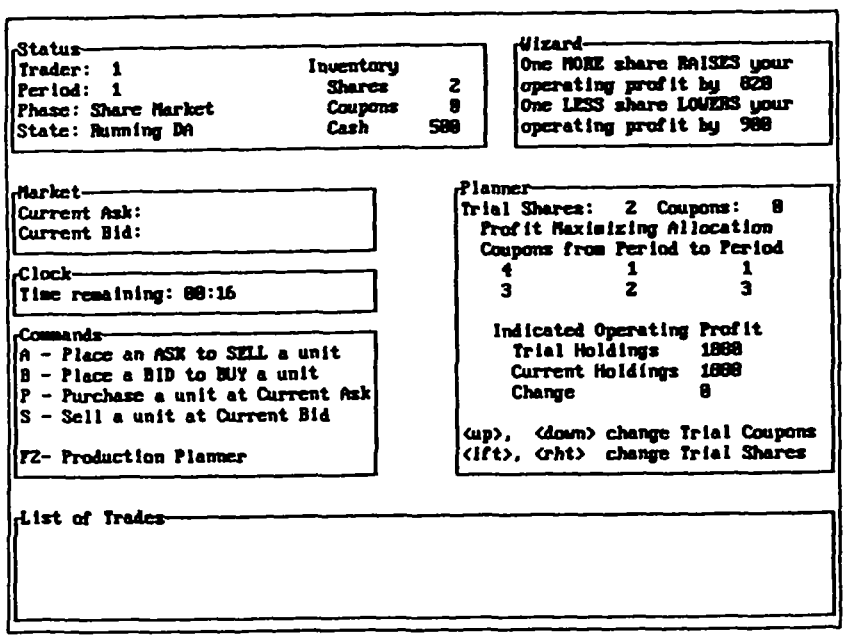

FIGURE 1 SHARE MARKET

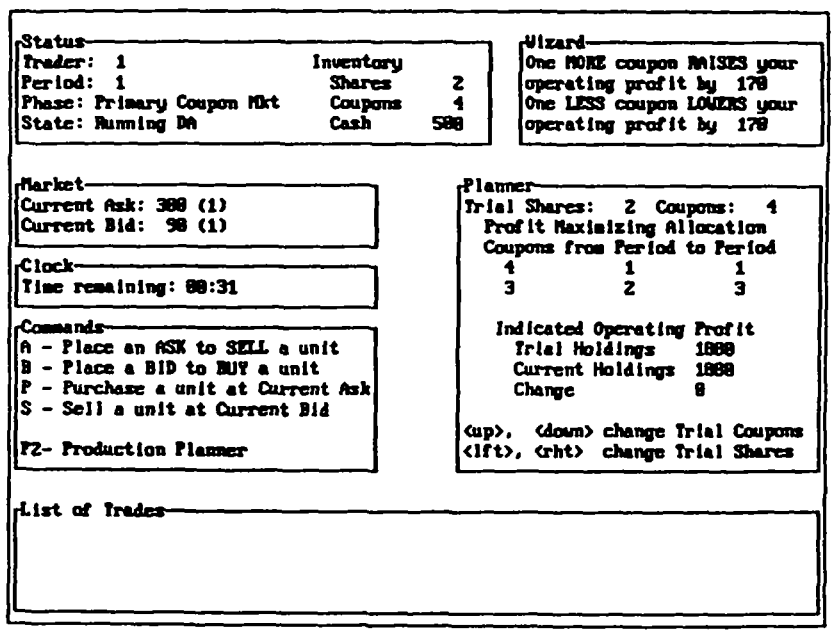

FIGURE 2 COUPON MARKET

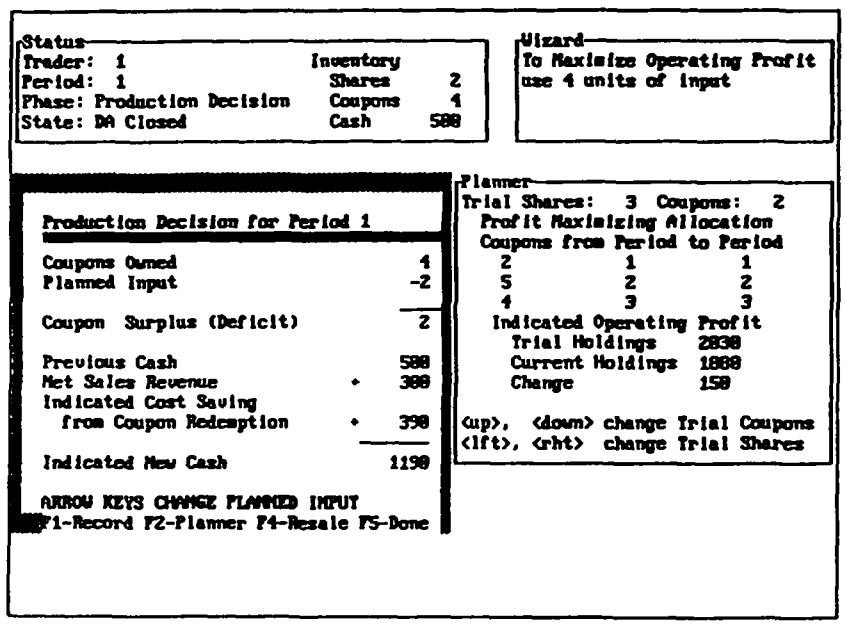

FIGURE 3 PRODUCTION DECISION

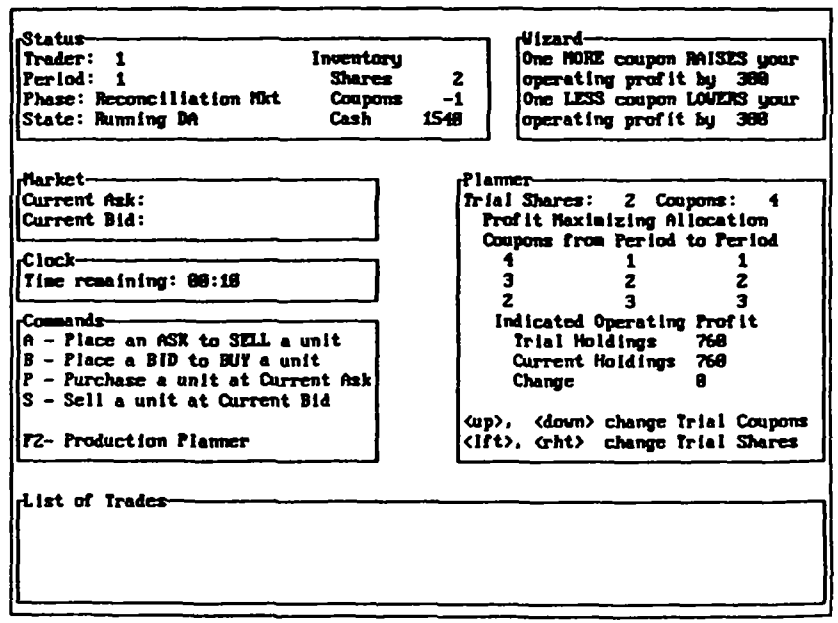

FIGURE 4 RECONCILIATION MARKET

ID 1

CASH ON HAND 500

Market	Period	Time	BID ID	BID PRICE	BID QNTY	ASK ID	ASK PRICE	ASK QNTY	INVNTRY	PRICE	QNTY
01 Market 1	1	0 00 00							10		

F1 BID F2 ASK F3 HIST Ctrl ACCEPT Alt CANCEL

CONTRACTS HISTORY

MARKET # MARKET 1

PERIOD	TIME	BUYER/SELLER	PRICE	QNTY	TOTAL VALUE
1	0:00:12	1/ 2	100	1	100
1	0 00:49	1/ 4	120	1	120

(+) NEXT MARKET (-) PREVIOUS MARKET ESC- PREVIOUS SCREEN

Figure 5 MUDA SCREENS

STATION ID: [s]

Messages:

You must allot between x and y tokens to market 2

Instructions:

Please enter period 1 allotment between [x - y]

Input/Status:

--- Allotments ---

Period	Yours	Others'	Your Payoff
1	[ ]		

Input/Status:

--- Allotments ---

Period	Yours	1's	2's	Your Payoff
1	[ ]			

Figure 6 PG SCREENS