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EXTERNALITIES AND CORRECTIVE POLICIES IN EXPERIMENTAL MARKETS*

Charles R. Plott

This paper reports on the behaviour of simple, laboratory markets which have an externality. Experiences with these markets provide some help in answering two broad questions. (1) Do markets with externalities behave in accordance with the law of supply and demand? (2) How do the pollution tax, pollution standard, and pollution licenses compare as methods for correcting the externality?

The first question is rarely, if ever, asked by those (primarily economists) close to the origins of the externality ideas. The theory of social cost has existed in the economics literature for at least sixty years and the application of the law of supply and demand to the case of externalities, when many transactions take place and bargaining internalisation is not plausible, has not changed at all over the period. Shown on Fig. 1 are the market demand function, the market supply function, and the 'social cost' function. The theory holds that the appropriate supply function is the private cost supply and that the quantities P_e, Q_e will be respectively the equilibrium price and quantity in the absence of corrective policies. The theory asserts that the market will behave as if there are no externalities at all.

Policy makers untrained in the finer aspects of economic theory have no trouble in rejecting this line of reasoning in favour of models more compatible with their intuitions. Why should the price and volume of a market be independent of the existence of externalities? Indeed, it is not obvious and goes against generalisations from personal experiences. People are aware, sensitive, and concerned about others so why should they behave in such an atomistic fashion? Intuitions, customs, ethics, and a host of instincts might guide us individually and as groups to behaviour other than that suggested by the model.

In reply to such criticisms the model can be defended by an appeal to the deeper principles which lead to the prisoner's dilemma, but the latter can be questioned on both theoretical (Howard, 1971) and empirical (Rapoport and Chammah, 1965) grounds.[1] Data gathered from case studies generally remain consistent with several modes of thought even after the application of modern statistical and econometric techniques. So, not only do social scientists have difficulty in getting policy makers to listen to policies based on this model, there remains room for disagreement among themselves.

How can laboratory experiments help resolve this controversy? We argue that models which do relatively poorly in simple cases should not be given

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[1] For an important recent contribution to the empirical literature consult Dawes *et al.* (1977).

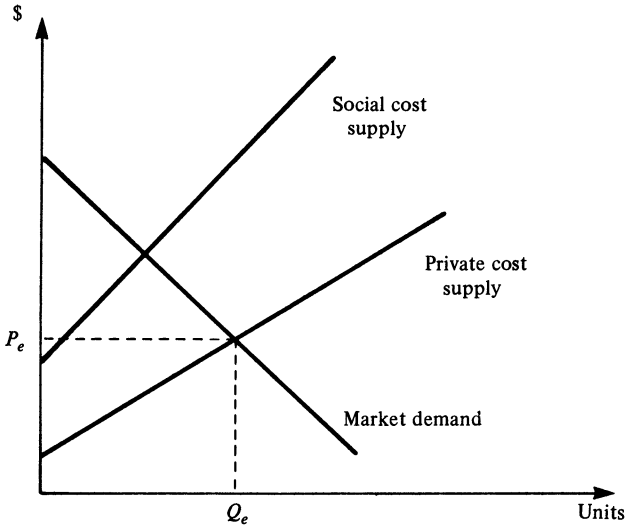

Fig. 1

priority in application to the complex. Both the *ad hoc* generalisations from personal feelings and experiences as well as the highly structured, refined models can be called into question if they fail to be predictive of the behaviour of simple cases. Thus we claim that our simple laboratory markets can be used as a screen to remove some of the competing ideas.

Extension of the above line of justification leads naturally to an examination of the 'corrective measures' found in the academic and policy-related literature. What are the comparative performances of policies in the simple cases? Perhaps from the simple cases we can get some ideas about relative performance in the complex cases.

The three policy measures we examine are the 'tax/bribe' approach, the 'standards' approach, and the 'pollution licence' approach. These are structured in the experiments so that the information available for policy purposes is roughly comparable in all cases. Individual demands and costs are assumed to be unavailable (except for distribution of income considerations) but the optimum pollution quantity is known for the license policy and the standards policy. Marginal social cost at the optimum is known for the tax policy.

The standards approach is the one found most frequently in application. The current air pollution policies are a good case in point. For example, standard welfare economics arguments lead to the conclusion that the area *ABCD* on Fig. 2 is the 'optimum' value of pollution damage. The 'standards' approach to policy is to translate the value into a legal standard governing the amount of admissible pollution. In this case the policy is to adopt the standard that pollution will be limited to the quantity which constrains damage value to *ABCD*. Naturally this effectively limits the quantity of Q to the quantity Q_o which must be rationed among demanders and suppliers. Individual demands

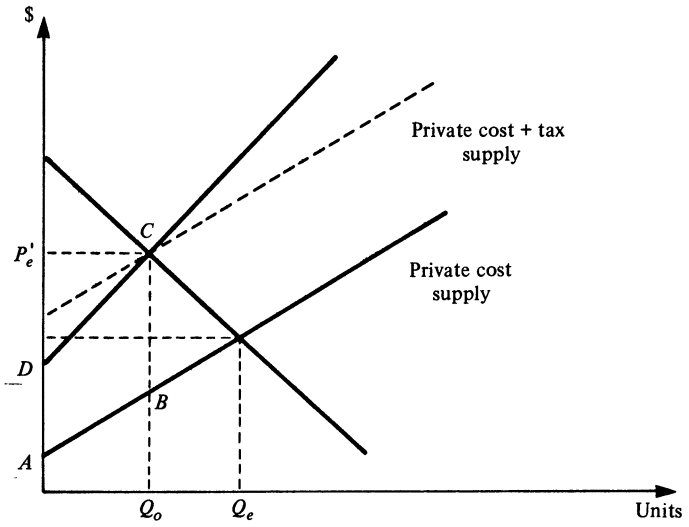

Fig. 2

and costs are assumed to be unknown to the policy maker so they cannot be used directly as part of the policy.

The second policy is the pollution tax.[1] The amount of the marginal social cost calculated at the optimum quantity, Q_o, is imposed as a per unit tax over all units. Tax revenues are then redistributed back to the population in some manner. On Fig. 2 this is the distance *BC*. When the amount *BC* is imposed as a per unit tax, the new supply curve is the dotted line marked 'private cost + tax supply'. The market price would be P'_e and the equilibrium quantity would be the optimum Q_o.

The third policy involves the distribution of licences (rights) to pollute. Only those who have acquired a licence may engage in the pollution-creating activity, which in the case discussed above is the purchase or sale of the commodity. If only Q_o licences exist, and if a separate licence must be held by the seller for each unit sold, and if the licences are marketable, then the price of the licence should equilibrate at the level *BC*. The market price of the primary commodity Q, should be P'_e, the quantity should be the optimum Q_o, and the licences should be held by the low cost sellers of Q.

The experiments reported below provide some experience against which these policies can be gauged. Three different dimensions are considered. The first is the price behaviour; the second is efficiency; and the last involves the distributional consequences.

[1] Readers familiar with the externality literature will also recognise the 'bribe' option. In our setting the two options will differ only by an accounting entry if the basic behavioural hypotheses for the tax case are correct. Thus we consider the two as equivalent in our setting.

I. EXPERIMENTAL PROCEDURES AND DESIGN

Student subjects were recruited from California State University at Los Angeles and Los Angeles City College through announcements made in classes. The markets with licences were conducted with Caltech students, many of whom had previous experience in experimental markets. All other subjects had no experience in experimental markets and all subjects participated in only one of the experiments reported here. Participants were told that they would be paid but the amount would vary depending on the decisions they made. They were also told the amount would likely be more than the hourly wage and that we had never had a complaint. Once the students were assembled the instructions, included in the appendices, were read. After all questions were answered and a period 'zero' was run on a 'trial basis' without compensation, the experiment was begun.[1]

Table 1

Capital Payments Per Period

Experiment no.	Individual											
	1	2	3	4	5	6	7	8	9	10	11	12
Experiments 1 and 2	0.45	0.25	0.80	1.25	1.50	1.50	0	0	0.30	0.95	1.50	1.50
Experiments 3 and 4	0.93	1.00	1.18	1.26	1.30	1.30	1.26	1.76	1.00	1.10	1.30	1.30
Experiments 5 and 6	0.45	0.25	0.80	1.25	1.50	1.50	0	0	0.30	0.95	1.50	1.50
Experiments 7 and 8												
Capital payment	0.45	0.25	0.80	1.25	1.50	1.50	0	0	0.30	0.95	1.50	1.50
Number of licences initially held	1	2	1	0	0	0	2	4	2	1	0	0

Each market had six buyers and six sellers. Limit prices were induced for the multiple unit trading case using the format developed by Plott and Smith (1978). Each individual buyer (seller) was given a redemption (cost) schedule which indicated the amount the experimenter would pay (charge) him for each unit purchased (sold) during a period. The differences between these limit prices and the price at which he purchased (sold) the unit was his to keep. Each subject was also paid a commission of five cents for each trade he made during the period. In addition to the limit prices, each subject was given a damage schedule indicating how much his profits from trades would be reduced as a function of the *total* number of trades in the market. This latter feature is the 'externality.' Each individual hurts all other individuals whenever he engages in trade and is hurt whenever anyone else engages in trade. Since this latter feature means that profit after damages can be negative and thus in violation of our contracts with the subject, each subject is given a capital payment each period as shown on Table 1.

[1] The experiments at Caltech did not include a period zero. However, because of the complications involved with two simultaneous markets, mistakes did occur during the first periods. In all experiments the subjects' accounting was reviewed by the experimenter from time to time between periods.

The parameters are shown in Fig. 3. Each number represents a seller (numbered 1–6) or buyer (numbered 7–12) for each of the twelve agents. Thus individual one is a seller. His limit prices are \$2.30, 2.30, 2.30, 2.31, 2.31, 2.36, 2.51, 2.70 for the first to eighth units respectively. Consequently his

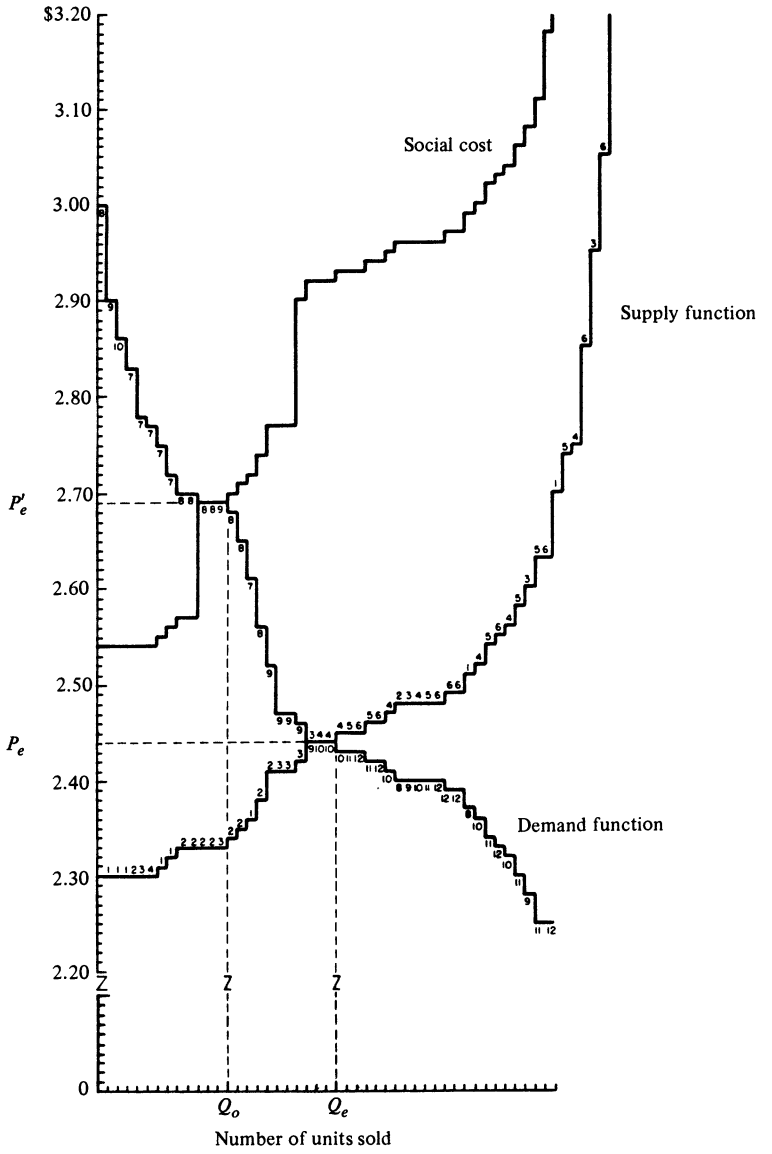

Fig. 3

competitive response to a constant market price of \$2.44 would be to sell six units. Individual eight is a buyer with limit prices \$3.00, 2.70, 2.70, 2.69, 2.69, 2.68, 2.65, 2.56, 2.40 for the first to ninth units respectively. All individuals had the same limit price schedule for all periods. Since the limit prices are unaffected by the capital payments, the latter are not shown on the figure. The market

equilibrium quantity is twenty-four units and the price is $2.44. The optimum quantity is thirteen units.

All markets were organised as oral double auction markets as described in the instructions in the appendices. All bids (offers) and contracts were written on the blackboard and remained there throughout the experiment.

A total of eight experimental sessions are reported and are categorised as follows. Experimental sessions one and two are markets with no corrective policies. These are simply oral double auctions in which each subject is aware of the externality damage (s)he is individually experiencing with each trade in the market. Sessions three and four are markets with the 'tax' policy. These are exactly as sessions one and two except the optimal tax has been imposed on sellers as an inescapable cost. Sessions five and six are markets with the policy standard. The experimental procedures of sessions one and two are again replicated, only market volume is limited to the optimal thirteen units on a first come, first served basis. Sessions seven and eight are the markets with pollution licences. Thirteen licences were distributed among subjects, which could be resold in an organised licence market. The sale of a unit in the primary market could only be made by a seller who had acquired a licence (one licence per unit) to make the sale.

Sessions three and four had an additional feature not covered above. As is the case with tax policies in general, a decision had to be made concerning the disposition of tax revenues. Here we chose the option of returning it to the agents by means of lump-sum grants and an expected balanced budget. Total grants equalled the tax revenue predicted by the competitive model. Each person was paid the individual loss theoretically resulting from the tax, plus an equal share of the social gains which would theoretically result from the policy. These calculations are all reflected in the capital payments listed in Table 1.

A special feature of the instructions was very important for sessions five and six. Ties on bids, offers, and acceptances were broken by a random process. Each subject had a card with his/her buyer (seller) number on it. Those subjects involved in a tie held up their cards and the experimenter used a random number table to resolve the conflict. In the case of the pollution standard almost every action involved ties throughout the entire session.

Sessions seven and eight also had special instructional provisions because two markets rather than one were involved. Appendix 4 makes clear the appropriate modifications. Both markets were oral double auction markets conducted simultaneously so a participant could purchase a licence and immediately make a sale in the primary market.

[1] An additional six experimental sessions were conducted but were discarded for various reasons having to do with 'contaminated' experimental settings. The results of the discarded experiments and the reasons for not including them with the experiments reported here may be obtained from the author.

II. EXPERIMENTAL RESULTS

(*A*) *Supply and Demand in Markets with Externalities*

The time series resulting from sessions one and two are shown on Figs. 4 and 5. The predicted equilibrium price is \$2.44 and the predicted quantity sold is twenty-four. As can be seen, the prices are near but below the predicted price. Average prices in the last two periods range from \$2.418 to \$2.434 within a 2.2 cent range of the predicted equilibrium. The quantity sold is twenty-four for three of these periods and twenty-six for the other (period four of session one), almost twice as much as the social optimum.

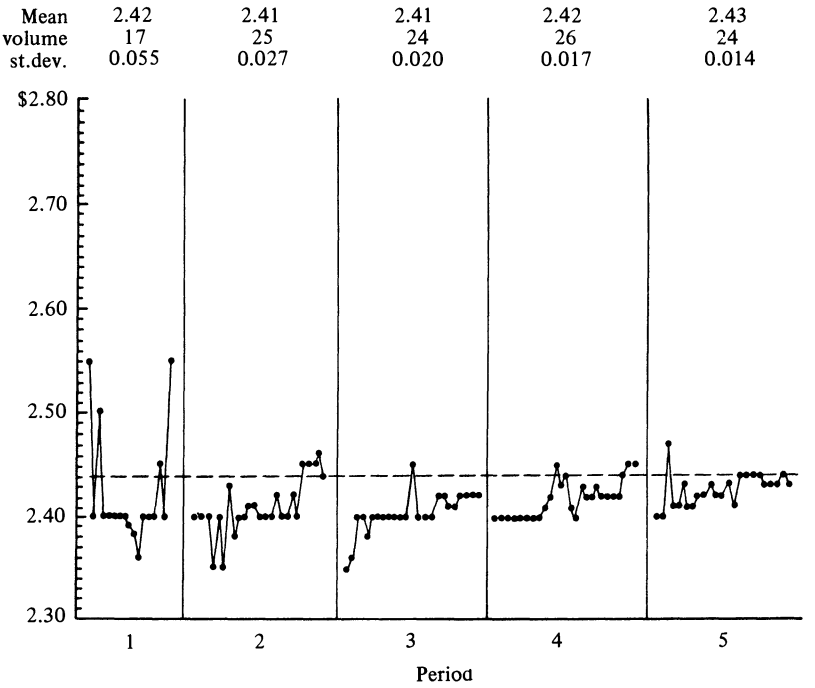

Fig. 4. Session 1, time series of contract prices.

We conclude that the existence of the externality had no effect on the market behaviour. That is, the market behaved as predicted by the direct application of the law of supply and demand. People were aware of the effects of their actions on others but this made no perceptible difference in behaviour. The slight deviation away from the predicted price is well within the margin of error one expects from market models especially when the net trading advantage is small.[1]

B. Comparative Performance of Corrective Policies

The three corrective policies, the tax, the standard and licences are compared along three different dimensions. First, the price and quantity behaviour are

[1] While the trading commission is 5 cents, the per person marginal damage in ranges near the predicted quantity is 4 cents, thus leaving a 1 cent commission. When commissions are low, small deviations from predictions are not unusual.

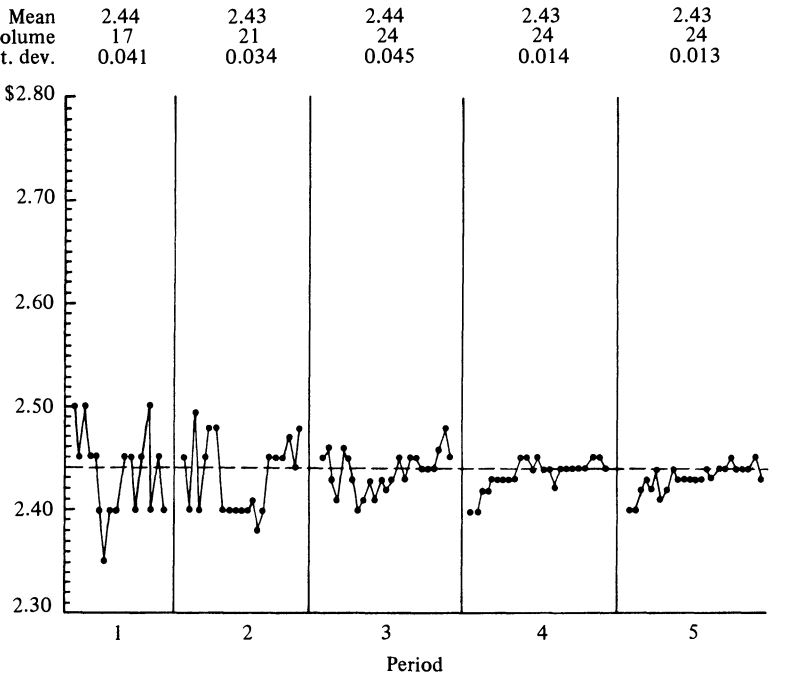

Fig. 5. Session 2, time series of contract prices.

compared. Second, the efficiency of all three are examined, and finally the distributional effects of the policies will be discussed.

B. 1. Price and Quantity Behaviour

The price and quantity results for the tax policy are shown on Figs. 6 and 7. Average price in the final period is less than $0.01 from the predicted price in one experiment and was exactly the predicted price in the other. Volume was one unit more than predicted in one and exactly as predicted in the other. The accuracy of the model in predicting the price and quantity behaviour in sessions three and four was to be expected in light of the results of sessions one and two. Once we know that the law of supply and demand applies to markets with externalities, the imposition of a tax simply becomes a change in supply as shown on Fig. 2. In this sense sessions three and four can be viewed as replications of sessions one and two.

The case of a policy standard is much different. The total number of trades is restricted to thirteen by the limitation on allowable 'pollution' damage. The 'optimum' quantity of pollution damage as calculated is compatible with only thirteen trades. Since trading activity is limited to the first thirteen contracts, subjects hurry to make bids (offers) and/or agree to any offers (bids) they find acceptable. This results in multiple-person ties both at the bid (offer) stage and the acceptance stage. These ties were resolved by a random number table.

The time series shown on Figs. 8 and 9 reflect the tendency for sellers (buyers), once given access to the 'trading floor', to make an offer (bid) at a high (low)

Mean	2.71	2.70	2.68	2.68	2.68	2.68
volume	6	11	12	13	11	14
st. dev.	0.049	0.043	0.031	0.009	0.008	0.010

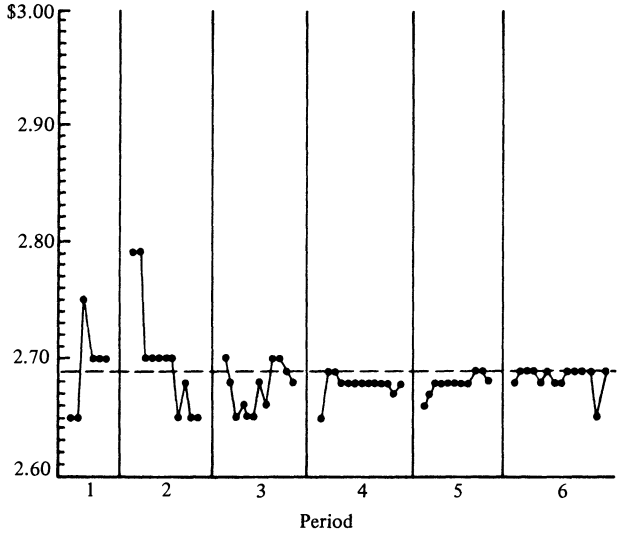

Fig. 6. Session 3, time series of contract prices.

Mean	2.73	2.70	2.69	2.69	2.69	2.69	2.69
volume	6	9	15	13	13	13	13
st. dev.	0.037	0.012	0.005	0.004	0.000	0.000	0.000

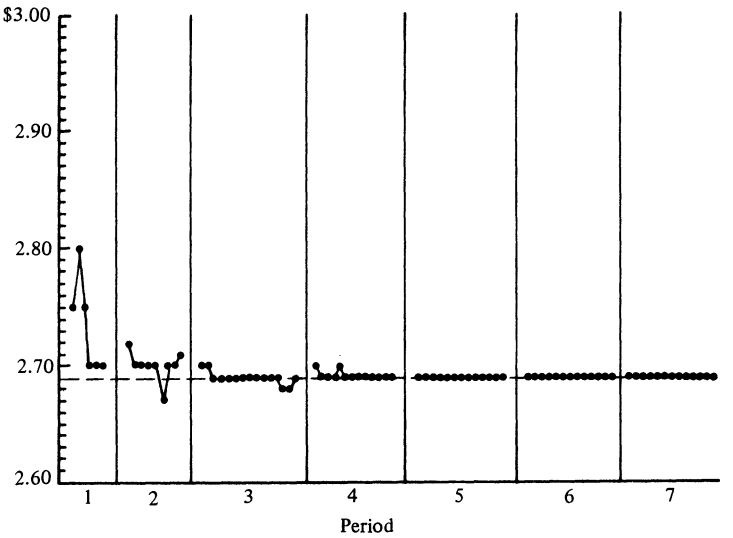

Fig. 7. Session 4, time series of contract prices.

price. Buyers (sellers) eager to have the opportunity to trade at all are eager to accept. Thus when the random process results in a seller (buyer) the price is high (low). Many periods were run and, as shown on the figures, prices all fall between the demand price evaluated at thirteen units (the upper dotted line shown in the figure) and the supply limit price evaluated at thirteen units (the lower dotted line in the figure) but there is little or no tendency to converge.

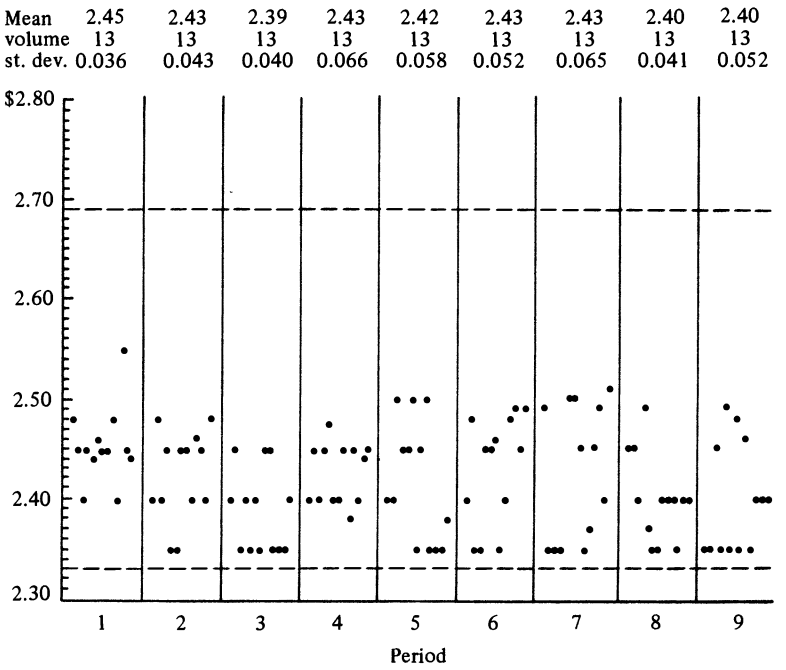

Fig. 8. Session 5, time series of contract prices.

The licence policy involves two markets, the primary market and the market for licences. The predicted price in the primary market is between $2.68 and $2.69. As can be seen in Figs. 10 and 11, in the last periods prices are within $0.04 of the equilibrium price range in market 7 and $0.01 of the range in market 8. Last period volumes are at the optimum thirteen units in both markets. The equilibrium price range of [0.35, 0.36] in the licence markets is to be compared with the actual final period average prices of $0.328 and $0.317. Volumes in the last period of both licence markets are the predicted nine trades. Since no commissions were paid for trades in licences, these values are probably as close to the predictions of the competitive model as might be reasonably expected.

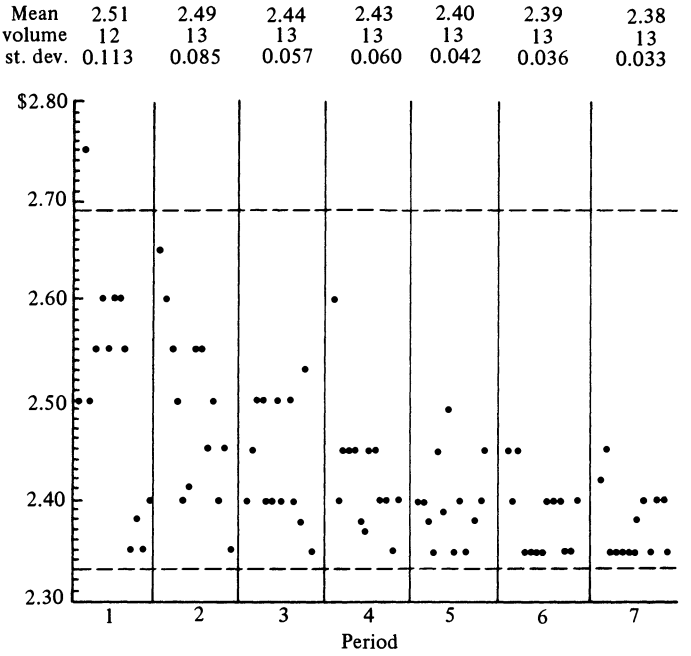

Fig. 9. Session 6, time series of contract prices.

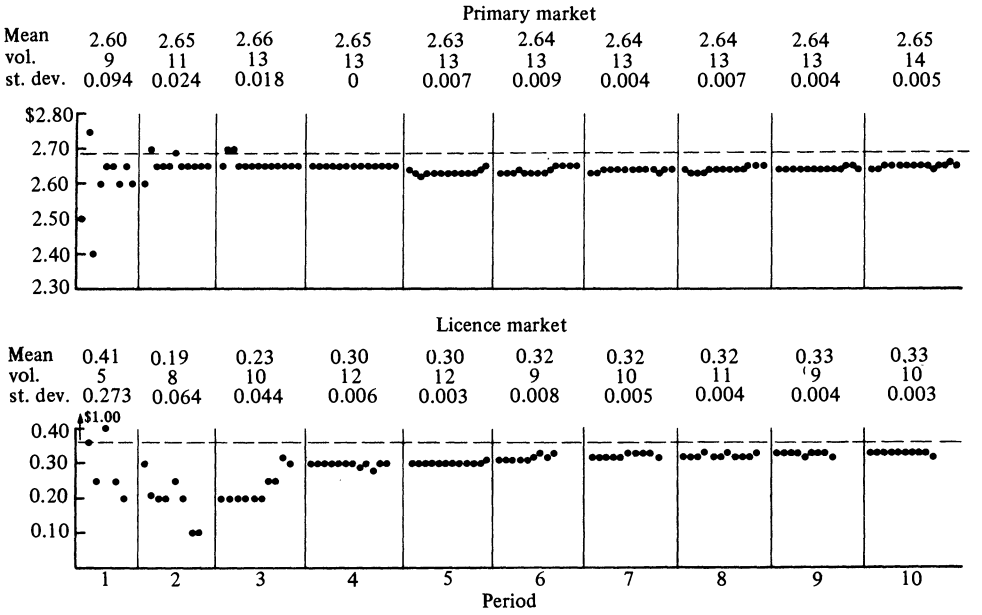

Fig. 10. Session 7, time series of contract prices.

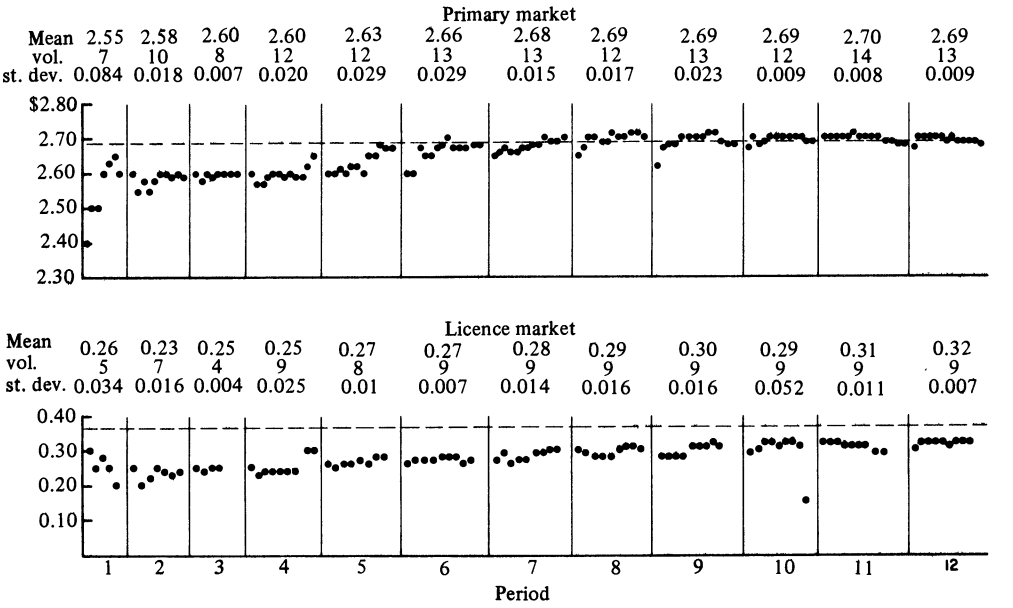

Fig. 11. Session 8, time series of contract prices.

B. 2. Efficiency

The trading patterns which emerge from these markets are Pareto optimal if and only if the total earning of the subjects is maximised. This occurs only in case the volume is thirteen units; all units sold have limit prices of $2.33 or less; and, the limit price of every unit purchased is no lower than $2.69. The efficiency is defined to be total earnings divided by total earnings possible (omitting commission). If the value of the external diseconomy is greater than the private gains from trading, total earnings can be negative, so the efficiency measure can be negative as it sometimes is.

The efficiency measures for each session are shown on Table 2. Least efficient of the modes of organisation are the unregulated externality cases. The most efficient mode of organisation was the licence policy. The differences in efficiency are significant except perhaps for the differences between the tax policy and the licence policy. For example, the average efficiency levels for periods other than the first two are −44·5 %, 34·4 %, 93·3 %, and 98·3 % for the no policy, policy standard, tax policy, and licence policy respectively.

The comparison between the licence policy and the tax policy should be qualified by the fact that many participants under the licence policy were experienced in laboratory market processes while those in the tax policy were totally inexperienced. Support exists (Smith and Williams, forthcoming) for the hypothesis that experience facilitates more rapid convergence. Of course the licence markets were more complicated in the sense that two markets were operating and subjects could be on both sides of the licence market as speculators.

A word of caution is in order about the interpretation of these efficiency

numbers and the use of efficiency concepts in laboratory markets in general. The degree of inefficiency which results from a process is probably sensitive to the structure of demand and supply. In these experiments there were several participants who were excluded from the market by just a few cents if the market attained a competitive equilibrium. Any process which leads to a high variance in prices will give such 'marginal' traders a chance to trade a unit or so each, and each such trade reduces market efficiency. If these extra-marginal units were controlled by a single subject who, by virtue of being a single trader, had fewer opportunities to trade, the efficiencies may have been elevated. In

Table 2

Efficiency Percentages

Policy session		Period											
		1	2	3	4	5	6	7	8	9	10	11	12
No policy	1	36·1	−111·9	−40·9	−85·3	−25·4	—	—	—	—	—	—	—
	2	15·9	−25·8	−42·8	−34·1	−38·5	—	—	—	—	—	—	—
Tax policy	3	68·3	83·3	89·7	92·1	96·4	96·8	—	—	—	—	—	—
	4	65·5	93·6	81·4	92·1	95·2	98·0	98·0	—	—	—	—	—
Policy standard	5	51·5	22·2	32·1	22·6	56·3	−0·4	39·7	−9·5	4·7	—	—	—
	6	54·4	17·7	59·1	45·6	36·1	53·6	72·6	—	—	—	—	—
Licence policy	7	88·6	95·9	96·5	98·3	96·0	99·6	—*	99·4	99·5	99·0	—	—
	8	90·7	93·9	88·4	99·5	97·2	98·8	97·6	—*	98·4	—*	96·3	99·6

* In these periods errors occurred in licence inventories, and the resulting efficiency numbers are not comparable to other periods.

addition, the efficiency of a licence policy might be affected by the initial distribution of licences by placing them in the 'right hands' initially. In these markets the maximum efficiency would have been 46 % had trading in licences been prohibited.

B. 3. Distribution

Subject earnings were determined by trading activity and capital payments. The latter, as explained above, were provided according to the experimenter's estimate (based on the hypothesis that the law of supply and demand works) of income due to trading. Thus individuals with poor limit prices were provided with high capital payments. The design was calculated to keep incomes for an experimental session in the 'no policy' case in the five dollar range for each subject (about $1 per period for five periods).

In the pollution tax case tax revenues were estimated and redistributed to participants as part of the capital payments. Thus capital payments to participants in the tax case are about $0.17 per period higher than in the 'no policy' case. Incomes in the pollution licence experiments depended upon trading activity, capital payments, and licence holdings. Capital payments in the licence experiments are the same as those in the 'no policy' case. Licences were initially distributed so that the ultimate income distribution predicted by the

competitive model would be as close as possible to the predicted distribution in the tax case.

The average income for the final periods of each session is shown in Table 3 along with the predicted values. Comparing income distributions averaged over the two experiments yields near unanimity of preference for any policy over no policy. Application of simple majority rule leads to the relation: standard beats licence (6 to 5), licence beats tax (8 to 4), and tax ties standard (6 to 6). Thus the standard policy is the core of a majority rule game and would be chosen by a majority from this set of policies given these parameters even though it is the least efficient of the three policies.

Table 3

Income Distribution: Predicted and Actual Averaged for the Final Two Periods

	Subject number											
Experiment no.	1	2	3	4	5	6	7	8	9	10	11	12
Predicted 1 and 2	0·84	0·82	0·85	0·88	0·84	0·84	1·46	1·89	0·86	0·86	0·84	0·84
Actual 1	0·65	0·53	0·72	0·76	0·82	0·86	1·27	1·98	0·80	0·91	0·89	0·90
Actual 2	0·77	0·76	0·55	0·95	0·91	0·84	1·41	1·70	0·92	0·99	0·84	0·87
Predicted 3 and 4	1·01	0·99	1·02	1·05	1·01	1·01	1·62	2·05	1·02	1·03	1·01	1·01
Actual 3	1·01	1·03	1·02	0·97	1·01	1·01	1·62	2·19	0·97	1·03	1·01	1·01
Actual 4	0·98	0·93	0·95	1·06	1·03	1·03	1·61	2·22	1·06	1·05	1·03	1·03
Predicted 5 and 6	No predictions											
Actual 5	0·76	0·24	0·84	1·12	1·21	1·30	1·18	0·27	1·16	1·42	1·33	1·44
Actual 6	0·70	0·50	0·76	1·14	1·21	1·21	1·58	1·15	0·76	1·32	1·35	1·25
Approximately 3 and 4	1·01	0·99	1·02	1·05	1·01	1·01	1·62	2·05	1·02	1·03	1·01	1·01
Actual 7	0·77	0·85	0·94	0·96	1·21	1·21	1·12	1·93	1·06	1·28	1·21	1·21
Actual 8	1·13	0·99	1·05	1·11	1·21	1·21	0·97	1·50	0·98	1·20	—	—

Least squares estimates of a linear model applied to the markets in which income predictions are possible yields:

$$Y = \underset{(0\cdot049)}{-0\cdot10} + \underset{(0\cdot046)}{1\cdot085X}$$

Y is actual income and X is predicted income and the numbers in parentheses are standard errors. The negative intercept term, which indicates the degree to which actual incomes are lower than the predicted, is probably due to efficiency losses. The high R^2 (0·90) demonstrates that the model is relatively accurate, but the combined hypothesis of zero intercept and slope of 1, as predicted by the competitive model, can be rejected.

III. CONCLUDING REMARKS

Within the simple setting explored here the traditional models found in the economics literature are amazingly accurate. Policies based on those models work as expected. Those who wish to offer competing theories about market

behaviour in externality situations must reconcile their ideas with these experiences.

California Institute of Technology

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APPENDIX I. UNREGULATED EXTERNALITY INSTRUCTIONS

General

This is an experiment in the economics of market decision making. Various research foundations have provided funds for this research. The instructions are simple and if you follow them carefully and make good decisions you might earn a considerable amount of money which will be paid to you in cash.

In this experiment we are going to simulate a market in which some of you will be buyers and some of you will be sellers in a sequence of market days or trading periods. Attached to the instructions you will find a sheet, labelled Buyer or Seller, which describes the value to you of any decisions you might make. *You are not to reveal this information to anyone.* It is your own private information.

Specific instructions to buyers

During each market period you are free to purchase from any seller or sellers as many units as you might want. For the first unit that you buy *during a trading period* you will receive the amount listed in row (1) marked *1st unit redemption value*; if you buy a second unit you will receive the additional amount listed in row (5) marked *2nd unit redemption value, etc.* The profits from each purchase (which are, after damages, yours to keep) are computed by taking the difference between the redemption value and purchase price of the unit bought. *Under no conditions may you buy a unit for a price which exceeds the redemption value.* In addition to this profit you will receive a 5 cent commission for each purchase. That is,

$$\begin{aligned}[\text{your earnings} = {} & (\text{redemption value}) \\ & -(\text{purchase price}) + 0.05 \text{ commission}].\end{aligned}$$

Your net income is the difference between earnings and damages due to operating environment. These damages are recorded along with your redemption schedule. *In addition* to this net income you will receive a capital payment each period of

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Suppose for example that you buy two units and that your redemption value for the first unit is \$200 and for the second unit is \$180. If you pay \$150 for your first unit and \$160 for the second unit, your earnings are:

$$\begin{aligned}\$ \text{ earnings from 1st} &= 200-150+0.05 &&= 50.05 \\ \$ \text{ earnings from 2nd} &= 180-160+0.05 &&= 20.05 \\ \text{Total } \$ \text{ earnings} &= 50.05+20.05 &&= 70.10.\end{aligned}$$

If damages total to \$30 your net income is

$$\text{net income} = \$70.10-\$30 = \$40.10.$$

The blanks on the table will help you record your profits. The purchase price of the first unit you buy during the first period should be recorded on row (2) *at the time of*

purchase. You should then record the profits on this purchase as directed on rows (3) and (4). At the end of the period record the total of profits and commissions on the last row (41) on the page. Total damages should be recorded on row (42) and your net income, row (41) minus row (42), should be recorded on row (43). In addition to this net income you will receive the capital payment listed on row (44).

Specific instructions to sellers

During each market period you are free to sell to any buyer or buyers as many units as you might want. The first unit that you sell *during a trading period* you obtain at a cost of the amount listed on the attached sheet in the row (2) marked *cost of 1st unit*; if you sell a second unit you incur the cost listed in the row (6) marked *cost of the 2nd unit, etc.* The profits from each sale (which after damages are yours to keep) are computed by taking the difference between the price at which you sold the unit and the cost of the unit. *Under no conditions may you sell a unit at a price below the cost of the unit.* In addition to this profit you will receive a 5 cent commission for each sale. That is,

$$[\text{your earnings} = (\text{sale price of unit}) - (\text{cost of unit}) + (0.05 \text{ commission})].$$

Your total profits and commissions for a trading period, which after damages are yours to keep, are computed by adding up the profit and commissions on sales made during the trading period. From this deduct the total of damages. The difference is your net income. In addition to this net income you will receive a capital payment each period of _____ .

Suppose for example your cost of the 1st unit is \$140 and your cost of second unit is \$160. For illustrative purposes we will consider only a two-unit case. If you sell the first unit at \$200 and the second unit at \$190, your earnings are:

$$\begin{aligned} \$ \text{ earnings from 1st} &= 200-140+0.05 &&= 60.05 \\ \$ \text{ earnings from 2nd} &= 190-160+0.05 &&= 30.05 \\ \text{Total } \$ \text{ earnings} &= 60.05+30.05 &&= 90.10. \end{aligned}$$

The blanks on the table will help you record your profits. The sale price of the first unit you sell during the 1st period should be recorded on row (1) *at the time of sale.* You should then record the profits on this sale as directed on rows (3) and (4). At the end of the period record the total of profits and commissions on the last row (41) on the page. Total damages should be recorded on row (42) and your net income, row (41) minus row (42), should be recorded on row (43).

Market organisation

The market for this commodity is organised as follows. We open the market for a trading period (a trading 'day'). The period lasts for _____ minutes. Any buyer (or seller) is free at any time during the period, to raise his hand and make a verbal bid (offer) to buy one unit of the commodity at a specified price. Any seller (or buyer) is free to accept or not accept the bid of any buyer (or seller). If a bid is accepted a binding contract has been closed for a single unit and the buyer and seller will record the contract price to be included in their earnings. Any ties in bids or acceptances will be resolved by a random choice of buyer or seller. Except for the bids and their acceptance you are not to speak to any other subject. There are likely to be many bids that are not accepted, but you are free to keep trying, and as a buyer or a seller you are free to make as much profit as you can.

Are there any questions?

Appendix Table 1

Sample Instructions Forms

Record of Purchases and Earnings, Buyer No. _____

Unit sold		Trading period number	1	2	3	4	5	. . .
1	1	1st unit redemption value						
	2	Purchase price						
	3	Profit (row 1 − row 2)						
	4	Profit + 5 cents commission						
		⋮						
10	37	10th unit redemption value						
	38	Purchase price						
	39	Profit (row 37 − row 38)						
	40	Profit + 5 cents commission						
	41	Total per period earnings						
	42	Damages						
	43	Net income						
	44	Capital payment						

Name _____ Soc. Sec. No. _____

Address _____

Total Payment _____

Record of Sales and Profits, Seller No. _____

Unit sold		Trading period number	1	2	3	4	5	. . .
1	1	Selling price						
	2	Cost of 1st unit						
	3	Profit (row 1 − row 2)						
	4	Profit + 5 cents commission						
		⋮						
10	37	Selling price						
	38	Cost of 10th unit						
	39	Profit (row 37 − row 38)						
	40	Profit + 5 cents commission						
	41	Total per period						
	42	Damages						
	43	Net income						
	44	Capital payment						

Name _____ Soc. Sec. No. _____

Address _____

Total Payment _____

Buyer No. _____

Capital Payment per Period _____

Damages Due to Operating Environment		
Unit traded in the market	Damage Value	Total value
1	2¢	2¢
2	2¢	4¢
⋮	⋮	⋮
10	2¢	20¢
11	3¢	23¢
⋮	⋮	⋮
20	3¢	50¢
21	4¢	54¢
⋮	⋮	⋮
45	4¢	150¢

APPENDIX 2. POLICY STANDARD EXPERIMENT INSTRUCTIONS

The instructions and forms are identical to those in Appendix 1 with the market organisation section in Appendix 1 modified as follows.

Market organisation

The market for this commodity is organised as follows. We open the market for a trading period (a trading 'day'). The period lasts for _____ contracts. Any buyer (or seller) is free . . . [continue as in Appendix 1 instructions].

APPENDIX 3. TAX/BRIBE EXPERIMENT INSTRUCTIONS

The instructions are identical to those in Appendix 1, with the following modifications to the sellers' instructions and instruction forms.

Specific instructions to sellers

During each market period you are free to sell to any buyer or buyers as many units as you might want. The first unit that you sell *during a trading period* you obtain at a cost of the amount listed on the attached sheet in the row (2) marked *cost of 1st unit*; if you sell a second unit you incur the cost listed in the row (8) marked *cost of the 2nd unit, etc.* The before tax profits from each sale (which after taxes and damages are yours to keep) are computed by taking the difference between the price at which you sold the unit and the cost of the unit. *Under no conditions may you sell a unit at a price below the cost of the unit.* In addition to this profit you will receive a 5 cent commission for each sale. That is,

[net profit on sale = (sale price of unit) − (cost of unit) + (0.05 commission) − tax].

Your total net profits and commissions for a trading period, which after damages are yours to keep, are computed by adding up the net profit and commissions on sales made during the trading period. From this deduct the total of damages. The difference is your net income. In addition to this net income you will receive a capital payment each period of _____ .

Suppose for example your cost of the 1st unit is \$140, your cost of the second unit is \$160 and taxes are \$10 per unit. For illustrative purposes we will consider only a two-unit case. If you sell the first unit at \$200 and the second unit at \$190, your net profits on sales are:

$$\begin{aligned} \text{\$ net profits from 1st} &= 200-140+0.05-10 = 50.05 \\ \text{\$ earnings from 2nd} &= 190-160+0.05-10 = 20.05 \\ \text{Total \$ net profits} &= 50.05+20.05 = 70.10. \end{aligned}$$

If damages total to \$30.00 your net income is

$$\text{net income} = \$70.10-\$30.00 = \$40.10.$$

The blanks on the table will help you record your profits. The sale price of the first unit you sell during the 1st period should be recorded on row (1) *at the time of sale.* You should then record the profits on this sale as directed on rows (3) and (4) and deduct taxes as directed in rows (5) and (6). At the end of the period record the total of profits and commissions on the last row (61) on the page. Total damages should be recorded on row (62) and your net income, row (61) minus row (62), should be recorded on row (63).

Appendix Table 2

Modified Seller Instruction Form tax/bribe Experiment

Record of Sales and Profits, Seller No. _____

Unit sold		Trading period number	1	2	3	4	5	. . .
1	1	Selling price						
	2	Cost of 1st unit						
	3	Profit (before tax) (row 1 − row 2)						
	4	Profit+5 cents commission						
	5	Tax						
	6	Net profit						
		. . .						
10	55	Selling price						
	56	Cost of 10th unit						
	57	Profit (before tax) (row 55 − row 56)						
	58	Profit+5 cents commission						
	59	Tax						
	60	Net profit						
	61	Total per period						
	62	Damages						
	63	Net income						
	64	Capital payment						

APPENDIX 4. LICENCE EXPERIMENT INSTRUCTIONS

These instructions are identical to those in Appendix 1 with the following modifications to the general section, the instructions to sellers, and the sellers' forms. In addition, special instructions and record sheets for the licence market were added. As a note to experimentalists, I need to add that the subjects in the licence experiment were experienced. Inexperienced subjects may need instruction in addition to those contained here because of the difficulty in understanding the operation of two simultaneous markets.

General

[Add the following paragraph to the General section in Appendix 1.]

Two markets exist: a primary market (*P*-market) and a licence market (*L*-market). They are related by the fact that sellers must buy licences in the *L*-market in order to participate in the *P*-market. A seller must acquire a licence for each unit (s)he attempts to sell in the *P*-market. The mechanics of both markets will be explained beginning with an explanation of the primary market.

Primary market

Specific instructions to buyers

[Unchanged.]

Specific instructions to sellers

During each market period you are free to sell to any buyer or buyers as many units as you have licences. The first unit that you sell *during a trading period* you obtain at a cost of the amount listed on the attached sheet in the row (2) marked *cost of 1st unit*; if you sell a second unit you incur the cost listed in the row (8) marked *cost of 2nd unit, etc.* The profits from each sale (which after licence costs and damages are yours to keep) are computed by taking the difference between the price at which you sold the unit and the cost of the unit. *Under no conditions may you sell a unit at a price below the cost of the unit.* In addition to this profit you will receive a five cent commission for each sale. That is,

$$[\text{net profit on sale} = (\text{sale price of unit}) - (\text{cost of unit}) + (0.05 \text{ commission}) - (\text{licence cost})].$$

Your total net profits and commissions for a trading period, which after damages are yours to keep, are computed by adding up the net profit and commissions on sales made during the trading period. From this deduct the total of damages. The difference is your net income. In addition to this net income you will receive a capital payment each period of _____ .

Suppose for example your cost of the 1st unit is \$140, your cost of the second unit is \$160, and suppose the licence cost \$10 per unit. For illustrative purposes we will consider only a two-unit case. If you sell the first unit at \$200 and the second unit at \$190, your net profit on sales are:

$$\begin{aligned} \$ \text{ net profits from 1st} &= 200 - 140 + 0.05 - 10 = 50.05 \\ \$ \text{ earnings from 2nd} &= 190 - 160 + 0.05 - 10 = 20.05 \\ \text{Total } \$ \text{ net profits} &= 50.05 + 20.05 = 70.10. \end{aligned}$$

If damages total to \$30, your net income is

$$\text{net income} = \$70.10 - \$30.00 = \$40.10.$$

The blanks on the table will help you record your profits. The sale price of the first unit you sell during the first period should be recorded on row (1) *at the time of sale.* You should then record the profits on this sale as directed on rows (3) and (4) and deduct licence costs as directed in rows (5) and (6). At the end of the period record the total of profits and commissions on the last row (61) on the page. Total damages should be recorded on row (62) and your net income, row (61) minus row (62), should be recorded on row (63).

Market organisation

[Unchanged.]

Licence markets

Each period you will have _____ licences which you can use as you wish; that is, you can sell them and keep the profits, you can buy more and attempt to resell them for a profit, you can use them in the primary market if you are a seller, or you can simply let them expire. Such decisions are yours to make.

The attached information and record sheets are to help you with these decisions. On row zero you will see your inventory of licences at the beginning of the period. The sales price should be entered in the appropriate column at the time of each sale.

Appendix Table 3

Modified Seller Instruction Form, New Record Forms Licence Experiment

Record of Sales and Profits, Seller No. ____ : P-Markets

Primary market	Unit sold		Trading period number	1	2	3	4	5	. . .
	1	1	Selling price						
		2	Cost of 1st unit						
		3	Profit (row 1 – row 2)						
		4	Profit + 5 cents commission						
		5	Licence						
		6	Net profit						
		.	.						
		.	.						
		.	.						
	10	55	Selling price						
		56	Cost of 10th unit						
		57	Profit (row 55 – row 56)						
		58	Profit + 5 cents commission						
		59	Licence						
		60	Net profit						
		61	Total per period						
		62	Damages						
		63	Net income						
		64	Capital payment						

Information and Record Sheet: L-Markets

Year ____

Licence market

Beginning of the year holdings

Transaction number	Transaction price: Sale	Transaction price: Purchase	Licences on hand
0	//////////	//////////	
1			
2			
.			
.			
.			
17			
Totals			
Profits = revenues from sales – cost of purchases			

Trader No. ____

Profit Sheet

Row	Market year	Profit
1	1	
2	2	
.	.	.
.	.	.
.	.	.
14	14	
15	Total dollars profit	

Name _____

Purchases should be similarly recorded and the inventory of licences should be kept current with each transaction. End of period profits (losses) are calculated at the bottom and added to profits acquired in the primary markets.

The following instructions were not used but are recommended for the licence market.

Accounting for the L-market

On line zero of your Information and Record Sheet for the *L*-market you are given a beginning of the year inventory of licences. You may use the licences in the *P*-market, sell them, or buy more if you wish. The purpose of the form is to provide you with a proper accounting of your inventory and profits in the *L*-market.

If you sell (buy) a licence enter the price in the column marked Sale (Purchase). You should then adjust the total of licences on hand in the right hand column. The total should never go below zero (no short sales).

If you are a seller in the *P*-market and wish to use one of your licences for a sale in the *P*-market, record a sale (to yourself) on the Information and Record Sheet for the *L*-market. Enter a price under the Sale column and adjust the inventory total downward. The price should also be entered as a cost in the *P*-market record sheet. You might notice that the price you record makes no difference to your profits because the revenue recorded on one sheet is exactly offset by the cost recorded on the other.

Profits at the end of the period should be calculated on the last line. Record end-of-period profits on the Profit Sheet.

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