Experimental Economics: Induced Value Theory

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It is the premise of this paper that the study of the decision behavior of suitably motivated individuals and groups in laboratory or other socially isolated settings such as hospitals (R. Battalio, J. Kagel, et al., 1973) has important and significant application to the development and verification of theories of the economic system at large. There are two reasons for this.

1. The results of laboratory studies can serve as a rigorous empirical pretest of economic theory prior to the use of field data tests. The state of economic hypothesis testing, as it is sometimes done, can be described roughly as follows: based on casual observation of an economic process and the self-interest postulate, one develops a model, which is then tested with the only body of field data that exists. The results of the test turn out to be ambiguous or call for improvements, and one is tempted to now modify the model in ways suggested by the data "to improve the fit." Any test of significance now becomes hopelessly confused if one attempts to apply it to the same data. Where it is possible and feasible, as in the study of price formation, the data from controlled experiments can be used to test hypotheses stemming from prescientific casual observations of a particular phenomenon. The fact that one can always run a new experiment means that it is never tautological to modify the model in ways suggested by the results of the last experiment. Since economic theories always deal with certain alleged behavioral tendencies in isolation, the experimental laboratory is uniquely well suited for testing the validity of such theories. It provides an exceptionally rigorous discipline of our ability to model elementary situations whether or not field data can be regarded ultimately as having been generated by such elementary models.

2. The results of experiments can be directly relevant to the study and interpretation of field data. Other so-called nonexperimental sciences such as meteorology and astronomy have depended crucially for their development on (a) small-scale laboratory experiments in the physics of mass motion, thermodynamics, and nuclear reactions; and (b) the postulate that such microphysical experimental results apply, with suitable modifications, to the study of the weather, the planets and the stars. This parallelism, "As far as we can tell, the same physical laws prevail everywhere" (Harlow Shapley 1964, p. 43), also has application to the study of social economy. Laboratory experience suggests that all of the characteristics of "real world" behavior that we consider to be of primitive importance—such as self-interest motivation, interdependent tastes, risk aversion, subjective transactions cost (time is consumed), costly information (it takes time to acquire and process information), and so on—arise naturally, indeed inevitably, in experimental settings. Anyone who had begun the study of economics in

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the laboratory without these concepts would soon find himself inventing them. Furthermore, the process of experimental design forces one to articulate rules and procedures, the collection of which forms an institution, organization, or "body of law" with striking "real world" parallels (cf. Martin Shubik 1974). The laboratory becomes a place where real people earn real money for making real decisions about abstract claims that are just as "real" as a share of General Motors.

I. The Theory of Induced Valuation

Control is the essence of experimental methodology, and in experimental exchange studies it is important that one be able to state that, as between two experiments, individual values (e.g., demand or supply) either do or do not differ in a specified way. Such control can be achieved by using a reward structure to induce prescribed monetary value on actions. The concept of induced valuation (Smith 1973) depends upon the postulate of *nonsatiation:*

> Given a *costless* choice between two alternatives, identical except that the first yields more of the reward medium (usually currency) than the second, the first will always be chosen (preferred) over the second, by an *autonomous* individual, i.e., utility is a monotone increasing function of the monetary reward, $U(M)$, $U' > 0$. [pp. 22–23]

This postulate applies to experiments designed to test price theory propositions conditional upon known valuations. Separate experiments can be designed to test propositions in preference theory.

Example 1. In the experimental study of competitive equilibria in isolated markets it is necessary to induce known (to the experimenter) supply or demand on individual subjects. Let subject buyers $i=1, 2, \ldots, n$ each be given a table listing increasing concave total receipts $R_i(q_i)$ representing the currency redemption or "resale" value of q_i units acquired by subject i in an experimental market. The instructions state that if subject i acquires q_i units at prices $p_1^i, p_2^i, \ldots, p_{q_i}^i$, he will receive cash earnings of $R_i(q_i) - \sum_{k=1}^{q_i} p_k^i$. Neoclassical demand is defined as the quantity that would be purchased as a function of a given hypothetical price p. By this definition, if for a fixed p a subject purchases q_i units, he earns $R_i(q_i) - pq_i$. If his utility for money is $U_i(M_i)$ he will wish to $\max_{q_i} U_i[R_i(q_i) - pq_i]$. We have an interior maximum if and only if

$$(R_i' - p)U_i' = 0, \; U_i' > 0, \qquad \text{or } q_i = R_i'^{(-1)}(p),$$

for the class of functions U_i, R_i such that $(R_i' - p)^2 U_i'' + U_i' R_i'' < 0$. This reward scheme induces arbitrary demand $R_i'^{\,(-1)}(p)$ on subject i, and the experimentally controlled market demand becomes $Q = \sum_{i=1}^{n} R_i'^{\,(-1)}(p)$ independent of the U_i.

Similarly, let $j=1, 2, \ldots, m$ subject sellers be given cost functions $C_j(q_j)$, and receive cash earnings $\sum_{k=1}^{q_j} p_k^j - C_j(q_j)$ from selling q_j units at prices $p_1^j, p_2^j, \ldots, p_{q_j}^j$. If utility is $V_j(M_j)$, $V_j' > 0$, then $\max_{q_j} V_j[pq_j - C_j(q_j)]$ implies a supply function $q_j = C_j'^{\,(-1)}(p)$. The experimentally controlled market supply is $Q = \sum_{j=1}^{m} C_j'^{\,(-1)}(p)$ independent of the V_j. Such induced supply and demand become flows per period in experiments in which trading is conducted in a sequence of periods.

Example 2: Let subject traders be given a table listing increasing concave currency receipts $M(x_1, x_2)$ to be paid by the experimenter for terminal stocks (x_1, x_2) of each of two abstract experimental commodities exchanged in an experimental general equilibrium market. Then subject i's unknown utility for currency $U_i(M)$ induces the value $U_i[M(x_1, x_2)]$ on terminal stocks (x_1, x_2). Consequently, the experimentally controlled indifference map given by the level contours of $M(x_1, x_2)$ are induced upon subject i independent of his particular U_i. That is, each subject's marginal rate of substitution of x_2 for x_1 is given by $U_i' M_1/U_i' M_2 = M_1/M_2$, $U_i' > 0$. This allows the "Edgeworth Box" representation of general exchange equilibrium to be reproduced experimentally by inducing a given indifference map on each member of one group of subjects, and another indifference map on each of a second group of subjects. With given endowments of the abstract commodities for members of each of the two trading groups, the experimental stage is set for exchange.

II. Some Qualifications

There are three important qualifications to the nonsatiation postulate:

1. There may be subjective costs (or values) associated with market decisions. In a competitive market experiment a subject may find it arduous to monitor and make quotations, and to execute transactions. If such considerations are not negligible, then we lose some control over the process of induced valuation. The effect of boredom and the subjective costs of decision making have been emphasized in the important study by Sidney Siegel (1961). Roger Sherman (1974) has interpreted alleged violations of the Savage axioms in terms of the subjective cost of making the appropriate computations. In terms of the utility interpretation of the previous section, the utility function can now be written $U^i(M_i, E_i)$ where E_i is the "transactional effort" required to obtain reward M_i (cf. Harvey Leibenstein 1969; and implicitly, Ronald Coase 1960). To see the potential implications of costly choice, consider example 1 of the previous section in which demand $R_i'^{(-1)}(p)$ is induced upon i. Utility is now $U^i\{R_i[q_i(E_i)] - pq_i(E_i), E_i\}$ where it is assumed crudely that "bargaining effort," E_i, results in the purchase quantity $q_i(E_i)$. Then $\max_{E_i} U^i$ implies $(R_i' - p)\, q_i' U_1^i + U_2^i = 0$, and now the induced demand is $q_i = R_i'^{(-1)}(p - U_2^i/U_1^i q_i') < R_i'^{(-1)}(p)$, if $U_2^i < 0$, $q_i' > 0$. Hence, if there is a cost (value) to transacting in the experimental task, the induced demand will be smaller (larger).

There are several ways of dealing with this problem:

(a) One is to examine the experimental results to see if the quantity exchanged is less than predicted. If it is, this is consistent with a significant transactions cost. Awareness of such transactions cost may provide valuable clues to understanding why certain experiments may fail to produce predicted results. The process is not tautological as long as one can redesign the experiment and show that such conjectured transactional effects can be reduced.

(b) Another approach is to use a reward structure to compensate for, or offset, the subjective costs of transacting. There are two ways of doing this. (i) One way (Siegel 1961) is to simply raise the reward level. This increases the subjective value relative to the subjective cost of acquiring units q_i. Let α be a scale parameter determining reward level. Then utility becomes $U^i\{\alpha(R_i[q_i(E_i)] - pq_i(E_i)), E_i\}$. Induced demand is now $q_i = R_i'^{(-1)}(p - U_2^i/U_1^i q_i'\alpha) \to R_i'^{(-1)}(p)$ in the limit as α increases provided that the marginal rate of substitution $-U_2^i/U_1^i q_i'\alpha$ decreases with the reward level. (ii) Alternatively, and this is the device used most extensively, subjects are promised a "commission," β, for *each* transaction in addition to their cash trading profits. Now utility is $U^i\{R_i[q_i(E_i)] - (p-\beta)q_i(E_i), E_i\}$, and induced demand is

$$
\begin{aligned}
q_i &= R_i'^{(-1)}(p - \beta - U_2^i/U_1^i q_i') \\
&\cong R_i'^{(-1)}(p) \qquad \text{if } \beta \cong -U_2^i/U_1^i q_i' > 0.
\end{aligned}
$$

Compare two experiments (Charles Plott and Smith 1975, pp. 20–21) in which the induced supply and demand conditions were identical but one paid no cash trading commission, only trading profit, while the other paid both: In the one experiment, volume was below (17–18 units) the "theoretical" equilibrium quantity (20 units) in all seven trading periods; in the second experiment, volume was below (19 units) equilibrium in only two of eight trading periods.

2. Individuals may attach game value to experimental outcomes. A profit in "points," $R_i(q_i)-pq_i$, may have subjective value $S_i[R_i(q_i)-pq_i]$. If S_i is monotone increasing then such game utilities create no methodological problems since they reinforce rather than distort the effect of an explicit monetary reward structure. Because of such game utilities it is often possible in simple-task experiments to get satisfactory results without monetary rewards by using instructions to induce value by role-playing behavior (i.e., "think of yourself as making a profit of such and such when . . ."). But such game values are likely to be weak, erratic, and easily dominated by transactions costs, and subjects may be readily satiated with "point" profits.

Qualifications 1 and 2 are illustrated in the convergence behavior of three experimental markets with no cash rewards and seven markets with complete and with random cash rewards. In the first three cases subjects were asked to imagine that trading profits and commissions were real. In each case the market was organized as a continuous double auction. (Buyers could make oral bids and sellers oral offers for a single unit, and any seller could accept a bid, any buyer an offer. Each subject knew only his own demand or supply conditions.) (See Smith 1964, pp. 199–201 for the instructions.) In the first case (Smith 1962, p. 118, Chart 3) subjects trade only one unit per trading period. The absence of cash rewards does not hinder convergence to prices near equilibrium by the third trading period. However, deviations increase in period 4. In the absence of cash rewards this is more likely to occur as gaming boredom follows an initial (pleasant) experience of learning.

In a second experiment (previously unpublished) buyers received multiunit revenue (or resale value) schedules, and sellers multiunit total cost schedules. There were three buyers with one schedule, eight with another; four sellers with one cost schedule, eight with another. Now the task is more difficult and incentives are weak. Price convergence is strong, especially in the second period, since the greater volume when traders are given multiple-unit capacities increases the learning experience within a trading period. But volume is considerably below (24 and 26 units in the first and second periods) the competitive prediction (30 units). This is consistent with the above theory where the task is more difficult (higher transactions cost) and monetary rewards are absent.

Case 3 (Smith 1962, p. 119, Chart 4) illustrates an experiment which fails to reach either the competitive price or quantity although the market stabilizes nicely. In this case equilibrium requires contract prices to fall to the common limit price of all sellers. They are to "imagine" themselves as making a 5-cent commission on

TABLE 1—MEAN CONTRACT PRICE BY TRADING PERIOD

Experiment	1	2	3	4	5	6	7
Excess Supply	5	5	5	5	8	8	8
Reward Condition	Complete	Complete	Random	Complete	Complete	Complete	Complete
Information Condition	Incomplete	Incomplete	Incomplete	Complete	Incomplete	Incomplete	Complete
Trading Period 1	3.48	3.67	3.60	3.51	3.26	3.49	3.56
Trading Period 2	3.29	3.26	3.44	3.40	3.15	3.28	3.25
Trading Period 3	3.19	3.12	3.31	3.34	3.11	3.13	3.20
Trading Period 4	3.14	3.10	3.24	3.37	3.10	3.12	3.17

trades at these limit prices, but clearly this is not real enough to induce many contracts at \$3.10 (the theoretical equilibrium). Not even a decrease in demand succeeded in lowering contracts to \$3.10 (Table 1). This contrasts with several experiments (1, 2, 5, 6 in Table 1) using complete cash rewards in which the supply and demand are even more asymmetric than in case 3. In Table 1, markets with an excess supply of five (eight) consisted of eleven buyers with limit prices \$4.20 and sixteen (nineteen) sellers with limit prices \$3.10. A different subject group participated in each double auction experiment. Convergence to the competitive price and quantity by trading period 4 was strong, although at the equilibrium price each buyer receives \$1.15 profit with commission per trade while each seller receives only the 5-cent commission.

A controlled measurement of the effect of complete versus random monetary rewards is shown in Table 1, experiments 1–3. In 1 and 2 all subjects were paid their trading profit plus commission in cash, while in 3 four of the 27 subjects were chosen at random to receive cash profits at the end of each trading period. The weaker random reward structure significantly retards the market's convergence.

Qualifications 1 and 2 lead to a precautionary corollary: with or without monetary rewards, the experimenter may be tempted to add "realism" by giving the abstract experimental commodity a name such as "wheat," or otherwise attempt to use instructions to simulate the alleged circumstances of a particular market. This runs the danger of so enriching induced values that control over valuation is lost. Suppose, as above, that a subject is paid $R_i(q_i)-pq_i$, but also perceives that he must attach instruction-induced value to q_i. Utility may now be $U^i[R_i(q_i)-pq_i, q_i]$, and demand becomes $q_i=R_i'^{(-1)}(p-U_2^i/U_1^i) > R_i'^{(-1)}(p)$. Consequently, it may be preferable *not* to embellish the instructions with well-intentioned attempts at "realism." Let the explicit reward structure be the singular source of valuation, insofar as this is possible.

3. Individuals may not be autonomous own-reward maximizers. Interpersonal utility criteria may qualify the theory of induced valuation. Thus subject i's utility may depend upon both i's and k's reward, $U^i[R_i(q_i)-pq_i, R_k(q_k)-pq_k]$. If this condition prevails, then the demand of i may depend upon that of k. However, this kind of interdependence is effectively controlled by the experimental condition of "incomplete" information, first defined and studied by Lawrence Fouraker and Siegel (1960, 1963) in experimental studies of bilateral bargaining and oligopoly. Under incomplete information subjects only know their own payoff contingencies. With $R_k(q_k)$ unknown to i, it cannot appear as a subjective argument of U^i.

The effect when subjects have complete information on each other's payoff contingencies is seen (Table 1) by comparing 1 (5) and 2 (6) with 4 (7). In 1 (5) and 2 (6) each subject knew only his own limit price. In 4 (7) the only change in the instructions was to add the information that there were eleven buyers, each with a \$4.20 resale value, and sixteen (nineteen in 7) sellers, each with unit cost \$3.10. From the mean price series it is seen that "complete" information of this kind retards the equilibrium tendencies of the double auction. Mean prices, especially in periods 3 and 4, tended to be higher under complete information than under incomplete information. The explanation is that with information on each other's payoffs, the way is open for "equity" considerations to modify self-interest choices. Sellers, believing that it is "fair" for trading profits to be shared between buyers and sellers, try to resist price decreases more vigorously than when they do not know what constitutes such a fair price. Buyers acquiesce in this sharing by accepting many contracts well above $3.10, but since there is an excess of sellers, those holding out for the higher prices are the sellers most likely to fail to make contracts. Consequently, contract prices tend to decline, if slowly, when excess supply is 5, but more rapidly when excess supply is 8. The tendency of prices to be higher under complete information is contrary to the view of those who have argued that "perfect" information is essential for establishing competitive prices. The results are consistent with the game-theoretic proposition that more information increases the prospect of collusion (Shubik 1959, p. 171), and with the results of Fouraker and Siegel (1963, p. 187) in which the tendency of the competitive equilibrium to prevail under duopoly bargaining is reduced under complete information.

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