EXPERIMENTAL TECHNIQUES IN ECONOMICS:
SOME LESSONS TO DATE

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INTRODUCTION

We are all familiar with the general public's opinion of Economists, encapsulated in the refrain that if the same question is put to ten economists the questioner will receive eleven different answers. Such jokes may be amusing when heard for the first time, but the frequency with which they are expressed should also serve as a warning signal that there is something fundamentally wrong with contemporary Economics.

The problem is the inadequacy of current procedures for testing new theories within Economics. At present the economics profession relies almost exclusively on econometric methods for testing rival theories. Unfortunately econometrics is usually only applicable to macroeconomic questions, and even then its findings are rarely convincing enough to demonstrate to both sides in a dispute whose theory is the better. This has allowed competing, mutually incompatible theories to co-exist, leaving the economists' decision as to which theory to accept to non-scientific criteria. Unsurprisingly, the reputation of economists has suffered in consequence.

However an alternative testing procedure has been available for some considerable time. Although grossly underused during the four decades since they were pioneered, laboratory experiments in economics have offered a practical procedure for testing a variety of theories. In recent years interest in these methods has seen phenomenal growth. But not all economic theories are susceptible to laboratory testing either. As a broad generalisation, microeconomic theories may be tested experimentally, whereas macroeconomic theories may not. Nevertheless, some of the results from the microeconomic experiments do have significant macroeconomic implications. It is also worth noting that due to their different strengths and
weaknesses, econometrics and laboratory experimentation can be seen as complements to one another, rather than as rival testing procedures.

In this paper I shall aim to provide a basic exposition of the methods and uses of a variety of the experimental techniques that have been used to date in economic research. I shall also discuss a selection of the experiments, chosen to reflect the variety of economic issues that may be addressed. This paper is not however intended to be a survey. My primary aim will be to provide a context within which the experimental results can be understood, as well as a discussion of what I see as the main lessons so far. For more survey oriented articles, the interested reader is referred to PLOTT (1988), and BUTLER & HEY (1987).

The paper will be divided into four sections. Following the introduction, section two looks at experiments involving market institutions. Section three considers a variety of experiments on individual choice behaviour. Section four considers some criticisms that have been made of experimental methods as well as drawing out some of the main conclusions to date and pointers for future research.

SECTION TWO

Economic theorists seek to understand real world markets by constructing simplified models of the relationships between relevant variables. But observation of those markets cannot offer adequate supporting evidence for any one theory because 'ceteris' is rarely 'paribus'. That is, if a certain sequence of events is observed to follow from a change in one variable, we cannot be confident of the causality unless all other variables are held constant, and that the results prove to be replicable.
The experimentalists' solution to this has been to construct miniature economic environments, where the experimenter is in control of some of the key variables. It is then possible to test the theories on their own terms. Control is established by inducing value in an essentially worthless commodity (see SMITH 1976). This is achieved by devising a media through which the buyers and sellers interact, in accordance with an incentive compatible method of payment. In this manner the experimenter can establish control over the economic environment within which the experiment is to take place.

Using WILDE’s (1981) terminology, we may define a miniature microeconomic environment as follows:

A list of agents..........(1,...,n);
A list of commodities...(1,...,l);
Each agent may be described by a utility function \( U_i \), a technology \( T_i \), and an initial endowment vector \( W_i \). Hence the \( i \)-th agent, \( e_i \), can be described by: \( e_i=(U_i,T_i,W_i) \). The economic environment is then given by: \( E=(e_1,...,e_n) \).

Now, the \( i \)-th agent can make a decision, \( d_i \), where \( d_i \in D_i \), and \( d_i \) is selected to maximise utility \( U_i \). We can define an economic institution (through which agent’s decisions are expressed) as the product of the agent’s decision sets, \( D=D_1 \times ... \times D_n \). If the commodity space is taken to be \( \mathbb{R}^l \), then the mapping \( I:D\to \mathbb{R}^l^n \) will take the agents decisions into final allocations via some institution through which the buyers and sellers are brought together.

Hence we can define a microeconomic environment, \( E \), by \( E=(e,I) \), assuming only that the agents are utility maximisers with consistent preferences. (The perceptive reader will notice how these apparently innocuous assumptions sit ill with the thrust of the third section of this paper). Despite their simplicity, these markets are identical to real world markets in the sense that the principles of economic analysis must hold in
them. This is because the decisions made in them are real, monetary decisions.

The different ways in which the buyers and sellers can be brought together to translate their preferences into outcomes illustrates what is meant by different market institutions. Although many rules governing the bidding and offering procedures could be specified, there are a few key types of institution that are most used in market economies, and which are therefore of the most interest. The parameters of these institutions can also be varied systematically under laboratory conditions to observe the impact on subject's behaviour.

The early experiments in miniature economic environments were concerned with bringing out the properties of the key market institutions. The questions examined were mainly the following:

i) Does trade occur? If so,

ii) Are all possible gains from trade extracted?

iii) How quickly are the equilibrium price and quantities, as defined by the relevant demand and supply schedules, achieved?

iv) Is equilibrium approached from above, such that the distribution of income favours the sellers, or from below, thus favouring the buyers?

The experimenter's attention was focused less on the absolute performance of these institutions, as it was recognised that trade was occurring in highly simplified environments, than on their relative performance. In other words, which institutions provide the best environment for a speedy, unbiased exploitation of the greatest gains from trade given a particular set of demand and supply conditions? What changes to these institutions would best help or hinder this process?

Once the key properties of these institutions were established, attention switched to identifying the limits of the models, such as how many buyers and sellers are needed for competitive outcomes to predominate. After identifying these
boundary conditions, it became possible to observe the impact on a well-tested market institution of the imposition of some new constraint of interest to the experimenter, for example a price control. In this manner, microeconomic experimentation proceeded in a similar way to model construction. It began with a test of a few essential relationships, and once the properties of these relationships were established, additional constraints on behaviour were imposed/removed so that the experiments became more relevant to real world problems.

Before going any further it is worth asking why the particular form of market institution should be expected to make any difference to actual market outcomes. It is tempting to assume that the mere fact that buyers and sellers have been brought together will guarantee the full exploitation of any gains from trade that could in theory occur. But in fact some of the ways in which the two sides interact can assist this process, while others can retard or even prevent it. That is, for resources to be allocated optimally, suitable institutions must be available. Different sets of rules governing the interaction of buyers and sellers can be expected to affect not only the objective constraints under which they must reach agreement, but also the flows of information which they have available when making their decisions.

A useful analogy is the variety of voting systems used by democratic countries. In the UK a winner-takes-all system is used, such that a candidate with a minority of the votes will often win if the opposition is divided. However under the single transferable vote system, the preferences of the weaker candidates would have been redistributed among the leaders according to their supporter’s second preferences and a different candidate might have won. So despite having an identical preference base in the constituency, the different mechanisms used to translate those preferences into outcomes can themselves have an impact on the outcome.
TYPES OF MARKET INSTITUTIONS

The most basic, least restricted method by which buyers and sellers can interact is called the double-oral auction. This institution is similar to that of an unregulated stock market. All buyers and sellers are free to make repeated bids and offers to secure trades. All of these bids and offers are openly displayed, and only one remains open at any given moment. Essentially, this institution is characterised by the easy availability of information about the market.

Market demand and supply schedules are replicated by the artificial creation of cost and redemption-value schedules. This is done in the following manner. Each subject is assigned a role as a buyer or seller. A redemption value is issued to each buyer, which tells him/her how much s/he will be paid for each unit s/he purchases of a hypothetical commodity. The buyer then seeks to purchase those units as cheaply as possible so as to maximise his/her gains from trade. Similarly, a unit cost is issued to each seller, specifying how much s/he must pay to the experimenter for the right to sell each unit of the commodity. His/her incentive is therefore to sell the unit for as high a price as possible, to maximise his/her gains from trade. If no trades take place, no profits can be earned. None of the subjects' own money is at stake.

Each agent knows only his/her own limit price/unit cost. Contracts can be agreed upon anywhere in the feasible region, depicted as the shaded area in the diagram below. Clearly, the competitive equilibrium position in this example is for 3 units to be traded, at $3.00 per trade. The question is, will the predicted number of trades take place at the predicted price? It is important to remember that the demand and supply schedules only set the limits to the price/quantity behaviour; they do not uniquely define any particular set of trades. Many disequilibrium trades are possible within the limits set by the rules of the market.
A typical double-oral auction proceeds along the following lines. Agents begin by making a bid/offer for a trade. Often these opening bids are most unrealistic, reflecting optimistic expectations on the part of the agents. Both sides begin to revise their positions as the realization dawns that if the gap between bid and offer remains, no deals will be struck, and no gains from trade will be realized. The observation that other participants have begun striking deals often acts as a spur to the more optimistic players to "get real" before the best trade opportunities are all taken.

When all agents have made as many attempts to secure a contract as they wish, within a reasonable time period such as 5-20 minutes, the market session is closed. Some agents may have failed to reach an agreement. This could be because they failed to lower their expectations sufficiently, or because their limit price/unit cost was such that no other agent found their best offer attractive. These agents would receive no payment for the period.
In our example the agents who are predicted to fail to secure a trade through no fault of their own are those buyers with limit prices of $2.00 and $2.50, and those sellers with unit costs of $3.50 and $4.00. These agents are known as submarginal traders. If a submarginal agent were to secure a trade, it would necessarily imply that a non-submarginal agent who could have extracted a greater gain from that trade, failed to do so. That is, the market would have failed to operate at maximum efficiency. Efficiency in our context is defined as the extraction of the maximum possible gains from trade. Maximum efficiency requires the entire consumer and producer surpluses as depicted by the demand and supply schedules to be extracted.

After the first period has ended, a second trading period is opened up, and the process begins again. In most cases the underlying demand and supply schedules are left unchanged, and in the simpler experiments so are the structural parameters. Often several of these trading periods are held in an experiment. Although clearly unrealistic from the point of view of real world markets, this procedure is useful for examining the underlying properties of the different institutions. In particular, it allows us to look at the strength of the equilibrium process within the market, and the direction of convergence to equilibrium (assuming there is convergence).

A similar procedure is used for testing the other types of market institution. The other most frequently tested basic market structure is known as the posted-offer market. This is the type of market we usually participate in when we do our shopping. In this institution, buyers face a set of fixed prices which they can either accept or reject. In most cases buyers are not free to propose a bid of their own, as they would be in a double-oral auction. The sellers are also constrained in their pricing behaviour because their offer price must remain fixed for the duration of the market period. A new offer can only be made at the beginning of the next period.
Both of the above institutions can be slightly altered to allow for the buying and selling of more than one unit by an agent in each period. This can be done simply by issuing the agents with the requisite number of limit prices. A variety of other market structures have also been tested, but these are mostly variants of the two described above. There have also been many experiments conducted on the single-object auctions, including the English, Dutch, and sealed-bid variants. We shall not be looking at these other experiments in this survey. The interested reader is referred to PLOTT (1988) for a survey of these experiments.

SUMMARY OF KEY EXPERIMENTS

The first market experiment was reported in CHAMBERLIN (1948). There then followed a break of fourteen years until SMITH (1962) published the results of another set of market experiments. Smith altered the methodology used by Chamberlin from a negotiated price formula to the double oral auction. But since then the basic methodology used has remained similar to that pioneered by Smith, which is similar to that described above. An overview of some of the main findings from these experiments follows.

The findings from the double-oral auction experiments are strongly supportive of the competitive equilibrium concept. Under this institution, some 97-100% of possible gains from trade are extracted. Convergence to equilibrium is achieved after 3-4 time periods. The direction of convergence, which affects the distribution of the gains from trade, is unbiased, provided that the areas of consumer and producer surplus, as defined by the demand and supply curves, are equal. If these areas are unequal, then the distribution of the gains is seen to be biased in favour of the side with the larger area of theoretical surplus (SMITH & WILLIAMS 1982).
The posted-offer institution was also found to be an efficient mechanism for the extraction of potential gains from trade. Efficiencies tend to be concentrated at the lower end of the 90-100% range. Prices also tend to be slightly but consistently higher than those found in the double-oral auction. Convergence to these near-equilibrium outcomes also takes rather longer than in the double-oral auction, typically some 6-8 periods. For a detailed comparison of the double-oral and posted-offer institutions see PLOTT & SMITH (1978).

No adequate theory yet exists to account for the sustained difference in the performance of these two institutions, mainly because our understanding of market processes is still in its infancy. However it seems likely that the knowledge that the offer cannot be altered within the time period is enough to reduce the power of the buyers sufficiently to lead to above equilibrium prices. The tighter constraints under which both sides operate may also be reducing the flexibility of the system, thus leading to a slower convergence process.

Following the establishment of the empirical properties of a number of key institutions, if not of the theory underlying the results, the focus of the experimenters shifted towards testing the conditions under which those regularities broke down. SMITH (1982) was an interesting example of this process. In his paper, Smith sought to test the Hayek hypothesis, that only a few market participants are required to produce competitive outcomes, against the traditional textbook view that very substantial numbers are required.

The experiment found that as few as four participants on each side of the market was sufficient to produce broadly competitive outcomes within a few periods. This finding is at odds with the traditional view that many agents are needed to provide the necessary discipline to turn each participant into a price taker. However, it was also established that if only one or two sellers are present, the competitive model ceases to
perform well. The discipline that competition imposes on agent behaviour is then no longer strong enough to restrain the agent’s desire to distort the market price in his/her favour.

Following the revolution in industrial organisation theory in the early 1980’s (see BAUMOL 1982), a number of experiments were held to test the new ‘contestable markets’ hypothesis. Briefly, this theory states that if there are no barriers to entry, a monopolist cannot exercise monopoly power because of the threat of potential competition. Baumol’s stated aim was to generalise the concept of the perfectly competitive market into perfectly contestable markets, which could be applied to all industries regardless of the number of firms in them. The theory was not intended to be a description of reality, as few industries are actually vulnerable to "hit and run" entry. It was instead developed to provide a more widely applicable benchmark for understanding industrial organisation theory.

A number of experiments have tested this theory, notably COURSEY, et al (1984); COURSEY, ISAAC and SMITH (1984). The results showed that when entry costs were set to zero, the equilibrium prices were in every case closer to the competitive prediction than the monopoly prediction, and were sometimes equal to the competitive price. This compares with the finding that when entry costs were set at infinity, prices were closer to the monopolistic model’s prediction in every case, and were equal to the monopoly price in some cases.

As may be expected, when entry costs were set in some intermediate range, the observed outcomes fell somewhere between these two extremes. However, efficiency scores were low, due to the duplication of sunk costs. Also, although the results for free and blocked entry were achieved regardless of the assumptions made about agent’s expectations, the attitudes of agents did affect the results in the intermediate cases. The policy implication to be drawn from these results is that anti-trust policy should focus less on the market share of firms in
an industry than on the extent of barriers to entry into that industry. After all, it is at least possible that one firm has a dominant share of an industry’s output because it is better at meeting consumer preferences than any other firm, which is not an unattractive attribute.

A number of thought-provoking experiments were also held to test the effects of price controls on laboratory markets (for example see ISAAC & PLOTT 1981; COURSEY & SMITH 1983; SMITH & WILLIAMS 1981). It is generally believed that only binding price controls will have any impact on a market. This view stems from the preoccupation of economics with end-states, or equilibria, and ignores the market process necessary to generate the equilibria. But the experiments mentioned above uncovered a more complex picture.

It was found that the imposition of a binding price control produced a pattern of behaviour much as expected. Contracts were quickly concluded at the level of the control, whether it was a price ceiling or a floor. For controls set at the equilibrium price, the convergence path obviously occurred only from the unrestricted side, depressing the average trade price in the case of a price ceiling, and raising it for price floors. It was also found that it took longer for the market to settle at the equilibrium position.

Surprisingly it was also found that even non-binding price controls had an effect on the market, although this effect petered out if the control was set too far from the equilibrium price. For instance, a price ceiling set slightly above the theoretical equilibrium price tended to depress prices, skewing the convergence process downwards. This clearly biases the distribution of the gains from trade in favour of the buyers. It also slowed the convergence process down, compared with the no-control case.
The most interesting aspect of these experiments was the finding that the removal of non-binding price controls causes prices to jump discontinuously to an above-equilibrium level, before beginning the convergence path from above. There is no explanation for this phenomenon in standard economics. It is sometimes argued that the removal of a binding price control will lead to a similar pattern due to the release of pent-up demand. This explanation is less plausible when the control isn't binding to begin with.

A better explanation might be that the removal of the control alters the expectations of the participants as to what is a feasible and sustainable price. We should not forget that the agents are not aware of the equilibrium price, and become even less sure of their guesses when a price ceiling is removed. Overall efficiency levels in these experiments were little different from normal, suggesting that the primary effect of the controls was to alter the dynamics of the market process rather than the static equilibria.

A particularly topical aspect of economic theory, externalities and pollution control, has also been investigated experimentally. PLOTT (1983) reported the results of a series of experiments which addressed two questions:

a) Do agents ignore the external consequences of their actions if they are not required to take them into account?

b) If so, which of the following policy instruments would best correct for the externality: a pollution tax, a pollution standard or pollution licenses?

Briefly, the pollution tax is set to equate the private cost of the firm's production with its social cost. The pollution standard aims to find the optimum value of pollution damage and sets the associated quantity of pollution as the maximum permissible; that is, it sets a limit on output. Licenses to pollute can be further divided into tradeable and non-tradeable varieties. Only those in possession of a license are allowed to
engage in the pollution-creating activity.

The results showed that an externality problem does indeed exist. Although agents knew their decisions would have a negative impact on others, this did not alter their behaviour. In these experiments, it was possible for market efficiencies to be negative if the cost of the externality outweighed the private gains from trading, making total earnings negative. The efficiency of the unregulated markets was negative, averaging -44.5%. The pollution standards approach was a significant improvement on the base case, but at 34.4% had the lowest efficiency score of the three policy instruments. The tax approach produced average efficiencies of 93.3%, and the licenses of 98.3%, although this difference was not significant. When a secondary market for trading in the licenses was forbidden, efficiencies were no higher than 46%. However, the pollution standards approach gave the most equitable distribution of gains from trade.

There have been numerous experimental investigations of bargaining problems, including the Coase theorem of externality theory (HOFFMAN & SPITZER 1982; PRUDENCIO 1982). Other bargaining experiments include: TIETZ & WEBER (1972); SELTEN (1972); ROTH (1986); ROTH & MURNIGHAN (1982); ROTH & SCHUMAKER (1983). Other areas which have been subjected to experimental testing include oligopoly theory (FRIEDMAN 1969; FOURAKER & SIEGEL 1963); public goods theory (BRUBAKER 1982; SCHNEIDER & POMMERHNE 1981); expectations formation (WILLIAMS 1987); speculation (MILLER, PLOTT & SMITH 1977) and the effects of uncertainty about product quality (MILLER & PLOTT 1985; LYNCH, et al 1986) to name several. I shall not attempt to describe these experiments in this paper.

Before finishing this section there is one particularly intriguing use to which experimental economic techniques have been put which deserves mention. This is the reconstruction under laboratory conditions of the market institution of some
real-world industry. In this way it is possible to mimic a proposed change to that industry's structure or practices and observe the effect on prices, efficiency and distribution.

GREThER & PLOTT (1979 & 1981) reported one example of this, involving the industrial practices of the anti-knock compound industry. Anti-knock compounds are used to reduce the adverse effects on motor vehicles of leaded petrol. This industry became the subject of an inquiry by the US Federal Trades Commission, which was concerned with four industrial practices in the industry. These were:

a) A 30-day advance notice was required for all price changes;
b) Prices charged to customers were identical regardless of differing transportation costs;
c) A "most-favoured customer" clause was included so that no customer would be offered a lower price than another;
d) A guarantee to meet any lower price that a customer might find, or release them from the contract.

At first glance these practices seem innocuous enough. But the more one thinks about the implications for tacit collusion between sellers, the more suspicious they sound. The authors sought to explore the impact on similarly structured experimental markets of the imposition and removal of these constraints. The actual market structure in this industry consisted of two large sellers with a third of the market each, and two smaller sellers sharing the remaining third. Excess capacity and a declining market (due to the growth of lead-free fuel) were also present. On the demand side, eight buyers accounted for some 60% of the market, and a multitude of small buyers made up the rest. The authors constructed an experimental market with these properties using the telephone system.

The results were clear cut. When the industrial practices described above were imposed on the market, prices immediately rose. When the practices were removed a few periods later, prices fell. In his survey, PLOTT (1988) offered the following
explanation for these surprising results. Advance notification of price changes, while nominally attractive to consumers by allowing them to plan their future purchases, is in fact designed as a signal to other sellers. If the other sellers do not respond with their own planned price increase before the end of the notification period, the originator of the price rise will rescind it. This prevents the firm from facing the devastating loss of market share predicted by the traditional "kinked demand curve" for competitive oligopolists.

As for price discounts, each firm knows that its competitors must match any price cut it might make, which reduces the incentive for it to do so as few additional customers would be gained. On the demand side, the customers know that any discount must be offered to all other customers, and so don’t expect to win any, thus reducing one source of pressure on the sellers. Taken together, these four practices inflict a damaging blow to the operation of competitive forces in this industry.

Another experiment in this genre compared the allocation of aircraft landing slots by a committee process with a competitive auction. The findings strongly supported the use of sealed-bid auctions for the initial allocation of landing slots, followed by a free-market for future developments. The results of this experiment were partly responsible for the subsequent setting up of a field experiment using competitive bidding, though starting with existing allocations. The interested reader will find these and other experiments replicating real world industries described by PLOTT in ROTH (1988).

END-STATE OR MARKET PROCESS ECONOMICS?

Beyond the lessons learnt from these experiments in their respective parts of economic theory, there are suggestions too of a deeper lesson. The focus in economics since at least the second world war has been on the end-state properties of markets,
that is, equilibria. But some of the key differences found between the institutions and practices reported above have been a direct consequence of the differing impacts these variables have on the process by which the equilibria are to be achieved.

While an invisible hand is clearly at work in guiding the agents toward making equilibrium trades, the equilibrium is only reached after a period of time, and is sustained only if the data remain unchanged. The "pull" of the system in each of the above environments is not powerful enough to bring about equilibrium trades from the outset. This implies that equilibria have to be established, i.e discovered, and their establishment is therefore characterised by a discovery procedure. A useful analogy would be to view the concept of equilibria as being similar to a magnet (or more accurately a 'strange attractor' to those familiar with chaos theory) of limited strength.

We should remember that the equilibrium position isn't desired in itself by so much as a single market participant; it is simply the result of a compromise reached when the participants recognise they have to make concessions if they are to achieve any gains from trade at all. The relative strengths of the buyers and sellers will clearly have an impact on the nature of the compromise, i.e equilibrium, reached. Competitive price theory merely predicts the most likely compromise from the raw data on the relative strengths of the two sides.

In the course of establishing an equilibrium, all trades are obviously disequilibrium trades. This does not mean that the equilibrium properties of a particular market and its institution are not interesting in themselves. Rather, we should abandon the false belief that a state of rest is the usual position for real markets and hence that equilibrium trades occur more often than fleetingly. We should instead learn to view equilibria as destinations, and moving ones at that. This implies that a greater emphasis on the market processes in the study of economics might repay the effort.
More work is needed to explain the manner in which the market process arises as a function of the equilibrium conditions which establish it. Some institutions appear to allow the "magnets" of equilibria present in the demand and supply conditions to operate freely, while others reduce the power of the attraction exerted on behaviour in certain markets. As yet there is no adequate theory to explain just why this should be so.

Although two institutions may have very similar 'end-state' equilibrium properties, they may exert a wholly different influence on the market process through which they are to be established. For instance, one equilibria may be established more rapidly than another, leading to long periods where the extraction of gains from trade under the two institutions differs widely. As in reality markets are always in periods of adjustment, these market process questions are probably at least equal in importance to the end-state conditions.

SECTION THREE: INDIVIDUAL CHOICE BEHAVIOUR

The other major area of experimentation in economics has been concerned with the rules governing how we make choices. In the real world the decisions we make necessarily take place across time. We make these decisions in the light of certain expectations about the future. These expectations are clearly tenuous; no-one can be sure of what the future will bring for the simple reason that it has yet to happen. One key point that will underlie the arguments of the next few pages is this: the future is not merely unknown, it is unknowable. The content of the future will change depending on the decisions we make now; the future is not simply "out there" waiting to be discovered, it has yet to be created.

Micro-economic theory is concerned with understanding the rules by which agents make economic choices. The cardinal belief underlying this quest is the view that man is a rational animal,
and he will seek to make those choices which he expects will
maximise his utility. The most important theory to explain how
individuals make choices under uncertainty has since the second
world war been "subjective expected utility theory", or SEU for
short. This theory is rooted in the work of the mathematicians
Von Neumann and Morgenstern (1944).

SEU theory consists essentially of a set of axioms which are
said to define "rational", or more accurately, "consistent"
choices. A detailed survey of the variants and uses of SEU
theory can be found in Schoemaker (1982). Before outlining this
theory and its performance in experiments, we should be clearer
about what is meant by rational behaviour.

Traditionally, economists have viewed rational choices as
being utility-maximising choices, or under uncertainty, expected-
utility maximising choices. Naturally, we can't actually observe
a person's utility function; all we can do is try to infer its
shape by observing that person's choices. From these
observations, certain consistency requirements can be laid down,
which constrain how that individual must choose in other contexts
if he is to choose "consistently" with his own preferences, i.e.
if he is to make utility maximising decisions. In this way,
tests of the rationality principle in economics have become
associated with tests of consistency. But tests of consistency
are always somewhat arbitrary as we must then ask the question:
with respect to precisely what are we to be consistent?

SEU theory requires that our future choices should be
consistent with the preference ordering established from
observation of our past choices. It is recognised that
preferences are subjective in that this preference ordering is
not required to hold for more than one individual. It is also
conceded that this preference ordering cannot be expected to hold
across time, even for the same individual, although this brand
of "inconsistency" is conceded more reluctantly by the theory's
advocates. This is because all choices necessarily take place across time, and if we cannot expect preferences to be consistent with respect to time, then the uses and relevance of the SEU model are more doubtful. By assuming that changes in tastes are in some way predictable, or can be represented by a probability distribution over bundles of future goods (known as contingent commodities), some economists hoped that consistency across time could be rescued (see SIMMONS 1974, pp 210-211). Complete theories of inter-temporal general equilibrium also rely on such devices (see ARROW & HAHN 1971).

However these theories have made the assumption of consistent preferences over time not so much because it is believed to be realistic, but to make the mathematics of the models tractable.¹ There would be no great harm in this provided that this point is not lost sight of. In fact however, economists have allowed their gaze to be sidetracked by the substantial achievements of mathematical economics, and have consequently overlooked other questions of potentially greater relevance.

To see the prescriptive power of SEU theory at its strongest, we must restrict its scope to the choices of one individual, at one moment in time. This is anyway a reasonable approximation to the choices made in experiments, as the decisions are made so soon after each other that we can arguably assume away any changes in preferences.²

Viewed in this way, this conception of rationality might seem to be uncontroversial. However, we stated earlier that an

¹ It is unrealistic not least because it assumes that the set of commodities itself remains unchanged across time, but also by assuming we all have well-defined preferences over all these contingent commodities.

² Actually, it is far from inconceivable that the subject would learn about his preferences in the course of the experiment and so change his choices even within this time frame. If so, this would reduce still further the applicability of SEU theory.
individual's utility function cannot be observed; we can only observe actual choices. Utility remains a subjective concept, residing within the mind of the decision-maker. The question is, if we observe an individual's choice patterns violating the consistency axioms contained in SEU theory, can we infer that the individual has not been choosing in accordance with his utility function, so that we may label those choices irrational? The answer to this question is at the heart of the current dispute among economists, decision theorists and psychologists working in this area. A number of alternative theories have been developed, which all have one thing in common: they weaken the consistency requirements of SEU theory. Much of the experimental research in this area has been concerned with documenting systematic violations of SEU theory, and developing and testing modified versions of that theory, or in a few cases, completely different theories.

Doubts as to the validity of SEU theory have existed ever since Allais's seminal paper in 1953. Since then, many hundreds of experiments have documented systematic violations, under certain circumstances, of almost every part of the theory. A review of these experiments is well beyond the scope of this paper. The interested reader is referred to MACHINA (1983); SUGDEN (1986); APPLEBY & STARMER (1987); WEBER & CAMERER (1987) and the references contained therein for an introduction to this voluminous topic. We shall focus here on the implications of these results for the entire enterprise of constructing a theory of rationality as consistency.

Experimental tests of SEU theory usually take the following general format. Subjects are presented with a choice between two risky prospects, nowadays usually shown on a computer. Their preferences between and valuations of the various prospects are recorded. These gambles are then altered systematically to compare the subject's choice patterns against the theory's predictions.
That preferences should be "independent in the probabilities" is implied by SEU theory. Briefly, this means that if an agent has expressed a certain preference for one lottery over another, then if the probabilities of winning in each of those lotteries are transformed by the same factor, the individual's preferences between them should not change. By imposing this restriction on the form of an individual's preference function, SEU theory acquires much of its predictive content. But ALLAIS (1953) reported a test of this axiom which cast doubt on its descriptive validity. Consider the following gambles, where the large number is an amount in Francs, and the small number is the probability of receiving that amount.

a) \( X = (3,000, 1.00) \) and \( X' = (3,000, 0.25) \)

b) \( Y = (4,000, 0.80) \) and \( Y' = (4,000, 0.20) \)

If \( X \) p \( Y \) in the first pair of gambles, then \( X' \) p \( Y' \) is required by SEU theory in the second pair, and vice versa. But numerous experiments have shown most people choose \( X \) from the first pair, and \( Y' \) from the second pair, of which ALLAIS (1953) was only the first. In other words, there are systematic violations of the linearity in the probabilities principle. It is now widely accepted that all forms of the independence axiom perform badly in their descriptive role. Consequently a number of theories have sought to modify SEU theory to weaken or dispense with the independence axiom (eg CHEW & McCrimmon 1979; Machina 1982). Theories developed for this purpose have one chief problem: they don't explain the systematic violations of the other SEU axioms. Nor do they challenge the normative desirability of complying with SEU theory. Consequently, they tend to appear rather ad hoc, containing no explanation from first principles as to why SEU theory should have failed in the first place. Some, like Kahneman & Tversky (1979) dispense with SEU as a descriptive model almost entirely in an attempt to fit the experimental evidence. However even they do not dispute the normative appeal of SEU theory.
Of all the consistency requirements of SEU theory, perhaps the most treasured and closely guarded is the transitivity axiom. This is regarded as the minimum requirement for a theory of rationality as consistency. A person’s preferences are transitive if after choosing:

\[ \text{ApB in } <A, B> \quad \text{and} \quad \text{BpC in } <B, C> \]

the individual then chooses:

\[ \text{ApC in } <A, C> \]

If the individual is making his choices simultaneously, rationality therefore requires consistency across choice sets. It is difficult to doubt that most people’s preferences will satisfy this type of consistency in most circumstances. But that isn’t the question at issue. What matters is whether this requirement is a universally valid canon of rationality for utility-maximising economic agents. As in the physical sciences, often a small discrepancy between theory and evidence can require an overhaul of the entire theory. For example, the tiny error in Newton’s theory for predicting the orbit of planets was only resolved after Einstein demonstrated that the planets were actually following a fundamentally different set of physical laws. It was only after this was recognised that physicists could move on to address a whole new series of questions, the significance of which was not understood within the framework of Newtonian physics.

The test of the transitivity axiom then, and by implication of the soundness of the entire enterprise of constructing a theory of rationality as consistency, is whether any systematic violations of the axiom will ever be observed by maximising agents. If experimentation can demonstrate such violations, it would have played a critical role in the re-writing of the economic theory of choice under uncertainty. But on what possible grounds could we expect the concept of transitivity as
described above to be rejected as a requirement of maximising behaviour?

Psychologists working in the field of decision research for the most part believe that individual choices are a direct function of the environmental constraints under which the choices are made. No maximising principle is believed to lie behind these choices (eg KAHNEMAN & TVERSKY 1979). Indeed, even some economists have doubted this cardinal rule of economics (eg GRETHE & PLOTT 1979). However most of these same researchers still argue that the normative appeal of SEU theory remains intact. The argument in this paper takes issue with both of these views. We will argue that although agents need not obey SEU theory, their behaviour can still be maximising, and consequently that the normative appeal of SEU as a general theory must be rejected.

We saw above that the validity of the transitivity axiom depends on whether choices must be consistent across choice sets. This means that an individual’s preferences must be independent of the nature of the unchosen alternatives. But for this to be true, we have to make detailed assumptions about the rules people use when making decisions. Specifically, an individual’s choices will always be independent of the choice context if a holistic (ie non-comparative) decision rule is used. But if a choice is made by comparing each option in the choice set with the other options, the option selected must partly depend on the characteristics of the unchosen alternatives.\footnote{Where the options in a choice set have only one significant characteristic, eg money values, the comparative choice rule collapses into the holistic choice rule. Hence the above argument only applies when selecting among multi-attribute options.} This is not to say that any choices made using a comparative decision rule must result in intransitivities; such occurrences may in most circumstances remain rare. It is simply to argue that if intransitive choices are observed, we cannot label them irrational unless we can show that the use of a comparative
decision rule is itself irrational.

To address the question of the rationality of comparative choice rules, we have to carefully specify the circumstances under which we should employ such rules. Consider the following example, known as "Packard's dice" (PACKARD, 1982).

\[
\begin{array}{ccc}
A & B & C \\
\begin{array}{ccc}
4 & 1 & 4 \\
3 & 3 & 3 \\
4 & 3 & 2 \\
4 & 3 & 2
\end{array} & \begin{array}{c}
3 \\
2 \\
2
\end{array} & \begin{array}{c}
5 \\
2
\end{array}
\end{array}
\]

Let us suppose that the rule of the game is that any two of these dice are selected, and played against each other. Every time one die beats another die, the owner of that die wins $1. The value of the prize remains the same regardless of the size of the victory of one die over the other; what matters is that it should have won.

In this game, which of the dice is it better to own? A series of pairwise comparisons between the dice leads to the following pattern of preferences:

For choice set \((A; B)\), we find the probability of winning with die A is 2/3 and with die B is 1/3, hence \(A \succ B\).

For choice set \((B; C)\), we find the probability of winning with die B is 2/3 and with die C is 1/3, hence \(B \succ C\).

For choice set \((A; C)\), we find the probability of winning with die A is 4/9 and with die C is 5/9, hence \(C \succ A\).

So the above series of pairwise comparisons leaves us with the following pattern of preferences:

\[A > B; \; B > C; \; C > A\]
Tversky (1969) provided a proof of how a comparative choice rule, as was used in this game, can lead to violations of transitivity. For this very reason, Tversky stated that such choice rules were irrational. But the validity of his claim is contingent on the context in which these rules are used. For example, if Tversky were playing Packard's game, he could scarcely avoid using a comparative choice rule. The question is, are there parallel circumstances in our everyday decisions which would also require, or justify, the use of a comparative choice rule?

In the above example, a weaker form of this rule would have been to allow a victory of one die over another to win its owner a bigger prize the larger was the magnitude of the win. For instance, a prize of $1 if one die beat another by one point, $1.20 if by two points, $1.40 for three points, etc. Note that if the size of the win is proportional to the size of the prize, ie $1 for a one point win, $2 for two points, etc, then this rule collapses back into the holistic choice rule. The use of rules in which the prize money is non-linear in the size of the victory is equivalent to claiming that utility can be non-linear in the differences between the attributes of options.

Perhaps the most important theory to be tested which requires the rejection of transitivity across choice sets is "Regret theory". Regret theory was developed independently by Loomes & Sugden (1982); Bell (1982); and Fishburn (1982). In this theory, the utility an individual receives from an option depends not only on the outcome of that option, but also on how that outcome compares to what he sees he would have got had he chosen differently. If such considerations are important, then a comparative choice rule is being used. Experimental evidence to date points strongly in this direction, both for regret theory (eg Loomes 1988) and more generally (Russo & Doshier 1983). But are agents right to choose in such a way?

There is scope for feelings of regret to affect our decision making if we face one-off decisions, so that instead of
"experiencing" the expected value of a gamble, we experience an "either-or" result. But if we were to repeat the same choice of gambles ten or a hundred times, would this reduce the importance of feelings like regret? The answer is surely yes. In a sequence of plays, choosing in accordance with the expected value rule would normally result in the greatest winnings. Shackle (1961) expressed this distinction as follows:

"When he looks upon his action as a unique, non-repeatable experiment, the decision-maker must abandon the idea of frequency and ask himself not what will happen in the long run, but what can happen, at the best and at the worst, on this unique occasion."

In other words, expected values are an imperfect guide to how we should make unique decisions, but their value increases the less unique a decision problem appears to be. If we were to choose between the same two gambles an infinite number of times, we would have no currently imaginable excuse for not choosing in accordance with expected values. We know that the average outcome from each option will be its expected value, so no uncertainty in fact exists. O'DRISCOLL & RIZZO (1985) argued that there are both unique and typical aspects to our decisions. For dealing with the typical, we tend to form decision heuristics, or rules of thumb, which have a low cognitive cost. For the unique, or time dependent aspects, no coherent decision metric has yet been developed. Shackle (1961), and later Ford (1987) suggested variants of the "Degrees of belief", or "Weight of Evidence" views, although these are still incomplete.

Consider the following example:

\[
\begin{array}{cccccc}
1-25 & 26-50 & 51-75 & 76-100 \\
A: 2 & 4 & 6 & 8 \\
B: 4 & 6 & 8 & 2 \\
\end{array}
\]
Here, the numbers at the top denote lottery tickets, and below are the sums in dollars that the subject would win if he chose the appropriate option and the associated lottery ticket number came up. It is obvious that the expected values of these options are equal, and in fact so are the gambles themselves except for one difference. The difference is that the subject realises that whichever option he selects, he will see how his payoff compares with what he could have had if he had chosen the other option. Will the subject care about such things? Experimental evidence suggests that he will. SEU theory dictates that no rational person should have a preference between these two options, as holistically speaking, they are equal. But if the subject employs a comparative decision rule, this need not be the case.

We argued earlier that utility is a subjective experience, rather than an objective property of the good concerned. The utility derived from a good will differ:

a) for different people;
b) for the same person over time;
c) for the same person at the same moment in time if that person assesses the utility of the good by comparing its various attributes with the attributes of the other goods in the choice set. Thus if an unchosen option is added to or subtracted from this choice set, this may affect how the individual ranks the other options in the set.

In the above example, an individual may reason as follows: If he selects gamble B, there is a 3/4 chance that he will win more than if he had selected gamble A. This may lead him to prefer B to A. On the other hand, he may view the possibility that he might suffer a comparative loss of $6 if a ticket numbered from 76-100 comes up with great concern, and so prefer A to B. The latter is the prediction of regret theory.

The regret-rejoice effect of a single large difference between attributes is said to produce a greater intensity of
feeling than the sum of the regret-rejoice effects if the
difference is broken into two or more parts (LOOMES & SUGDEN
1982). So in our example, the extra increment of utility to be
obtained from having selected B if ticket numbers 1-75 come up
is in total less than the decrement of utility which would result
if a ticket numbered 76-100 should come up. The key to seeing
how regret theory fits into our framework is that this argument,
also known as the convexity condition of the regret-rejoice
function, is simply specifying the direction in which utility
will be non-linear in the differences between the attributes of
options. It is thus a particular case of the broader argument
that comparative choice rules can be utility maximizing, while
still violating transitivity across choice sets.

The experimental evidence in favour of the regret effect is
strong in many contexts. However the results have on occasion
been more mixed, (LOOMES 1987a&b) perhaps indicating that the
opposite motivation, the desire to come out ahead no matter by
how much, could also sometimes be significant. Which effect will
predominate may be a function of the parameter values of the
problem, although at present this is still speculation.4

But is it rational for an individual to allow feelings such
as expected regret to affect his decisions? Should he not
instead banish such considerations from his mind, as SEU theory
would have him do? But utility is a purely personal experience.
Who is to say which sources of utility we should rule in or rule
out? A person may prefer one good to another for the most
pervasive of reasons, but this doesn’t hide the fact that they do
prefer it, and as maximizing agents will choose accordingly.
Hence if an individual should experience increments or decrements
to their utility for reasons such as regret, it would be

4 A common argument used in defence of transitivity is the
money pump: for an explanation and refutation of this argument
see LOOMES & SUGDEN (1987).
irrational, ie non-maximising, to ignore those sources.\textsuperscript{5}

The argument of the last several paragraphs can be summed up as follows: transitivity across choice sets is not an essential feature of rational choice for all types of decision rules. If an individual establishes his preferences in a comparative manner, then his preferences will depend in some way on the nature of the unchosen alternatives. If so, then an option selected from one choice set cannot be used to bind his choices from a different choice set. Hence if $A, B \& C$ are all multi-attribute options and we see the following:

In $(A;B)$ he selects $A$, and in $(B;C)$ he selects $B$, we cannot conclude from these observations what his choice must be in $(A;C)$. Again, we may strongly suspect that $A$ will be preferred to $C$, but that is a different matter from requiring such a choice as a cornerstone of rationality.

One implication of the use of comparative choice rules is that individuals don’t have a complete preference ordering over all possible goods that they can refer to.\textsuperscript{6} An individual establishes his preferences by choosing, and choice is inherently comparative. True, in familiar situations one doesn’t need to go through this process; we already know which item we prefer and our choice process is essentially holistic. But this is akin to our earlier claim that in repetitive-type decision problems, the individual uses rules-of-thumb to choose by, having found at some earlier stage that the rule normally produces adequate results.

The use of rules-of-thumb may also be the optimum strategy,

\textsuperscript{5} That is unless such feelings are outweighed by the individual’s erroneous sense of devotion to SEU theory. In this case allowing one’s decisions to knowingly violate the theory may cause acute distress to some people, notably economists. This source of dis/utility should not be ignored when predicting choices!

\textsuperscript{6} For example, BUTLER & LOOMES (1988) reported the results of an experiment that found individual preferences were often hazy, and held with less than complete conviction.
as cognitive costs should not be underestimated: we all have limited time, cognitive abilities and inclination to effort, so the utility-maximising strategy in repetitive environments may often be to develop and use such rules (see SIMON 1959). If the consequences of a particular repetitive-type decision appear in some instance greater than normal, this "unique" aspect of an otherwise familiar problem can then induce greater effort than usual. The best way to treat each decision will therefore depend on the degrees of uniqueness and typicality it involves.

HEY (1982, 1987a&b) investigated the use of rules of thumb in a number of economic experiments, particularly on search theory. The results demonstrated that the use of rules-of-thumb is common when dealing with uncertainty, and that most of these rules produce reasonable outcomes. Behaviour was not found to be optimal in the strict sense, but may well be near optimal once the constraints of limited time, cognitive capacities et al are taken into account.

The recognition that there are both familiar and unique aspects to the many decisions we make, which may require different choice rules, was most clearly explained in O'DRISCELL & RIZZO (1985). SEU theory by contrast, implicitly assumes that all decisions are of the repetitive type. As such, it only deals with half of the picture. We should not therefore seek to apply this theory outside of its appropriate context. Hence the normative value of SEU as a general theory must be rejected.

Comparative choice rules are valid when we're seeking to establish a preference, rather than simply implementing an already existing preference. To expect us to have a complete, well-ordered preference function already existing over all possible goods is clearly absurd, not least because our tastes are constantly changing so that the ordering would never stand still. This is due to our limited capacity to absorb and store information, as well as the fact that the environment's stock of information is itself constantly changing. The cognitive costs
of establishing and maintaining a complete, up-to-date preference ordering far exceed the benefits. Conversely, it does pay to maintain a partial preference ordering for some repetitive decision contexts, so some of our behaviour may justifiably be modelled by theories such as SEU, or its many variants.

If the argument of this section is correct, what are the implications for economics? The old distinction between risk and uncertainty, which disappeared when SAVAGE (1954) introduced subjective probability, must be reintroduced. The future therefore is not simply unknown, but unknowable. This is not to say that there is no continuity between past, present and future; people make plans in the light of experience and there is much about future economic conditions that will be familiar to us. The key is not to focus exclusively on either the unique or the typical, but to recognise that both exist and to develop our theories accordingly.

The role of experimentation in first establishing that there was a problem with SEU theory and then in creating and exploring alternatives cannot be overstated. Progress in this area has been due to the interplay between theory and experiment more than in any other area of economic theory so far.

SECTION FOUR: CONCLUSIONS

A conclusion from the findings of the experiments in section two is that coordination takes place over time, so most decisions are made with uncertain expectations about the future. Section three investigated how uncertainty affects the way individuals do or should make choices. The fundamental concern of economics therefore is the efficient allocation of scarce resources across time, under uncertainty. We saw that this question requires a greater emphasis on the processes induced by the different economic institutions, market-based or otherwise. How do these institutions create or affect the flows of information to
economic agents? How will this information, much of it transitory, reach the appropriate agents while it is still useful? What types of economic institutions are best suited to this task, and under what circumstances?

Economists wish to believe that the view of man as a rational animal is correct. Psychologists are less concerned with this, but with few exceptions, both groups believe SEU theory describes how individuals should behave under uncertainty. The argument presented above is that the experimental evidence suggests SEU is not appropriate as a general theory, and that in some cases it is rational to violate the axioms of that theory. The idea that we should try to squeeze our preferences to fit the SEU model under all circumstances is also rejected.

BEACH & MITCHELL (1990) present experimental evidence to suggest that human action is essentially goal-directed, which meshes nicely with the view of VON MISES (1949) that we choose to take that course of action which seems best to us at the time. This clearly allows scope for errors, and the need for error correction mechanisms (ie institutions which encourage learning). Overall, the results of the experiments mentioned in this paper are not inconsistent with the postulate that individual behaviour can be viewed as rational, provided we don’t identify rationality with a certain limited class of choice rules that ignore the consequences of uncertainty and limited cognitive capacity. As utility is subjective, we cannot label a person’s choices as irrational without first enquiring as to their intentions when they made the decision.

Finally, we will finish with a brief look at some of the problems of experimental economics. Initially some experiments were undertaken without payment of the subjects. Against these experiments it could plausibly be argued that the decisions of the subjects were not real economic decisions, so the results are of little value. Although the second point is debatable, the first clearly carries weight. All the key results reported here
have been obtained in experiments where subjects received payment, the level of which was tied to their choices. For the experiments in section two, an incentive compatible means of payment was described in SMITH (1976), and for the experiments in section three see BECKER, DeGROOT, MARSCHAK (1964).

Another criticism is that the experiments generally use college students as subjects, and that this sub-group may not be representative of people at large. This is a potentially significant argument. However various experimenters have tested for this by comparing the behaviour of a group of students with the behaviour of non-students. To date, no significant differences have been found.

It can also be argued that in reality demand and supply curves are unlikely to be so well defined as they are in the experiments of section two. Furthermore, the market conditions are unlikely to remain stable for several successive time periods, so that the convergence to equilibrium often observed in these experiments is unlikely to occur. Both of these points are valid. However, we should remember that all economic models require simplifications in order to be useful. There are many useful lessons to be learnt from the experiments under these admittedly unrealistic assumptions. What is more, it would also be possible to alter the experimental conditions to test the markets with rapidly changing demand and supply curves. This has not been a popular strategy with experimentalists because with so many variable factors it would be difficult to recognise the effects on the market of the underlying institutions, thereby defeating the purpose of the experiments in the first place.

Laboratory experiments do however have a number of uses. They provide an additional method of testing economic theories, usually in those areas where econometrics has least to offer. The results can provide new sources of information into the effects of altering market practices and institutions, where previously only pure and often contradictory theory was
available. The information from the experiments can be added to our stock of knowledge when seeking to understand the world. Hence it reduces uncertainty and aids theory development. In some areas experimentation can become an integral part of the theory development, as has happened for choice under uncertainty. Experimentation is also useful as a teaching aid, for creating a feeling of greater involvement for students, and it may offer deeper insights into the operation of market institutions. But these tools are still in the fairly early stages of development, and there is much still to be done in putting economic theories to the test.
BIBLIOGRAPHY


Butler, D.J. and Loomes, G.C. 1988, "Decision Difficulty and


Grether, D. and Plott, C. 1984, "The Effects of Market Practices in Oligopolistic Markets: An Experimental Examination of


Smith, V.L. and Williams, A. 1982, "The Effect of Rent Asymmetries in Experimental Auction Markets", Journal of


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