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Reaction to Uncertainty and Market Mechanisms: Experimental Evidence

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Abstract

Much of the evidence supporting the Ellsberg's paradox comes from experiments on individual choice and judgement.

In this study, we address the issue whether, in market experiments, there is a tendency for anomalous behaviour to disappear or to be reduced as a consequence of market experience and feedback. We empirically test the validity of this assumption by running an auction market for the sale of both risky and uncertain prospects. We compare bidding behaviour and prices in market-like settings with valuations obtained from individual pricing tasks.

We conclude that, with the repetition of the market experience, there is a tendency for subjective expected utility to perform better. However, economists' general assumption that, in laboratory experiments, poor performance of SEU is due to the lack of financial incentives or to the lack of market-like settings is by no means supported by our data.

JEL code: D81

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Introduction

Many decisions in the market place are generally taken without knowledge of their outcomes. The decision to buy stock is made without previous knowledge of whether dividends will be paid or capital gains will be realised, the purchase of insurance is made with no definite knowledge of the likelihood of the loss insured or of its size, and so forth.

Since Knight (1921) economists have drawn a distinction between risk, when probability is exactly known, and uncertainty, when probability is unknown, unknowledgeable, vague. According to the standard theory of individual behaviour under uncertainty, subjective expected utility (SEU) theory, risk and uncertainty are the same as it is always possible to recover subjective probabilities from choice. In particular, rational decision makers should be indifferent between uncertain and risky prospects characterised by equivalent expected probabilities.

Ellsberg's (1961) seminal experimental work questioned the descriptive power of SEU for individual choice by showing that individuals prefer to bet on events having known probabilities of occurring rather than on equivalent events whose probabilities are vaguely known. Ellsberg's findings have been widely replicated in the laboratory (see Camerer and Weber (1992) for a review), thus proving that aversion to uncertainty is a robust phenomenon. However, most experimental tests of the descriptive performance of SEU have not attempted to recreate the type of incentives typical of markets and, therefore, are of little guidance for the prediction of market outcomes in settings characterised by the presence of uncertainty such as securities and insurance markets.

More recently, the effects of uncertainty on market behaviour have inspired new theoretical work. Harsen, Sargent and Tallarini (1999), Hansen and Sargent (2000), Harsen, Sargent, Turmuhambetova and Williams (2001), for example, modify rational expectation models acknowledging the idea that models can be misspecified. Agents are supposed to be averse to misspecification, but they might achieve "robustness" rendering themselves less vulnerable to it. Epstein and Wang (1994), Epstein and Melino (1995), Chen and Epstein (1998), and Epstein (2000) have also introduced ambiguity aversion in asset pricing models. Aversion to uncertainty or to misspecification has the effect of boosting market prices in asset pricing models and of introducing precautionary savings in permanent income models.

In spite of increasing experimental evidence and of the growing use of the concept of ambiguity in theoretical models of the presence of uncertainty, many economists continue to believe that deviations from the expected utility model are due to lack of incentives or to decision frames which do not replicate those of real markets. The market — the argument goes, provides incentives for individuals to behave rationally, through the interaction with the other market participants and the repetition of the experience.

More specifically, the following arguments are generally used to support the idea that individuals behave rationally in a market setting:

i) Markets produce information which is not available in individual decision making frames, such as prices, and – according to the market institution – also bids, offers and sales volumes (Cox and Grether, 1996).
ii) the interaction between market participants implies that individuals can learn either implicitly or explicitly from more rational ones (Camerer, 1987).
iii) The repetition of the experience which takes place in a market implies that individuals may learn something about the probability distribution of relevant events, and that information about prices and allocations in one period may shape their decisions in the next (Cox and Grether, 1996). Also, through the repetition of the experience, individuals may learn to "live" with uncertainty.
iv) Markets provide financial incentives, while this is not always the case in individual decision making settings (Camerer, 1987; Cox and Grether, 1996).
v) Finally, irrational agents may be driven out of markets by bankrupcy (Camerer, 1987).

Even if the normative model of individual behaviour were violated by many individuals operating in a market, market prices and allocations may still be consistent with this model. The following arguments can be used to support this claim (see again Camerer 1987): (i) mistakes by individuals will be zero on average; (ii) only few rational individuals are needed to make market outcomes rational.[1]

In markets where both risky and uncertain prospects are traded, two implications of this list of "invisible hand" arguments are that individuals' willingness to pay/to accept to acquire/sell risky assets should approach those for equivalent uncertain assets, and that their equilibrium price should converge to the same value. The corollary for economic theory is the following: if individual-level violations of subjective expected utility do not affect the functioning of markets, then models of market behaviour may ignore them.

As already mentioned, laboratory evidence concerning this issue is scarce, as most tests of individual behaviour under uncertainty have not simulated a market environment (see for instance the papers by Einhorn and Hogarth, 1985, 1986).

Notable exceptions are the papers by Camerer and Kunreuther (1989) and by Sarin and Weber (1993) which compare market prices for assets whose outcomes occur with a known probability (risky assets) with those for assets in which probabilities are not exactly known (uncertain or ambiguous assets). In Camerer and Kunreuther (1989) a double oral auction is used to build an experimental market for insurance. Equilibrium prices at which ambiguous liabilities are insured tend to converge to those for risky ones, indicating that SEU behaviour prevails in a market setting. In an experiment in which both risky and uncertain assets (stock) are evaluated using either a double oral auction or a sealed bid fifth price auction, however, Sarin and Weber (1993) find that the equivalence of risky and uncertain prospects does not hold and that, in particular, ambiguity aversion, i.e. the preference to bet on known probabilities rather than on vague ones, persists in the

[1] On the other hand, counter arguments may be represented by the fact that rational individuals may not be identifiable by other market participants or that, in real markets, rational individuals may need more capital to impose their views. Also, in the presence of irrational individuals, it may not be optimal to be rational (see Camerer (1995) for a discussion).

face of market experience when the probability of gain is 50%, while convergence occurs when the probability is low (5%). Since the two papers use the same types of market incentives, the difference in their findings is probably due either to the outcome domain or to the way the concept of uncertainty is made operational.[2]

Fox, Rogers and Tversky (1996) give indirect evidence on the relevance of uncertainty in market settings, by showing that professional option traders exhibit sub-additive decision weights in the pricing of uncertain assets.[3]

Other experimental studies provide mixed evidence about the ability of markets to reduce violations of the normative model of behaviour under risk and uncertainty. For instance, Cox and Grether (1996), find that the rate of preference reversals is reduced in a repeated English clock auction. Evans (1997) finds that prices (but not individual bids) in a fifth-price sealed bid auction display a low rate of violations of the betweenness axiom of the expected utility theory. However, this result is attributable to the statistical properties of the pricing rule adopted, rather than to a change in preferences induced by the market framework.

A related issue which has received some attention is that of the updating of judged probabilities. Camerer (1987) tests whether Bayesian posterior probabilities are formed in the determination of trading prices for uncertain assets in a double oral auction. Market prices converge to Bayesian predictions, although there is also some evidence of small biases. Similar evidence is reported in Duh and Sunder (1986) and in Ganguly, Kagel and Moser (1998), although this latter study also finds strong biases when a context treatment is used, rather than an abstract bingo cage setting.

In this paper, our aim is to explore the following two issues by means of a laboratory experiment:

(i) whether the operation of markets affects individual valuations under uncertainty
(ii) whether market prices are affected by the presence of uncertainty.

As in Camerer and Kunreuther (1989), we investigate the impact of vague probabilities in the market for insurance in which liabilities are traded. In our experiment, subjects evaluate both risky and ambiguous liabilities with equivalent probabilities of outcomes. Our work departs from the latter paper in three directions:

1. In the market institution we simulate in the laboratory, an English clock auction, the dominant strategy for players is to bid their true reservation price. This will allow us to carry out the analysis of market-induced behaviour not only through the observation of equilibrium prices, but also at the individual bids level, by calculating certainty equivalents for the liabilities traded.
2. Preference towards the risky lottery is generally called ambiguity or uncertainty aversion, although recently the term *source preference* has also been used in the literature to indicate the

[2] Camerer and Kunreuther use the loss domain and a characterisation of uncertainty in terms of a uniform second order probability distribution. Sarin and Weber refer to the securities market and make use of the Ellsberg urn to operationalize uncertainty.
[3] Even if a market is not explicitly simulated in this experiment, the use of professional market traders should shade some light on the functioning of real markets.

same phenomenon (Tversky and Wakker, 1995). We test for the presence of ambiguity aversion by checking that the sum of certainty equivalents for complementary ambiguous events is less than the sum that is obtained when probabilities are exactly known.[4]

3. We compare subjects' valuations in a market setting with subjects' responses to a questionnaire given either as part of a classroom assignment in decision theory or in exchange of a flat payment. Moreover the market experiment is run under two alternative payment schedules: in one treatment, subjects are paid a fraction of their accumulated earning in the auction, while in the other, subjects receive a flat payment against their participation in the experiment.

The organisation of the paper is the following: first, we discuss the theoretical background of our test, second we describe the experimental design and the organisation of the experiment, third, we discuss the results. Finally, we conclude with a discussion of the implications of the results with respect to the theory of behaviour under risk and uncertainty.

1. The hypotheses tested

Although SEU remains the dominant theory of behaviour under risk and uncertainty, today several alternative models are available that explain individual behaviours at odds with SEU's predictions. In recent years, Cumulative Prospect Theory (CPT henceforward), (Tversky and Kahneman, 1992 and Tversky and Wakker, 1995) and Choquet Expected Utility models (see Schmeidler, 1989 among others) have emerged as the main competing paradigms to SEU.

According to Expected Utility Theory, given the risky prospect (X, p; 0, 1-p), the value of this prospect to the decision maker is measured by the utilities of the outcomes weighted by their respective probabilities. According to competing theories, the values assigned to outcomes are weighed by decision weights, w(p), which are not a linear transformation of "objective" probabilities. Non linearity allows for decision weights which *might* not be additive, i.e.:

$$w(p) + w(1-p) \neq 1$$ [5]

This property can be extended to uncertain prospects, i.e. prospects characterised by vague or unknown probabilities. Consider two events, A_1 and A_2, which are mutually exclusive and such that $A_1 \cup A_2 = S$, where S denotes the state space. If A_1 occurs, the individual receives a payoff of X, whereas if A_2 occurs the payoff to the individual is zero. The decision weights assigned to the two complementary events, $W(A_i)$, i = 1,2, are not necessarily additive:

$$W(A_1) + W(A_2) \neq 1$$

Ellsberg's (1961) well-known experiment showed that people prefer to bet on an urn containing 50 black and 50 red balls (the risky urn), rather than on an urn containing 100 red and black balls in an unknown composition (the ambiguous urn). This pattern of preference, which implies that individuals prefer to bet on known rather than on unknown probabilities, has been called ambiguity

[4] See Keppe and Weber (1995) and Tversky and Fox (1995a) for similar tests in a non market setting.

[5] The condition that the sum of the decision weights must be different from 1 is a sufficient but not a necessary condition for non linear decision weights If the weighting function has a symmetric inverse S-shape, then W(p) + w(1-p) =1. In this case we have additivity but non linearity in probabilities . On the other hand, pessimism is characterized by a convex weighting function while optimism by a concave weighting function.

aversion.[6] Tversky and Wakker (1995) argue that risk and ambiguity can be considered two different sources of uncertainty, and use the term *source preference* to refer to the preference of one source over the other. Henceforward, we shall define *source preference for risk* the preference to bet for and against a risky prospect rather than on an equivalent ambiguous prospect.

Source preference for risk implies that, if X>0, the sum of decision weights assigned to drawing red and black both from the risky urn is greater than the sum of the decision weights assigned to drawing red and black from the ambiguous urn. Let's define p = probability of red being drawn from the risky urn; (1-p) = probability of drawing black from the risky urn; A_1 = drawing red from the ambiguous urn; A_2 = drawing black from the ambiguous urn. Then, risk will be preferred to ambiguity if:

$$W(A_1) + W(A_2) < w(p) + w(1-p) \tag{1}$$

In models which allow for a different treatment according to the outcome domain (Tversky and Wakker,1995), when losses are considered, i.e. X<0, then source preference for risk implies that:

$$W(A_1) + W(A_2) > w(p) + w(1-p) \tag{2}$$

The condition that (1) and (2) imply on certainty equivalents is:

$$C(X, A1) + C(X,A2) < C(X, p) + C(X,1-p) \tag{3}$$

where C(·) denotes the certainty equivalent of the prospect considered (Tversky and Wakker,1995).

Consider now a decision maker who owns a sure sum M and the following risky prospect R = (-M,p;0,1-p): the individual loses M if red is drawn from the risky urn and stays put if black is drawn.[7] WTP_{max}, the individual's maximum willingness to pay to sell (i.e. not to play) lottery R solves the following equation:

$$v(M - WTP_{max}) = w(1-p)v(M)^{8} \tag{4}$$

hence $M - WTP_{max}$ is the certainty equivalent of the R gamble. The sum of the certainty equivalents for the two complementary prospects is given by:

$$SUM(CE_R) = C(M, p) + C(M,1-p) = v^{-1}(w(p)v(M)) + v^{-1}(w(1-p)v(M)) \tag{5}$$

If the decision maker is instead endowed with a sure sum M and the uncertain prospect A, where $A = (-M, A_1; 0,A_2)$, the sum of certainty equivalents for complementary prospects in this case is:

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[6] For the sake of completeness, it must be added that in the literature ambiguity aversion is used more generally to indicate preference to bet on a risky prospect than on an equivalent uncertain one. See Camerer and Weber (1992) for a review.

[7] This is equivalent to a prospect of the type (M,1-p) whose complementary prospect is (M, p).

[8] The value function v(·) is continuous and strictly increasing.

$$SUM(CE_A) = C(M, A_1) + C(M,A_2) = v^{-1}(W(A_1)v(M)) + v^{-1}(W(A_2)v(M)) \qquad (6)$$

According to SEU, in an Ellsberg-type problem, the sum of certainty equivalents should depend only on the risk attitude and on the expected probability of X and should not be affected by the presence of vague probabilities. By the principle of insufficient reason, the expected probability of drawing red or black from the ambiguous urn is ½ exactly the same as in the risky urn. Hence, SEU-consistent behaviour implies that:

$$SUM(CE_A) = SUM(CE_R) \qquad (7)$$

However, if individuals prefer risk to uncertainty, i.e. they display a source preference for risk, the SUM(CE) is lower for uncertain prospects than for risky ones. Hence, source preference for risk implies:

$$SUM(CE_A) < SUM(CE_R) \qquad (8)$$

The sign of the above inequality will be reversed if individuals show source preference for uncertainty.

If individual reaction to uncertainty is considered a departure from "rational behaviour", then one can raise the question of whether the provision of appropriate incentives, such as those supplied by the market, may lead to a smaller discrepancy between $SUM(CE_A)$ and $SUM(CE_R)$, i.e. may reduce the source preference effect.

Thus we have two testable hypotheses which can be formulated as follows:

HYPOTHESIS 1 – *Source preference in individual behaviour tends to disappear when certainty equivalents are elicited through a market institution. In particular, with market experience and feedback:*
1.a. the number of source indifferent subjects increases
1.b the average $SUM(CE_R)$ and $SUM(CE_A)$ tend to converge.

As discussed in the introductory section to this paper, even if this hypothesis were not verified, market prices may nevertheless not reflect deviations from rationality, since the presence of a few rational individuals may be sufficient to determine the equilibrium price. Hence, market prices for risky and uncertain prospects should be the same, or at least they should converge with the repetition of the experience.

HYPOTHESIS 2 – *In a market setting, the difference between the selling prices of the ambiguous prospect and of the risky prospect tends to disappear with market experience.*

The following sections describe the experiment designed to test these hypotheses.

2. Experimental Design

In our experimental study all subjects evaluated the same risky and ambiguous prospects. However, we adopted four treatments which differed according to the elicitation and incentive procedures.

Experiment 1 – Forty-six students at York University were recruited through the EXEC mailing list. They participated in six experimental sessions which were organised as English clock auctions. The aim of this first experiment was to test how individual bids and market prices reacted to the presence of vague probabilities of loss.

In each session, eight subjects[9] participated in four markets. In each market, the object of the trade was *one* of the following potential liabilities:

(i) A prospect yielding a loss of £100 with probability p and 0 with probability (1-p);

(ii) a prospect yielding a loss of £100 with probability (1- p) and 0 with probability p;

(iii) a prospect with the same outcomes as in (i) but with vague probabilities. These vague probabilities were represented through an Ellsberg–type probability distribution having a mean probability value (p') equal to the probability of the risky urn (p);

(iv) a prospect with the same outcomes in (ii) but with vague probabilities having mean $p' = 1-p$;

Prospects (i) and (iii) were complementary to (ii) and (iv) respectively.

We ran three sessions (1.1 to 1.3) in which the reference probability was $p = p' = .05$, and three sessions (1.4 to 1.6) in which $p = p' = .5$. The value of p was not announced to the subjects, who had to deduce it from the description of simple chance devices which will be discussed later. We will call the liabilities (i) and (ii), in which the probabilities of loss are exactly known, *risky prospects* while we will term the liabilities (iii) and (iv) *ambiguous prospects*, since probabilities are not exactly known.[10]

For illustration, let us consider the risky prospect at the probability level of .05. Subjects had to evaluate the following scenario: [11]

Liability A *yields a loss of £100 if a ball drawn from bag A carries number 1 on it, otherwise you will not lose anything. Bag A contains 20 numbered balls with numbers going from 1 to 20. Each ball carries a different number, so that each of the numbers from 1 to 20 appears only once.*

The complementary prospect was defined as follows:

Liability C *yields a loss of £100 if a ball drawn from bag A carries any number but number 1 on it, otherwise you will not lose anything. Bag A contains 20 numbered balls with numbers going from 1 to 20. Each ball carries a different number, so that each of the numbers from 1 to 20 appears only once.*

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[9] One session was run with six participants only as two subjects did not turn up. The dominant strategy in English clock auctions is however robust to small changes in the number of bidders (see Kagel, 1995).

[10] In the course of the experiment, however, the labels *risky* and *ambiguous* were never used. We simply referred to the risky prospect as liability A and to ambiguous prospect as liability B. The respective complementary prospects were called C and D.

[11] The equivalent ambiguous scenarios are described in section 3.

Each market was made up of eight market days. In each market day, subjects were endowed with £100 cash plus one potential liability, and they were asked to participate in an English auction in which they had to bid their maximum willingness to pay to sell the potential liability. Trivially, this was equivalent to bidding for purchasing complete insurance. Since all potential liabilities lived one period, their value was determined by their expected loss.

In each of the eight days which made up a market the same liability was auctioned and only one participant was allowed to purchase insurance, i.e. sell the liability.

The value of the liability was resolved at the end of each market day: by means of a random device, which will be fully explained in the next section, the experimenter determined whether the potential loss occurred or not. Subjects were paid a specified fraction of their total earnings (1%), i.e. earnings accumulated in the course of the four markets. For each market, earnings in pounds sterling were thus calculated:

$$E = 0.01[\Sigma_i (100 - L_i)]$$

Where i =1,…..,8 stands for the market day and L_i is the loss that ensued, i.e. either £100 or zero. The experiment lasted two hours. Average earnings in the experiment were £16, a fairly substantial amount for students, as was proven by the high demand to EXEC to get a place in the sessions.[12]

Experiment 2 - In this version of the experiment we run an English auction for the sale of the potential liabilities, but subjects received a flat payment which did not depend on their performance in the auction. We run six sessions; forty-six undergraduates in Economics of Catania University, Italy, participated in this group of experiments. They received a reward of £5 in exchange for their participation, irrespective of their earnings in the auction. As in experiment 1, each market lasted eight periods and risk/uncertainty was resolved at the end of each market day.

This version of the experiment was meant to separate the incentives created by markets from those of financial remuneration[13].Although there is evidence that financial incentives do not matter for simple pairwise choice problems (see for instance Beattie and Loomes (1997)), there is also the suspicion that financial incentives may interact with the market setting in reducing departures from SEU (Camerer, 1995).

Table 1A summarises the sessions run in the market experiments.

[Insert table 1A about here]

Experiment 3 - In this experiment, the same potential liabilities described in experiment 1 and 2 were evaluated by six classes of undergraduate students in Economics of Hull University as part of a classroom assignment, for a total of fifty-eight students. No financial or market incentive was

[12] Of course when subjects are the winner of the lotteries they are given the prize minus the premium (prise) at which the last person dropped out of the auction.

[13] Some small participation fee was however necessary to induce students to participate in the experiment. The participation fee was at any rate less than 1/3 of the expected payoff in experiment 1.

used and students had not taken any previous class on expected utility and uncertainty. In this version of the experiment, our objective was to replicate the kind of stimuli that are typical in experiments run by psychologists. Since our working hypothesis was that in the absence of a market institution, uncertainty has a greater impact on valuation, we aimed at assessing the extent of this difference.

Experiment 4 - Fifty undergraduate students in Economics and Politics of the University of Cosenza, Italy participated in this last experiment. Subjects were asked to complete a questionnaire in which they had to state their maximum willingness to pay for the same potential liabilities described in the previous three experiments. Students had not taken any previous class on uncertainty or on expected utility theory. The aim of the experiment was to replicate the results of Experiment 3 in a situation in which subjects received a small participation fee for completing the task: 5000 Italian lire (around $2.30).

Table 1B summarises the four treatments according to the incentives adopted.

[Insert table 1B about here]

To sum up, in the four experiments uncertainty/risk and the valuation of complementary events were manipulated on a within-subject basis, as each experimental subject evaluated both risky and uncertain prospects and their complementary prospects. On the contrary, the reference probability and the type of incentive were manipulated on a between-subjects basis.

3. The operationalisation of risk and uncertainty

In order for market participants to learn from the interaction with other players and from the experience of several market days, it is necessary to determine whether a loss occurred or not at the end of each market day, i.e. the experimenter has to resolve the value of the liabilities. The determination of losses, in turn, implies the resolution of risk or uncertainty. In this respect, a problem we had to face was that of operationalising uncertainty in such a way as to induce expected probabilities comparable with those for risky prospects.

Risk was made operational by means of a simple chance device. For prospects in which the loss occurred with probability .5, all participants, except the winner of the auction, were asked to draw a ball out of an urn containing 10 black and 10 white balls. If a black ball was drawn, that person lost £100 and thus ended up with zero. If a white ball was drawn, the subjects kept their initial endowment of £100. The procedure was repeated for every participant. When considering the complementary event, the prospect obviously yielded a loss if a white ball was drawn.

In the case in which the loss occurred with probability .05, all participants, except the winner of the auction, were asked to draw a ball out of an urn containing 20 balls carrying numbers from 1 to 20 on them. If a subject drew number 1, then she or he lost £100 and thus ended up with zero. Otherwise, the subject kept the initial endowment of £100. The prospect for the complementary event yielded a loss if a number greater than 1 was drawn.

As in Sarin and Weber (1993), the operative definition of uncertainty we used is the Ellsberg's urn. Doubts in fact exist concerning whether a second order uniform probability distribution, as used by Camerer and Kunreuther (1989) is regarded by experimental subjects as real uncertainty (see Yates and Zukowski (1976), Bernasconi and Loomes (1993)). As in Ellsberg (1961), in order to make $p' = .5$ operational, subjects were asked to draw a ball out of an urn containing 20 white and black balls in unknown proportions. The type of scenario subjects were asked to evaluate was the following:

Liability B *yields a loss of £100 if a white ball is drawn from bag B, otherwise you will not lose anything. Bag B contains a total of 20 balls, but you do not know how many of these are black or how many are white.*

The proportion of white and black balls in the urn was determined by means of the following random device. At the end of each market day, the winner of the auction was asked to draw a ticket (we replaced the ticket after each draw) out of a bag containing 21 tickets numbered from 0 to 20. The number drawn determined the proportion of white balls. Since this process was repeated at the end of each market day, the amount of ambiguity faced by participants was not diminished as the experiment proceeded. At the beginning of the experiment, subjects received detailed explanations about how the proportion of white and black balls would have been determined. According to SEU, by the principle of insufficient reason, a rational decision maker should act on the basis of the expected probability of drawing white, which is $p' = .5$. Hence, the ambiguous prospect should receive the same valuation as the risky one.

To make $p' = .05$ operational, subjects were asked to draw a ball out of an urn containing 20 balls bearing numbers from 1 to 20. They were asked to evaluate the following scenario:

Liability B *yields a loss of £100 if a ball drawn from bag B carries number 1 on it, otherwise you will not lose anything. Bag B contains 20 numbered balls with numbers going from 1 to 20. However, there is an unknown number of balls bearing any single number.*

To determine the composition of the ambiguous urn we used the following random device: we prepared a bag containing 20 tickets carrying numbers from 1 to 20. We made twenty draws out of this bag, each time replacing the drawn ticket; the numbers drawn were used to determine the composition of the ambiguous urn. Since every number had 1 in 20 chances of being drawn, the expected probability of drawing number 1 was $p' = .05$. We prepared eight bags using the same procedure, one for each market day.[14]

[14] Subjects chose the ambiguous bag at the end of each market day. We replaced the chosen bag each market day. The sequences of numbers contained in the bags were recorded by the experimenters and subjects were told that they could check the composition of the bags after the end of the experiment.

4. Organisation of market experiments

As mentioned in section 2, experiments 1 and 2 were organised as English clock auctions. The choice of this market institution was motivated by two features of this type of auction:

1. In English auctions subjects directly interact with each other, since information about submitted bids is public;
2. the dominant strategy is to reveal one's true valuation of the good traded, independently of risk attitude and of the number of players in the auction. Hence, subjects' bids in the auction may be used to build individual certainty equivalents for the prospects traded.

In experiments 1 and 2, two trial auctions (one for a risky prospect and one for an ambiguous prospect) were staged for 2 periods each in every experimental session, prior to the beginning of the first market. This was done in order to make auction participants familiar with the decision task and with the auction procedure. In this phase of the experiment, subjects also received detailed explanations about how risk/uncertainty would have been resolved. This was meant to make the expected value of the probability distribution of the ambiguous losses as transparent as possible.

The four potential liabilities were traded in random order in the six sessions of the experiment.[15] Hence, in some sessions the prospects with ambiguous probabilities were traded before those with known probabilities. Table 1B summarises experiments 1 and 2.

Before the hypothetical market periods, subjects received detailed explanations as why it was their best strategy to bid their true reservation value in an English auction. This explanation was necessary because, in the course of an auction run for several rounds, subjects may learn the auction's optimal strategy. This knowledge could be confused with the knowledge about the probability distribution of the uncertain events. Hence, the provision of detailed explanations about optimal behaviour in an English auction was meant to isolate the learning induced by the market in the choice under uncertainty from the learning of the auction strategy.

For each of the four markets, subjects received a record sheet with a description of the liabilities auctioned in that market, on which their earnings for each day were to be recorded. Subjects' bids were instead written by the experimenter on a slide which was clearly visible to all participants, so that at every point in the experiment everybody had immediate feedback as to what the other subjects' reservation prices were in the current and previous market days and about how many participants were still in the auction.

The auction itself was run by an auctioneer who called out prices aloud, going from zero up to 100 pounds, one pound at a time. Subjects had to shout out their participation number when they wanted to leave the auction. When all subjects but one had dropped out of the auction, the auctioneer declared the market day closed and announced the winner and the sale price, which was the bid submitted by the last person to drop out of the auction. After the winners and the sale price of the goods were announced, the experimenter proceeded to resolve the value of the prospects by means of the risky/ambiguous urns as described in section 3.

[15] The random ordering of gambles is standard procedure in economic experiments. However, in the case of comparison of risky and uncertain prospects, the random ordering has also the aim of controlling for "comparative ignorance effects" (see Tversky and Fox, 1995b).

In experiment 1 earnings in each market were calculated as the sum of earnings over all market days. We chose not to have hypothetical, i.e. non-binding, market days at the end of which asset values were not determined, as this may have led to the building of bargaining positions to be used by players later on in binding market periods (Gregory and Furby, 1987). Also, for the sake of greater realism, we chose to pay the sum of accumulated earnings rather than pay subjects on the basis of one randomly-drawn market day. Participants in real life markets are, in fact, not paid on the basis of just one experience. The drawback of not using a random lottery selection procedure is of course that a wealth effect may build up.[16]

In experiment 2 subjects received a flat payment of £ 5 for their participation, although at the beginning of the experiment they were told to take their decisions as if they were going to be paid according to their accumulated earnings. Otherwise, experiments 1 and 2 were the same.

5. Results

The analysis of results from the four experiments is divided in two parts: first, in sections 5.1. and 5.2., we test hypothesis 1, that the sum of the certainty equivalents for complementary events tends to converge to the same value under risk and uncertainty in a market setting. Second, in order to test hypothesis 2 that prices do not reflect source preference, in sections 5.3 and 5.4 we check whether sale prices in experiments 1 and 2 display reaction to uncertainty and whether this vanishes with market experience.

5.1. Analysis of certainty equivalents in experiments 1 and 2

In this section we address the issue of whether "source preference" is reduced or disappears when certainty equivalents are elicited in a market setting. As already mentioned, although equilibrium market prices may not reflect deviations from "rational" behaviour, this needs not extend to individual willingness to sell/pay. Market prices in an English auction, in fact, may be determined by few rational individuals, whereas the rest of market participants' valuations may be greatly affected by uncertainty. In the following analysis, we will use the term source preference for uncertainty/risk when the individual sum of certainty equivalents for the two complementary prospects under risk is smaller/bigger than the sum of the certainty equivalents for the two corresponding ambiguous prospects. Certainty equivalents for each subject are calculated as (£100 – bid), under the assumption that auction bids reflect the subjects' true maximum willingness to pay to sell the potential liability. In order to assess the impact of probability uncertainty on individual valuations, we compare the sum of certainty equivalents for complementary prospects under risk and under uncertainty in experiments 1 and 2, and we verify whether this sum is affected by market repetition and feedback.

[16] But Kachelmeier and Shehata (1992) and Cox and Grether (1996) do not find evidence of this.

Figures 1A-2B provide diagrammatic analysis of individual data, while tables 2a and 3a show respectively summary statistics and individual attitudes for the sum of certainty equivalents.[17]

[Insert table 2, table 3 and figures 1A-2B about here]

The scatter diagram in Figure 1A refers to experiment 1 when the probabilities of the two complementary events are 5% and 95% (sessions 1.1-1.3). Auction participants in sessions 1.1 to 1.3 have been pooled. The horizontal axis shows the sum of certainty equivalents for complementary risky prospects, i.e. SUM(CE_R); the vertical axis displays SUM(CE_A), i.e. the sum of CEs of equivalent events for the corresponding ambiguous lottery. Each subject is represented by a point in the diagram. The diagonal line corresponds to the absence of source preference, i.e. subjects' SUM(CE)s is the same under risk and under uncertainty. The point (100,100) implies that the sum of certainty equivalents is exactly equal to the sum of the expected values of the prospects. Points off the diagonal indicate source preference. In particular, source preference for risk/uncertainty is represented by points below/above the line. The diagram gives the distribution of SUM(CE)s for the first and last market day of the auction.

Data points for the first market day show that several subjects display SUM(CE_A) > SUM(CE_R), i.e. a preference for ambiguity. Mean SUM(CE_A) is 142.08 while mean SUM(CE_R) is 120.17. A paired t-test shows that reaction to ambiguity is significant since the mean sum of certainty equivalents under risk is statistically different from that under uncertainty ($t = 2.81$, $p = .01$).[18] On the last market day, there is a reduction in reaction to ambiguity, as more subjects cluster around the (100,100) point. In particular, on the first market day the prevalent attitude is source preference for uncertainty (16 out of 24 subjects) and only three subjects are source-indifferent.[19] On the last market day, only five subjects exhibit preference for uncertainty and thirteen show absence of source preference. The means of the sum of certainty equivalents are fundamentally the same: mean SUM(CE_A) is 114.46 while SUM(CE_R) is 116.71, and so are the medians (median SUM(CE_A) SUM(CE_R) are respectively 101 and 104.5). A paired sample t-test shows no effect of ambiguity on the last market day ($t = -.31$, $p = .76$). Further, a t-test of equality of the means of SUM(CE_R) on day 1 and day 8 leads us to accept the null hypothesis ($t = .57$, $p = .57$) while equality of the means of SUM(CE_A) on day 1 and day 8 is rejected ($t = 3.22$, $p = .04$). This result (as well as observation of Figure 1A) implies that most of the adjustment of individual bids brought about by market experience concerns the valuation of uncertain lotteries rather than of risky ones.

Figure 2A shows SUM(CE_A) and SUM(CE_R) in experiment 2 when the probabilities of the two complementary events are 5% and 95% (sessions 2.1- 2.3). Recall that in this treatment subjects competed in an English auction but their remuneration was fixed and independent of their performance. Like in experiment 1, we observe that, on the eighth market day, more individuals

[17] In calculating these data we assumed that the evaluation of the winner of the auction was equal to the price at which the last person left the auction. Of course her/his evaluation was at least as great as that value.

[18] Both sums are statistically different from 100, which is the risk neutrality point (one-sample $t = 5.53$, $p= 0$, for uncertainty; one-sample $t = 4.30$, $p= 0$, for risk).

[19] Indifference between sources was defined as a difference of less than ± 5 in absolute terms between SUM(CE_R) and SUM(CE_A).

cluster around the expected value point, whereas the sums of certainty equivalents on the first day are more spread out. On the first day, fifteen market participants preferred ambiguity to risk, eight exhibited the opposite pattern, and only one was source indifferent. On the last day, the number of subjects who display no source preference increased to eleven. Also, as table 2a shows, the mean and median values become slightly closer on day eight. The difference between mean values of the sum of certainty equivalents under risk and under uncertainty, however, is not statistically different both on day 1 (paired t = .45, p = .658) and on day 8 (t =.81, p=.427). Also, comparison of SUM(CE_A) on the first and on the last day show that the means are not statistically different (paired t = -.81, p = .427), and the same applies to SUM(CE_R) (t = -.66, p = .51).

The above results can be summarised by saying that when complementary reference probabilities are 5% and 95%, both in experiments 1 and 2, the feedback obtained from price and bid information and the repetition of the experience leads to an increase in the number of subjects who display no source preference. This pattern of behaviour is common to the two experiments, irrespective of the payment schedule used. However, adjustment appears to be stronger in experiment 1: in this treatment both summary and individual values suggest that market experience works in reducing the effect of uncertainty on certainty equivalents. Besides, on the last market day, not only reaction to uncertainty tends to disappear but also prospects tend to be evaluated on the basis of expected values.

Figure 1B shows SUM(CE_A) and SUM(CE_R) in experiment 1 when the probability is p = .5 (sessions 1.4.-1.6). In Figure 1B, the first market day shows reaction to uncertainty but risk neutrality. Comparing SUM(CE_A) and SUM(CE_R) for each individual we find that the number of subjects who display no source preference is roughly the same on the first and on the last market day (10 subjects in the first day and 8 in the last market day, out of 22), so that market experience does not seem to reduce the impact of uncertainty on individual valuations. Note however, that whereas with complementary probabilities 5%-95% there were very few source-indifferent subjects on the first day, with a reference probability of 50%, the number of subjects who exhibited source indifference from the start was substantially higher. This result can be reconciled with behavioural models such as Einhorn and Hogarth's (1985), according to which the attitude towards ambiguity switches from aversion to preference according to the reference probability, so that there shall be a probability value at which individuals will be indifferent between sources of uncertainty. Summary statistics in table 2a show that mean SUM(CE_A) is practically the same on the first and on the last market day. We cannot reject the hypothesis that mean SUM(CE_A) is equal to the mean SUM(CE_R)) both on day 1 (t = 1.59, p = .13) and on day 8 (t = .84, p = .41).

Figure 2B shows the sum of certainty equivalents for complementary prospects of experiment 2, when p =50%. In this experiment, unlike in experiment 1, source preference for risk prevails both on the first and on the last market day. Most data points, in fact, lie below the diagonal line. The number of source indifferent subjects, however, increases slightly from day 1 to day 8 (one subject on day 1 and five on day 8). Table 2 shows that the mean and median SUM(CE_R) and SUM(CE_A) get closer on the last market day (mean SUM(CE_R) is 123.91 on day 1 and 108.05 on day 8, while mean SUM(CE_A) is 101.41 on day 1 and 92.68 on day 8). The SUM(CER) on day 1 is statistically different from day 8 (paired t = 3,73, p = 0.01) and the same holds for SUM(CE_A) (paired t = 1,85, p = 0.07). The means of sum of certainty equivalents under risk and uncertainty are strongly and significantly different on day one (t = -5.5, p = 0), but only weakly significant on day eight (t = -2.94, p = .08). Hence, with respect to experiment 1, in experiment 2 when p = 50% there is more source preference but competition brought about by the auction mechanism partially reduces the impact of ambiguity.

Summing up, the market framework does induce a change in behaviour, regardless of whether subjects' remuneration in the experiment is on the basis of performance or not. The market environment in itself does not eliminate the effect of ambiguity from individual certainty equivalents. However, there is evidence that it reduces the source preference phenomenon. When the difference between complementary probabilities is large (p = 5% and 95%) both in experiment 1 and 2 the number of source-indifferent bidders increases substantially in the last market day with respect to the first. When complementary prospects have equal odds (p = 50%), in experiment 1 the difference between SUM(CE_A) and SUM(CE_R) is statistically insignificant already on the first day. In experiment 2, however, source preference tends to become weaker, exactly like in the sessions with reference probability equal to 5%. A remuneration based on performance (Experiment 1) seems to improve the performance of the market as an incentive mechanism.

5.2. Comparison of market values and questionnaire responses.

To further investigate whether markets reduce distortions and violations of SEU, we contrast the distribution of the sum of certainty equivalents in experiments 1 and 2 against the results obtained in experiment 3 and 4, in which no incentive-compatible elicitation mechanism was adopted. Hypothesis 1 implies that in experiment 3 and in experiment 4 the sum of certainty equivalents for complementary risky prospects will display a greater divergence from the certainty equivalents for ambiguous prospects with respect to CEs obtained from auction bids of experiments 1 and 2.

Figure 3A shows the sum of CEs in experiment 3 when p = 5%. Comparison with figures 1A and 2A reveals that lack of market and financial incentives leads to several outliers which reflect high risk-proneness. However, mean values of certainty equivalents under risk and under ambiguity are very close (SUM(CE_R) = 132.13, SUM(CE_A) = 136.27), although median values reflect a marked source preference for uncertainty. A paired sample t-test for the equality of means leads us to accept the null hypothesis (t = .64, p = .5). A surprising result is that the proportion of source indifferent subjects was quite high (12 out of 28) if compared with the proportion observed on the first day of the market experiments (see table 3b).

As far as Experiment 4 is concerned (no market incentives and a small flat payment), Figure 4A shows the sum of CEs in experiment 4 when p = 5%. Also in this experiment, we have a high number of outliers: the standard deviation is higher in experiment 4 than in experiment 3, and this is true under both risk and uncertainty. The number of source indifferent subjects is 7 out of 25.

Contrary to what we find in experiment 3, most subjects display source preference for risk, as it is revealed also by median values of the sum of the CEs (median values are 180 under risk and 150 under ambiguity). However, as in experiment 3, a paired sample t-test for the equality of means leads us to accept the null hypothesis (t = 0.36, p=.72).

In figure 3B, with complementary prospects having equal odds (p = 50%) data from experiment 3 reflect risk neutrality but marked source preference. The difference between the mean SUM(CE)s under risk and under ambiguity is weakly different (t = -1.75, p = 0.09). The number of subjects who display no source preference is 8 over a sample of 30.

Figure 4B shows an even higher dispersion of subjects' CEs when p=50%. Most subjects exhibit source preference for risk (15 out of 25) and only 5 subjects are source indifferent. This result is also confirmed by the mean and median values of the CEs under risk and uncertainty. The mean values are respectively $SUM(CE_R)$ = 148 , and $SUM(CE_A)$=117 while the medians are 160 and 100. We performed a paired sample t-test for the equality of means and we rejected the null hypothesis for this level of probability (t = 2.28, p = .03).

In order to compare the difference between $SUM(CE_A)$ and $SUM(CE_R)$ in experiments 3 an 4 with those observed on the first market day of experiments 1 and 2 we ran a two-way ANOVA in which the main effects were the type of experiment and the reference probability. When we compare $[SUM(CE_A) - SUM(CE_R)]$ relating to the first day of experiments 1 and 2 with $[SUM(CE_A) - SUM(CE_R)]$ in the questionnaire experiments 3 and 4, we find a strong significant effect both for the type of treatment (F = 4, p = .09) and for the reference probability (F = 11.7, p = 0.01). On the contrary, if the differences of SUM(CE)s in experiments 3 and 4 are compared with those relating to the last market day of experiments 1 and 2, the treatment no longer appears significant (F = 1.7, p = 0.16) while the probability still is (F = 5.27, p = 0.02).[20]

This result is also confirmed if we look at the difference in the number of source indifferent subjects in the four alternative treatments. When p = 5%, while on the first day of the market experiments subjects exhibiting source indifference are respectively 2 and 1, in experiment 3 and 4 they are respectively 13 and 7. When the probability level is 50%, the number of ambiguity neutral subjects in experiment 1 and 2 are respectively 11 and 1, and 8 and 5 in experiment 3 and 4. Looking at these data we notice that (with the exception of experiment 1, p=50%) the proportion of subjects showing no source preference is always higher in the experiments in which no market setting is used. However tables 3a and 3b show that this is not anymore the case when we compare the behaviour on the last market day with the one of the experiment 3 and 4.

Given these results, we have to conclude that evidence of individual deviations from rational behaviour is not necessarily stronger in experiments in which values are elicited in a questionnaire format. Nevertheless, individual WTPs obtained from questionnaires show a higher variability with respect to market values. Finally, one can still question whether the repetition and feedback typical

[20] This result seems to be contra intuitive. However it is simple due to the fact that participants in the market experiment exhibited a higher level of uncertainty reaction on the first market day respect to the participants in experiment 3 and 4 . However they reaction to uncertainty diminished on the last market day so the test was not any more significant

of a market setting may increase the number of ambiguity neutral subjects. Drawing from the results of experiments 1 and 2 we are tempted to conclude that this would be the case.

5.3. Market prices

In this section and in the following one, we present the results of our market experiments looking at the effects of uncertainty on market prices. While in this section we analyse the effect of ambiguity on the single market prices, in the next section we concentrate on the existence of a source preference bias in equilibrium prices.

To this end, when considering each price, we shall identify the presence of ambiguity aversion with a sale price for the ambiguous prospect which is higher than the sale price of the equivalent risky prospect. In this case, the equilibrium market price incorporates a positive "ambiguity premium". Ambiguity neutrality will be defined as identity between the market price under risk and the market price under uncertainty. Ambiguity preference will be revealed by an equilibrium price for a risky liability which is higher than the price for the equivalent ambiguous liability, i.e. a negative ambiguity premium.

Let us start by looking at the sale prices of the liabilities auctioned in each of the sessions of experiments 1 and 2. Table 4a presents the prices for the risky prospect, (R), and the ambiguous prospect, (A), on the first market day, on the last market day, as well as the average price in the eight days of each market. The rows titled C give prices for the complementary prospects.

[Insert table 4a about here]

Let us consider the first three sessions of experiment 1 (1.1-1.3). In these sessions the traded prospects had a reference probability of p = .05 in the case of risk and an expected probability p' = .05 in case of uncertainty. As shown in the table, on the first market day, prices display ambiguity aversion. Aversion to uncertainty is reduced – but still persists – on the last market day.[21] The prevalence of ambiguity aversion at low probabilities of loss is in line with the predictions of several models of individual behaviour under uncertainty, for instance Cumulative Prospect Theory (Tversky and Kahneman, 1992) and "Anchoring and Adjustment" (Einhorn and Hogarth, 1985).[22]

As for the experimental sessions in which liabilities with the complementary reference probability were evaluated, we can see that (see rows corresponding to sessions 1.1C to 1.3C in table 4a) the prices for the liabilities in which p' = .95 display reaction to uncertainty on the first market day (ambiguity aversion in session 1.1C, ambiguity preference in session 1.2C and 1.3C). This reaction to uncertainty disappears along with the market days and on the last market day equilibrium prices do not reveal any reaction to uncertainty. The average premium for uncertainty

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[21] We also calculated ambiguity premiums as the proportional change of sale prices for the ambiguous liability with respect to the risky one. We performed a one-sample t-test of the hypothesis that the mean ambiguity premium was statistically different from zero. We rejected this hypothesis for sessions 1.1 and 1.2 (t = 2.28, p = 0.057; t = 6.34, p = 0 respectively).

[22] These models predict that if a prospect is framed as a loss, individuals' valuations will exhibit ambiguity aversion at low probabilities of loss and preference for ambiguity at high probabilities of loss.

on the eighth market day was in fact zero in the 1.3C and 1.2C sessions and we have a small preference for uncertainty in session 1.1C in the last market day.[23]

[Insert table 4a about here]

When the reference probability of loss is 50% (sessions 1.4-1.6), we find practically no reaction to ambiguity at all: in sessions 1.5. and 1.6. prices for risky and ambiguous prospects not only are the same, but also coincide with the expected value of the loss, thus displaying risk neutrality both on the first and on the last market day. Prices in session 1.4. display a small measure of ambiguity aversion.

In experiment 2 where subjects were not paid according to their earnings in the auction, the pattern of sale prices is slightly different from what is observed in experiment 1. On the first market day there is a large divergence between prices for risky and for ambiguous prospects when the reference probability is 5%; in particular, prices reveal strong ambiguity preference. However, this preference disappears in one session on the last market day and it is strongly reduced in the other two. Moreover, in these sessions we also observe higher risk-aversion with respect to experiment 1.

When p = 95%, prices are higher than the expected value and practically the same values are observed in all market days both under risk and under uncertainty. Subjects in all three relevant sessions (2.1-2.3) behaved as if the loss was certain and hence preferred to bid up to insure rather than play the lottery. In individual decision making settings, this sort of "certainty effect" has been explained by discontinuous probability weighting functions when the reference probability approaches one.

When p = 50% (sessions 2.4-2.6), prices show some ambiguity aversion on the first and last market day but practically no ambiguity reaction in the market for the complementary liability. A small aversion still persists when we consider the average market prices for risk and ambiguity.

Therefore, as far as Experiment 1 and 2 are concerned, the analysis of data on market prices can be summarised as follows:

a) Reaction to ambiguity is stronger when the probability of loss is 0.05. On the last market day the ambiguity premium decreases; this convergence process is clearer in experiment 2.
b) When we consider the complementary bet at the 0.95 probability level, we have a very weak reaction to ambiguity in Experiment 1. In Experiment 2 market prices do not reveal the presence of ambiguity since the very first market day.
c) At the probability level of 0.5, for both complementary bets, market prices reveal a slight positive ambiguity premium in Experiment 2 and no ambiguity premium in Experiment 1.

From this summary we can conclude that – with market experience – the effect of ambiguity on prices decreases whichever level of probability we are considering. We cannot find any remarkable

[23] Preference for ambiguity, i.e. a willingness to pay to insure against an ambiguous loss lower than the willingness to pay for an equivalent risky loss, is a common result when the probability of loss is high. It has been observed by Hogarth and Einhorn (1986, 1990) and Di Mauro and Maffioletti (1996) among others.

difference in market behaviour in the two treatments, except for the higher risk aversion when we use a simple flat payment to reward subjects.

5.4 Source preference bias in prices

The analysis of prices for the first and last market days of experiments 1 and 2 (table 4a) has shown that prices display very little effect of uncertainty and that a convergence process towards risk neutrality values seems to be at work.

In this section, we carry out a more comprehensive analysis of this convergence process by studying whether there exists a source preference bias in prices analogous to the one we analysed for certainty equivalents, and whether this bias disappears with the repetition of the market experience.. For this reason we are going to call this effect "source preference bias in market prices".

To maintain a strict analogy to the analysis carried out for certainty equivalents, and to allow a straightforward comparison with the sum of certainty equivalents reported in table 2, we do not define a source preference price bias as the difference between the sum of prices of complementary assets under uncertainty and under risk. Instead, we build some sort of "market sum of certainty equivalents" calculated as (£200 – SUM(P_R)) for risk and (£200 – SUM(P_A)) for uncertainty, and compute the difference between the two. If market repetition and feedback brings about some form of learning of the rational behaviour, the price bias should disappear as the number of market periods increases.

In an experimental market in which two complementary lotteries (such as A and C) are simultaneously traded, owning both assets gives a sure payoff. Arbitrage should, therefore, make the sum of prices for the two lotteries equal to that payoff, irrespective of the trader's risk attitude. However, Rietz (1999) and Weber, Keppe and Meyer-Delius (1999) find that this is not so even in a double auction market, and that the sum of prices for complementary lotteries is higher than the sure payoff, a result called over-pricing. Also, Weber, Keppe and Meyer-Delius find that the degree of over-pricing is amplified when a negative frame is used. In our experiment, no arbitrage is possible as lotteries are sold independently; nevertheless, we think it is still interesting to look at the sum of prices for complementary lotteries to test whether the degree of over/under pricing with respect to the aggregate payoff is affected by uncertainty.

Table 4B shows the values thus calculated for the first, the last, and the average of market days. When looking at the table, we have to keep into mind that each cell has been calculated as (200 - price – price complementary bet) and that, consequently, if the sum for market prices for complementary bets under ambiguity is bigger than under risk then we have a source preference towards risk.

When we look at the sum of sale prices in experiment 1 with complementary bets at the 0.05 and 0.95 probability levels, we can see that we have no source preference on the last market day and very little on average. Source preference is slightly higher when we consider the 0.5 probability level and this is so irrespective of the market day.

In the second market experiment, however, source preference is more evident, and over-pricing is present both under risk and under uncertainty. Market experience reduces the degree of source preference in those sessions in which the reference probabilities are 0.05 and 0.95. As far the 0.50 probability is concerned, we find that some source preference for uncertainty persists on the last market day. Finally, with respect to experiment 1, there is clearly a higher variability in the pattern of prices across auction sessions.

In order to formally test the hypothesis that the price bias disappears with market experience, we follow Camerer (1987) and consider – for each of the 12 market sessions, the time series of price biases in the eight market days. Since prices in various market periods tend to be autocorrelated, we estimate the long run price bias from a simple first order autoregressive model:

$$[SUM(P_A) - SUM(P_R)]_t = \alpha + \beta[SUM(P_A) - SUM(P_R)]_{t-1} + \varepsilon_t$$

where $SUM(P_A) - SUM(P_R)$ is the price bias. The above formulation entails that the equilibrium bias can be measured as $\mathbf{b} = \alpha'/(1-\beta')$ where α' and β' are OLS estimators of α and β.

The calculation of the standard error of **b** must, however, be obtained from a Taylor series approximation using the variances of α' and β' and their covariances.[24]

Results of the estimates are presented in table 5. Unless otherwise stated, estimates reported are OLS and errors are uncorrelated and homoschedastic.[25] The t test reported is a test that the long term price bias is zero. This t is simply calculated by dividing the estimate of **b** by its approximated standard error. In four out of twelve sessions, however, results cannot be considered reliable, as standardised residuals exceeded the hypothesis of normality at the 5% level.

Looking at table 5, we see that the price bias is significantly different from zero in nearly all the experimental sessions. The fact that the long term bias is significantly different from zero suggests that markets do not eliminate violations of source preference completely. Biases also tend to be negative in most experimental conditions (in 8 sessions out of 12): thus source preference for uncertainty (ambiguity proneness) is the market long-run attitude.

However, it must also be observed that the value of biases is small.[26] The price bias in our experiment is even smaller in the experiments in which auction participants were rewarded according to performance (sessions 1.1-1.6). Thus, the ability of markets to induce a more rational

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[24] See Camerer (1987), p.987. The variance of b is approximated by $V(b) = V(\alpha)/(1-\beta)^2 + \alpha^2 V(\beta)/(1-\beta)^4 + +2\alpha Cov(\alpha,\beta)/(1-\beta)^3$ evaluated at α' and β'.

[25] Where first-order serial correlation was detected, the equation was re-estimated using GLS.

[26] This result parallels that of Camerer (1987) with reference to learning of the Bayesian posterior.

behaviour actually seems to be tied not only to the repetition of the market experience but rather to the financial incentives of the market.

6. Discussion of results and relation with previous studies

The results concerning market prices do not differ substantially from those obtained comparing the sum of the certainty equivalents over complementary bets. Both analyses allow us to conclude that market feedback and learning – especially in experiment 1 - induce a change in subjects' behaviour, reducing reaction to ambiguity. Source preference tends to disappear and the difference between ambiguous and risky prices decreases. The analysis of the long run source bias which we have applied to prices has shown that the bias remains significant, although its magnitude is small.

Moreover, even in experiments 3 and 4 on average there is a very slight ambiguity reaction and a substantial number of subjects is ambiguity neutral. Therefore, we can conclude that incentive compatible mechanisms are not necessary to achieve a low rate of violations of the rational model of behaviour. In other words, the "economist's prejudice" that markets do predict rational models of behaviour better is not supported by our data.

The issue whether markets induce a better performance of Expected Utility (EU) or Subjective Expected Utility has been addressed by few other studies. For example, Evans (1997) argues that the superiority of markets over individual behaviour may be due to a statistical artifact, i.e. the fifth-price rule used in her experiment. This author also casts doubts over the good performance of EU with other pricing rules.[27] In our experiment the price is set by the second highest bid; nevertheless prices for risky and ambiguous prospects tend to converge. Also certainty equivalents are affected by the repetition of the auction, showing that repetition tends to change individual preferences. Cox and Grether (1996) suggest that "..the repetitive nature of the task in market experiments in conjunction with feedback" (page 401) can be a crucial factor in reducing violations of EU. In their experiment, the observed violations of EU in markets falls irrespective of the payment schedule (fixed payment or payment according to performance).

In our experiments, a weak amount of violation of Subjective Expected Utility was performed by the group with individual pricing task and no financial incentive. Therefore, we can conclude that markets tend to reduce violations of Subjective Expected Utility, but they do not necessarily perform better. In another experiment in which behaviour revealed by a questionnaire is directly compared with market behaviour, Myagkov and Plott (1997) find "strong consistency between answers to the questionnarie and experimental market behaviour (p.816)".

It is possible that market institutions and incentives play different roles according to the decision task performed in the experiments. In an experiment on the role of financial incentives on individual choice/judgement experiments, Beattie and Loomes (1997) reach the conclusion that, "incentives make no significant difference" (p.166) when simple choices are involved. In our experiments, indeed, subjects were asked to perform quite a simple task.

[27] Smith and Walker (1993) show that financial incentives and market-like-settings reduce "noise" or reduce violations without eliminating them completely.

The impact of market–like settings and financial incentives may also differ according to the context used in the experiment. In an experiment on the insurance market, for instance, Camerer and Kunreuther (1989) find no impact of ambiguity on prices. Our results too suggest that, in a loss frame, reaction to ambiguity is weak. Markets institutions reduce reaction to uncertainty, but the initial degree of bias is relatively small.

When prospects evaluated involve gains instead of losses, reaction to uncertainty is usually stronger. Fox, Rogers and Tversky (1996) find that option traders exhibit subadditive decision weights under uncertainty but not under risk. Evidence of the presence of reaction to uncertainty is found in a study by Sarin and Weber (1993) who use a market setting. Their data show that asset prices display ambiguity aversion at the 50% probability level, and convergence to ambiguity neutrality at a probability level of 5%. Evidence of reaction to uncertainty is obtained regardless of the different incentive systems used in the two studies.[28]

The above analysis seems to reinforce the conclusion that the influence of market incentives might strongly depend on the tasks that individual are asked to perform in the experiment.

Conclusions

We have presented an experimental study which has investigated individual bids and prices in a market for a potential liability characterised either by known or ambiguous probability of loss. We have compared bidding behaviour and prices in a market-like setting with valuations obtained from individual judgement. In the market experiment, the institution used was an English auction. In one treatment subjects were rewarded according to their performance in the auction, while in another subjects received a flat payment. In the individual judgement experiment, subjects performed a pricing task; they had to state their willingness to pay to sell the same prospects valued in the auction.

We find that prices for the ambiguous prospects tend to converge to those for risky prospects. The analysis of the sum of certainty equivalents shows that the reduction in the source preference effect is at work also for individual values. On the last market day of the auction, the sums of certainty equivalents under risk and under uncertainty get closer, although the convergence effect is stronger for prices.

These results may be interpreted by saying that market forces tend to reduce the impact of uncertainty on trade prices and to change individual preferences. However, we find that there is strong similarity between the data obtained in market experiments and the data obtained from the answers to simple questionnaires without incentive compatible mechanisms. Hence, we cannot conclude that SEU performs better in markets, although the market reduces deviations from the rational model.

Acknowledgements

[28] Sarin and Weber (1993) adopted a double oral auction and a third price sealed bid auction, while Fox, Rogers and Tversky (1996) used the Marshak device.

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APPENDIX

INSTRUCTIONS OF EXPERIMENT 1

(Probability levels 0,05 and 0,95)

You are about to participate in an experiment about decision making under risk and uncertainty. The purpose of the experiment is to gain insight into certain features of economic behaviour. If you follow the instructions carefully you can earn a considerable amount of money. You will be paid in cash at the end of the experiment. The mechanism according to which you will be paid is explained below.

During the experiment you are not allowed to communicate with the other participants. Communication between participants will lead to an automatic end of the session.

This is a market experiment. You will participate in 4 markets plus 2 practice markets. The practice markets will consist of 2 market periods. Each real market will be composed of 8 market periods. At the beginning of each market period you will receive a cash endowment of £100 and one potential liability. This liability lives only one period and cannot be carried over to subsequent market periods. It involves either a potential loss of £100 or £0 with some probability. The cash endowment is meant to allow you to sell the potential liability if you want to.

Try to think of each liability and of each market as of a real situation.

For each liability you will be asked to state the maximum amount you are willing to pay in order to get rid of the potential liability.
For each liability and in each market period, you will indicate your maximum willingness to pay through the following auction mechanism.

An auctioneer will shout an ascending price for the liability on the market. The auctioneer will start with the lowest price of £0 and will increase the price till £100. You will indicate your willingness to pay (i.e. the price at which you no longer want to be in the auction) by raising a hand and shouting your subject number and shouting the price out (i.e. subject no.1 out at £45).
Your best course of action is to go out when the price reaches the most that you are willing to pay; that is, when you want to leave the auction. The experimenter will record on a transparency sheet your maximum willingness to pay.

A market period ends when only one participant is left in the auction. The last participant left in the auction will acquire the right to sell the potential liability and he or she will pay a price equal to the price at which the last person dropped out of the auction.

At the end of each market period, the winner of the auction will receive **1% of his total earnings** as profits**.** Earnings for the winner are given by the initial cash endowment, £100, minus the price at which the last person dropped out of the auction.
For example, if you are the winner of the auction and the maximum willingness to pay of the last person who dropped out of the auction was £45, your earnings are £(100 – 45) = £55. Your profit is 1% of £55, i.e. 55 pence.

The other participants keep their own liability. The liability, however, expires at the end of the market period and its value (i.e. either -£100 or £0) is thus resolved at the end of each period for each market. Subjects will be paid accordingly.
For example assume that your potential liability involves a probability of 10% of losing £100 and a probability of 90% of not losing anything. You will be presented with a bag containing 20 numbered balls with numbers going from 1 to 20. Each ball carries a different number, so that each number from 1 to 20 appears only once. If you draw a ball that carries number 1 or number 2 you will lose £100, otherwise nothing will happen. If a ball that carries number 1 or 2 is drawn you will have to pay £100 (which

corresponds to your endowment), so you will end up with zero earnings. If a ball that carries any number but number 1 or 2 is drawn you will not lose anything, so you will get 1% of your initial endowment for that market period, that is to say £1.

[In the experiment with complementary probability at 0,5 the instruction differ in the following section:

For example assume that your potential liability involves a probability of 90% of losing £100 and a probability of 10% of not losing anything. You will be presented with a bag containing 20 balls, 2 of which are black and 18 are white. If you draw a white ball you will lose £100, otherwise nothing will happen. If a white ball is drawn you will have to pay £100 (which corresponds to your endowment), so you will end up with zero earnings. If a black ball is drawn you will not lose anything, so you will get 1% of your initial endowment for that market period, that to say £1.]

The experiment is organised as follows:

Step 1
At the beginning of the experiment, the experimenter will explain the auction procedure. Two practice markets each made up of two periods will take place. These practice markets take place in order to help you become familiar with the problem, the auction procedure, and the payment procedure.

Step 2
You will be given the first potential liability and the corresponding cash endowment. You will be allowed a few minutes to think about what you are willing to pay to get rid of it.

Step 3
The auction for the first scenario will take place. You will be asked to raise your hand and shout your number and the price at which you are leaving the auction. This price should correspond to your maximum willingness to pay in order to get rid of the potential liability.

Step 4
At the end of the each period the winner of the auction will acquire the right to sell the potential liability. He or she will be paid accordingly.

Step 5
The potential liability is played out for real and uncertainty is resolved. All the subjects are paid accordingly.

Step 6
Another market period starts. The above procedure is repeated.

Step 7
After 8 periods the first market trade is terminated.

Step 8
A new market trade starts. You will be given a different liability to trade and a new cash endowment.

You will participate in 4 markets of 8 periods each plus two practice markets of two periods each.
The trade mechanism as well as the payment procedures followed are the same for each market. The liability traded will differ from market to market.

The mechanism whereby the uncertainty will be resolved for the different liabilities will be explained in greater detail at the end of the practice markets periods. Please note that you will be free to check whether the stated probability corresponds to the combination of balls inside the opaque bag.

INSTRUCTIONS Experment 3 and 4

You are about to participate in an experiment about decision making under risk and uncertainty. The purpose of the experiment is to gain insight into certain features of economic behaviour. At the end of the experiment you will receive 5000 lire as participation fee. The experimental session will last 10 minutes and you will be asked to answer four questions.

During the experiment you are not allowed to communicate with the other participants.
During the experiment try to consider the decision problem as real life situations.

In this experiment you will be asked to evaluate four assets. Each asset (potential liability) involves either a potential loss of £100 or £0 with some probability. The potential loss depends on whether some specific event described in the asset occurs or does not occurs.

For each potential liability, you are endowed with an initial amount of 100 pounds: each time you have to make the decision whether to keep your potential liability or to get rid of it. If you decide to keep your liability you run the risk of loosing 100 pounds. If you get rid of your potential liability you will not loose anything whichever event will occur.

For each liability you will be asked to state the maximum amount you are willing to pay in order to get rid of the potential liability.

Look carefully at the scenarios and try to think of each liability as a real situation.

When you finished to fill in your questionnaire , please give it back to the experimenter and you will receive immediately 5000 lire in cash as participation fee. Take care that the experimenter will put a number on each questionnaire (This last sentence was just for experiment 4)

Thank a lot for you participation

Instructions given to students in experiment 1 and 2 to explain the best strategy in auction

PLEASE READ CAREFULLY!!

WHAT IS YOUR BEST COURSE OF
ACTION IN THE AUCTION?

In the auction your best course of action is to drop out when the price reaches the most that you are willing to pay, i.e. when the price announced by the auctioneer corresponds to the maximum value you assign to selling the potential liability.

We try to explain briefly why bidding your value is your best strategy.

Assume that the maximum value you assign to selling the potential liability is £50.

If you bid less that £50, you cannot increase your earnings, since the price you pay is determined by the bid at which the last person dropped out of the auction. Rather, a bid below £50 would simply lower your chances of winning the auction, without changing the price paid in the event of a win.

I you bid higher than £50, you will raise the probability of winning the auction, but in the case you win, you would regret purchasing at the bid price that exceeded your value.
Consider this example. Suppose you are the last person left in the auction and the last player who dropped out placed a bid higher than £50, say £60. Then you would win the auction and you would pay a price (£60) which is £10 higher than what you valued the sale of the liability.

DESCRIPTION OF PROSPECTS EVALUATED IN THE EXPERIMENT

Prospects at probability level 0.05 and 0.95

Market 1
You are endowed with the following potential liability:

Liability A yields a loss of £100 if a ball drawn from bag A carries number 1 on it, otherwise you will not lose anything. Bag A contains 20 numbered balls with numbers going from 1 to 20. Each ball carries a different number, so that each of the numbers from 1 to 20 appears only once.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 2
You are endowed with the following potential liability:

Liability B yields a loss of £100 if a ball drawn from bag B carries number 1 on it, otherwise you will not lose anything. Bag B contains 20 numbered balls with numbers going from 1 to 20. However, there is an unknown number of balls bearing any single number.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 3
Liability C yields a loss of £100 if a ball drawn from bag A carries any number but number 1 on it, otherwise you will not lose anything. Bag A contains 20 numbered balls with numbers going from 1 to 20. Each ball carries a different number, so that each of the numbers from 1 to 20 appears only once.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 4
You are endowed with the following potential liability:

Liability D yields a loss of £100 if a ball drawn from bag B carries any number but number 1 on it, otherwise you will not lose anything. Bag B contains 20 numbered balls with numbers going from 1 to 20. However, there is an unknown number of balls bearing any single number.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Prospects at probability level 0.5

Market 1

You are endowed with the following potential liability:

Liability L2A yields a loss of £100 if a white ball is drawn from bag C, otherwise you will not lose anything. Bag C contains 20 white and black balls: 10 balls are white and 10 balls are black.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 2

You are endowed with the following potential liability:

Liability L2B yields a loss of £100 if a white ball is drawn from bag D, otherwise you will not lose anything. Bag D contains a total of 20 balls, but you do not know how many of these are black or how many are white.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 3

You are endowed with the following potential liability:

LiabilityL2C yields a loss of £100 if a black ball is drawn from bag C, otherwise you will not lose anything. Bag C contains 20 white and black balls: 10 balls are white and 10 balls are black.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Market 4

You are endowed with the following potential liability:

Liability L2D yields a loss of £100 if a black ball is drawn from bag D, otherwise you will not lose anything. Bag D contains a total of 20 balls, but you do not know how many of these are black or how many are white.

You are asked to state which is the maximum amount of money you are willing to pay to sell this potential liability.

Table 1A – Summary of market experiments

Experimental session	Sequence of trade	Reference probability	Number of subjects
Experiment 1 – Second-price auction with payment according to performance			
Session 1.1	R,A,CR,CA	.05	8
Session 1.2	A,R,CA,CR	.05	8
Session 1.3	CR,CA,R,A	.05	8
Session 1.4	R,A,CR,CA	.5	8
Session 1.5	A,R,CA,CR	.5	8
Session 1.6	CR,CA,R,A	.5	6
Experiment 2 – Second-price auction with flat payment			
Session 2.1	R,A,CR,CA	.05	8
Session 2.2	A,R,CA,CR	.05	8
Session 2.3	CR,CA,R,A	.05	8
Session 2.4	R,A,CR,CA	.5	8
Session 2.5	A,R,CA,CR	.5	8
Session 2.6	CR,CA,R,A	.5	6

Table 1B - Incentive schemes adopted in the experiments

Experiments	**Market institution**	**Kind of Payment**
York-Experiment 1	English Auction	According to performance
Italy-Experiment 2	English Auction	Flat participation fee
Hull-Experiment 3	Absent	Absent
Italy-Experiment 4	**Absent**	**Flat participation fee**

Table 2A – Certainty equivalents for complementary lotteries in market experiments **(Means, Medians in italics, and St.dev. in parenthesis)**

Type of prospect	Sum (CE_R)		Sum (CE_A)	
EXPERIMENT 1				
	Day 1	**Day 8**	**Day 1**	**Day 8**
P = 50% (sample size 22)	108.05 *107.5* (11.42)	108.73 *102* (28.29)	113.64 *110* (23.06)	113.68 *110* (17.09)
P = 5% (sample size 24)	120.17 *113* (23)	116.71 *104.5* (30.51)	142.08 *134.5* (37.26)	114.46 *101* (28)
EXPERIMENT 2				
	Day 1	**Day 8**	**Day 1**	**Day 8**
P = 50% (sample size 22)	123.91 *129.5* (29.79)	108.05 *100* (28.80)	101.41 *98.5* (26.42)	92.68 *89* (26.38)
P = 5% (sample size 24)	87.17 *81.5* (47.81)	93.33 *94.5* (7.42)	92.04 *95.5* (21.42)	95.71 *98.5* (10.48)

Table 2B– Certainty equivalents for complementary lotteries
(Means, Medians in italics, and St.dev. in parenthesis)

Experiment 3		
P=50%	CER	CEA
Mean	113	101.6
Median	100	100
St.Dev.	(25.03)	(48.77)
N. 30		
P=5%		
Mean	132	136
Median	106	132
St.Dev.	(41.4)	(39.36)
N.28		
Experiment 4		
P=50%	CER	CEA
Mean	148	117
Median	160	100
St.Dev.	(44.49)	(53.83)
N. 25		
P=5%		
Mean	151	147
Median	180	150
St.Dev.	(54.80)	(53.01)
N.25		

Table 3a - Individual attitudes towards uncertainty (Market experiments)

Experiment 1					
Market Day	DAY 1		DAY 8		
Probability level	**5%-95%**				
	Source preference attitude	Number of subjects	Source preference attitude	Number of subjects	Total number of subjects
AU Payment according to performance	AA	5	AA	7	24
	AN	2	AN	11	
	AP	17	AP	6	
Probability level	**50%**				
	AA	4	AA	3	22
	AN	11	AN	7	
	AP	7	AP	12	
Experiment 2					
Market Day	DAY 1		DAY 8		
Probability level	**5%-95%**				
AU Flat Payment	Source preference attitude	Number of subjects	Source preference attitude	Number of subjects	Total number of subjects
	AA	8	AA	5	24
	AN	1	AN	11	
	AP	15	AP	8	
Probability level	**50%**				
	AA	16	AA	13	22
	AN	1	AN	5	
	AP	5	AP	4	

Table 3b - Individual attitudes towards uncertainty (questionnaire experiments)

Experiment 3				
Probability Level				
	5%-95%		**50%**	
No AU No Payment	Source preference attitude	Number of subjects	Source preference attitude	Number of subjects
	AA	6	AA	14
	AN	13	AN	8
	AP	9	AP	9
Total subjects	28		31	
Experiment 4				
Probability level				
	5%-95%		**50%**	
No AU Flat Payment	Source preference attitude	Number of subjects	Source preference attitude	Number of subjects
	AA	9	AA	15
	AN	7	AN	5
	AP	9	AP	5
Total subjects	25		25	

Table 4A – Market prices in experiments 1 and 2

EXPERIMENT 1						
Session	**$R_{1\ day}$**	**$R_{8\ day}$**	**$A_{1\ day}$**	**$A_{8\ day}$**	**$R_{average}$**	**$A_{average}$**
1.1 (5%)	2	*7*	9	*10*	4.88	7
1.2 (5%)	6	*8*	12	*14*	7.63	13
1.3 (5%)	1	*3*	5	*5*	4.25	4.25
1.1C (95%)	86	*98*	96	*94*	96.25	95.88
1.2C (95%)	95	*95*	85	*96*	96.25	93.88
1.3C (95%)	95	*98*	90	*98*	97.50	96.38
1.4 (50%)	55	*52*	62	*55*	55.75	57.25
1.5 (50%)	50	*49*	49	*49*	49.50	47.13
1.6 (50%)	50	*50*	50	*50*	51.88	50.75
1.4C	50	*60*	55	*50*	55.25	52.12
1.5C	49	*49*	50	*50*	49.13	47.88
1.6C	55	*50*	50	*55*	59.13	56.75
EXPERIMENT 2						
	$R_{1\ day}$	**$R_{8\ day}$**	**$A_{1\ day}$**	**$A_{8\ day}$**	**$R_{average}$**	**$A_{average}$**
2.1 (5%)	70	*18*	14	*11*	28.64	14.63
2.2 (5%)	30	*12*	10	*5*	13.50	6.13
2.3 (5%)	96	*20*	45	*22*	42.88	31.50
2.1C (95%)	98	*99*	99	*99*	98.87	99
2.2C (95%)	99	*99*	98	*99*	98.87	98.87
2.3C (95%)	99	*99*	99	*99*	99	99
2.4	41	*55*	51	*55*	52.75	56.63
2.5	65	*70*	72	*75*	68.5	72.88
2.6	44	*65*	62	*70*	55.9	65.25
2.4C	48	*51*	52	*70*	54	57.88
2.5C	69	*66*	65	*68*	63.75	67.13
2.6C	50	*50*	52	*60*	53.13	58

Table 4B - Sum of market prices for complementary lotteries

Session	First day price		Last day price		Average all days	
EXPERIMENT 1						
	$R_{I\ day}$	$A_{I\ day}$	$R_{8\ day}$	$A_{8\ day}$	$R_{average}$	$A_{average}$
1.1 (5%)	112	95	95	96	100	98
1.2 (5%)	99	103	97	90	97	94
1.3 (5%)	104	105	99	97	99	99
1.4 (50%)	95	83	88	95	94	93
1.5 (50%)	101	101	102	101	102	104
1.6 (50%)	95	100	100	95	92	94
EXPERIMENT 2						
	$R_{I\ day}$	$A_{I\ day}$	$R_{8\ day}$	$A_{8\ day}$	$R_{average}$	$A_{average}$
2.1 (5%)	32	87	83	90	74	87
2.2 (5%)	72	92	89	96	89	96
2.3 (5%)	5	56	81	79	59	70
2.4 (50%)	111	97	94	75	94	87
2.5 (50%)	66	63	64	57	69	61
2.6 (50%)	106	86	85	70	92	77

Table 5 – Estimates of bias in buying prices

Experimental Session	Reference Probability	Bias (¨ denotes GLS estimates)	Standard error	t-statistic
1.1 (8)	5%	- 0.0448	.772	- 0.058*
1.2 (8)	5%	4.016	1.075	3.736
1.3 (8)	5%	- 1.141	0.912	-1.252
1.4 (8)	50%	- 3.006 ¨	1.401	- 2.146
1.5 (8)	50%	- 4.145	1.936	- 2.14*
1.6 (8)	50%	- 5.205 ¨	6.71	- 0.775*
2.1 (8)	5%	- 3.81	1.919	- 1.99
2.2 (8)	5%	5.46	0.739	7.389
2.3 (8)	5%	6.31 ¨	2.242	2.814
2.4 (8)	50%	- 6.862	3.37	- 2.036
2.5 (8)	50%	8.52	1.26	6.757
2.6 (8)	50%	- 13.419	2.55	- 5.26*

* Asterisk denotes standardized residuals greater than ± 2 standard errors.

Table 4 (old) – Average Ambiguity Premium in prices $(P_a – P_r)/P_r$
(t-value shown in parenthesis when null hypothesis of zero mean premium is rejected at p ≤ .05)

Session 1.1 - 5%	1.01 (t = 2.28, p = .057)
Session 1.2 - 5%	.76 (t = 6.34, p = 0).
Session 1.3 - 5%	.48
Session 1.1C - 95%	0
Session 1.2C - 95%	- .01
Session 1.3C - 95%	- .02
Session 1.4 - 50%	.03
Session 1.5 - 50%	- .05
Session 1.6 - 50%	-.02
Session 1.4C - 50%	- .05
Session 1.5C - 50%	- .03
Session 1.6C - 50%	- .04
Session 2.1 - 5%	.27
Session 2.2 - 5%	- .51 (t = - 9.61, p = 0)
Session 2.3 - 5%	-.13
Session 2.1C - 95%	0.0
Session 2.2C - 95%	0.0
Session 2.3C - 95%	0.0
Session 2.4 - 50%	.08
Session 2.5 - 50%	.06 (t=3.28, p = .01)
Session 2.6 - 50%	.18 (t=3.99, p = .05)
Session 2.4C - 50%	.08
Session 2.5C - 50%	.05 (t=2.86, p=.02)
Session 2.6C - 50%	.10 (t=3.02, p=.02)

Figure 1.A

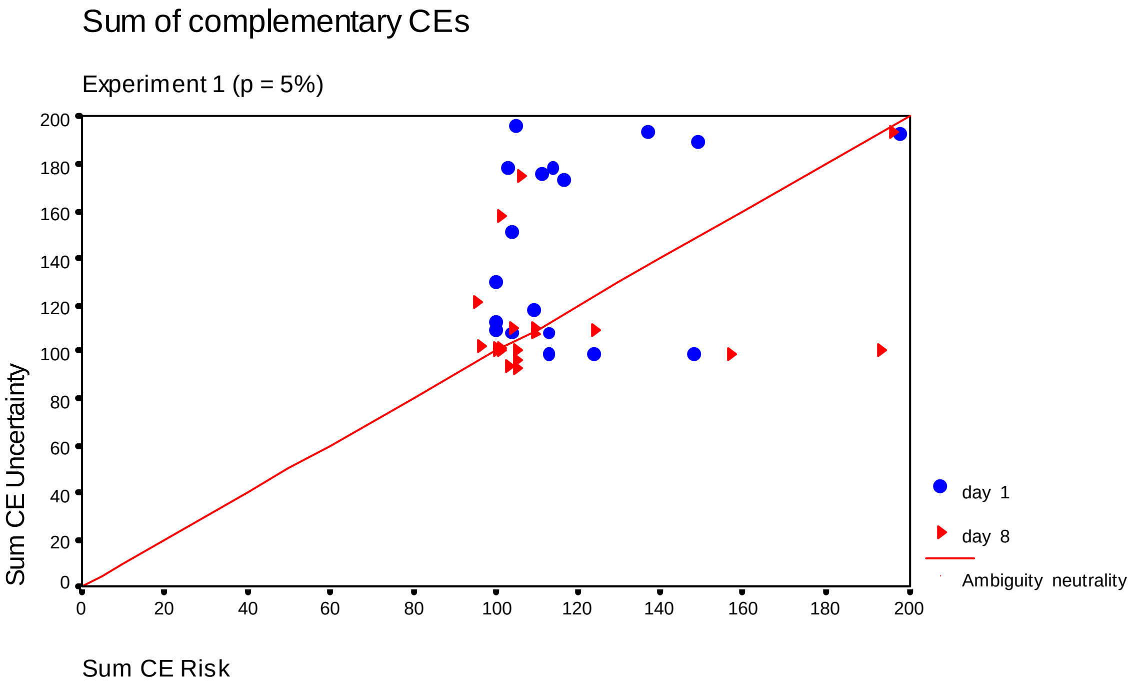


Figure 1.B

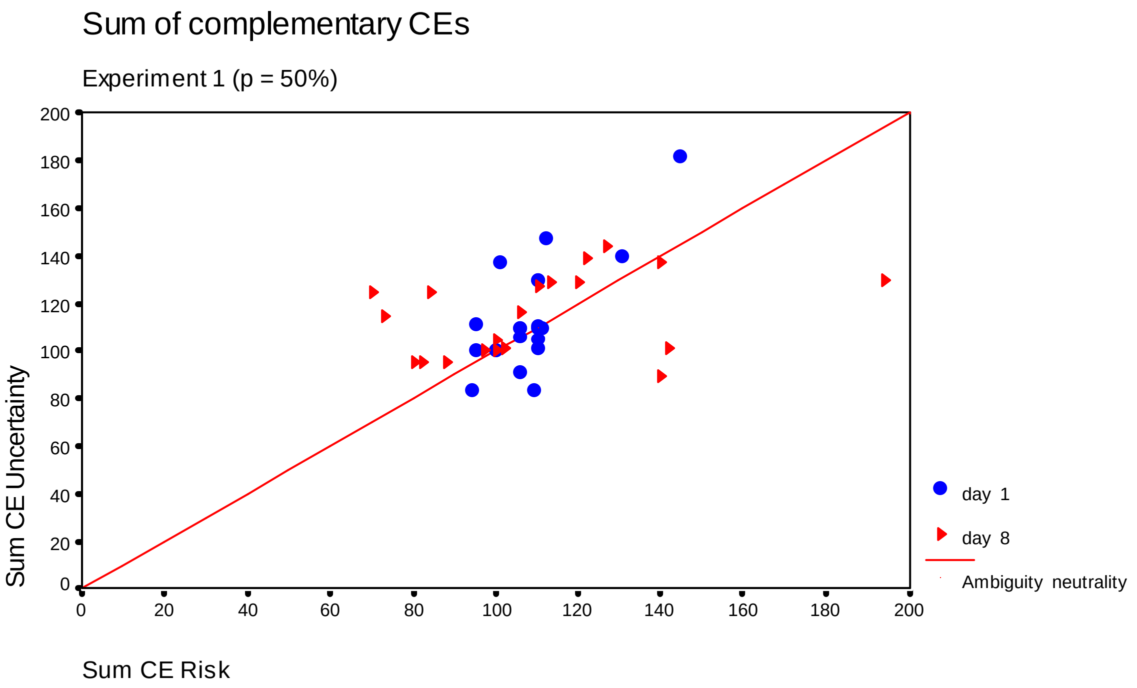


Figure 2.A

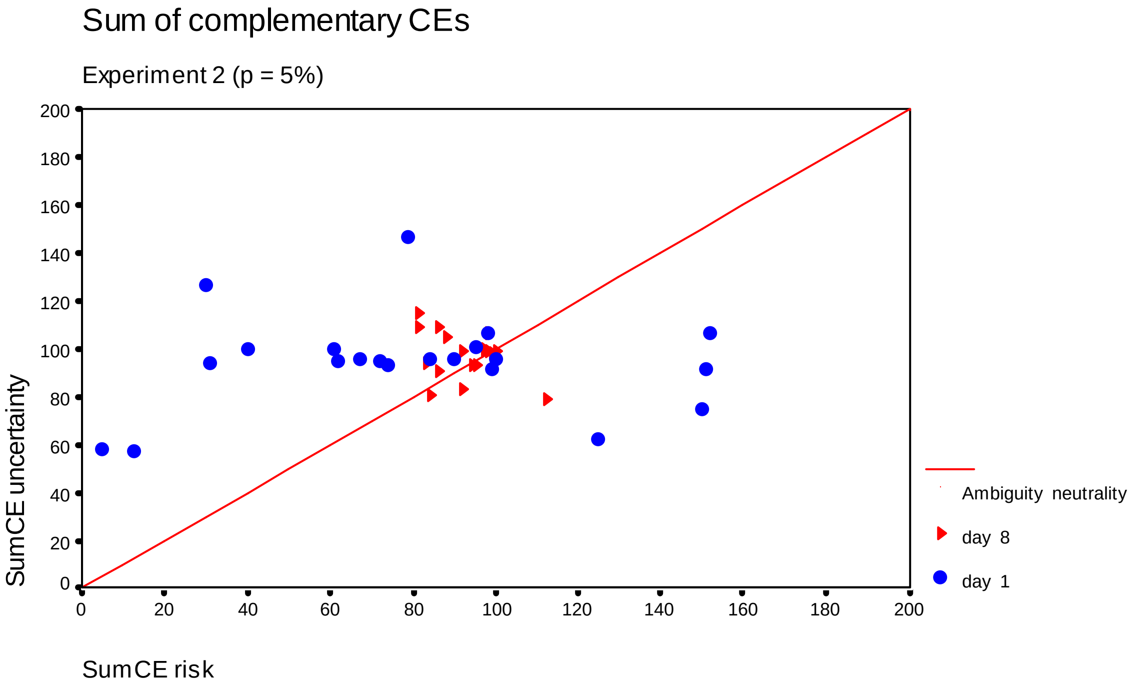


Figure 2.B

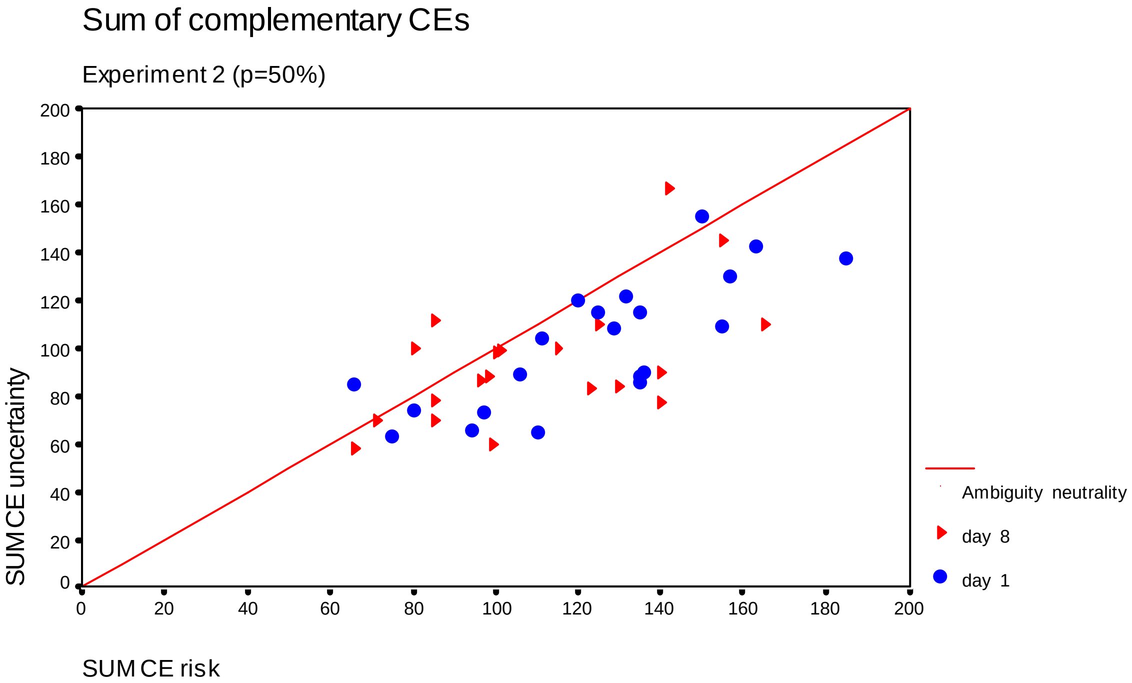


Figure 3.A

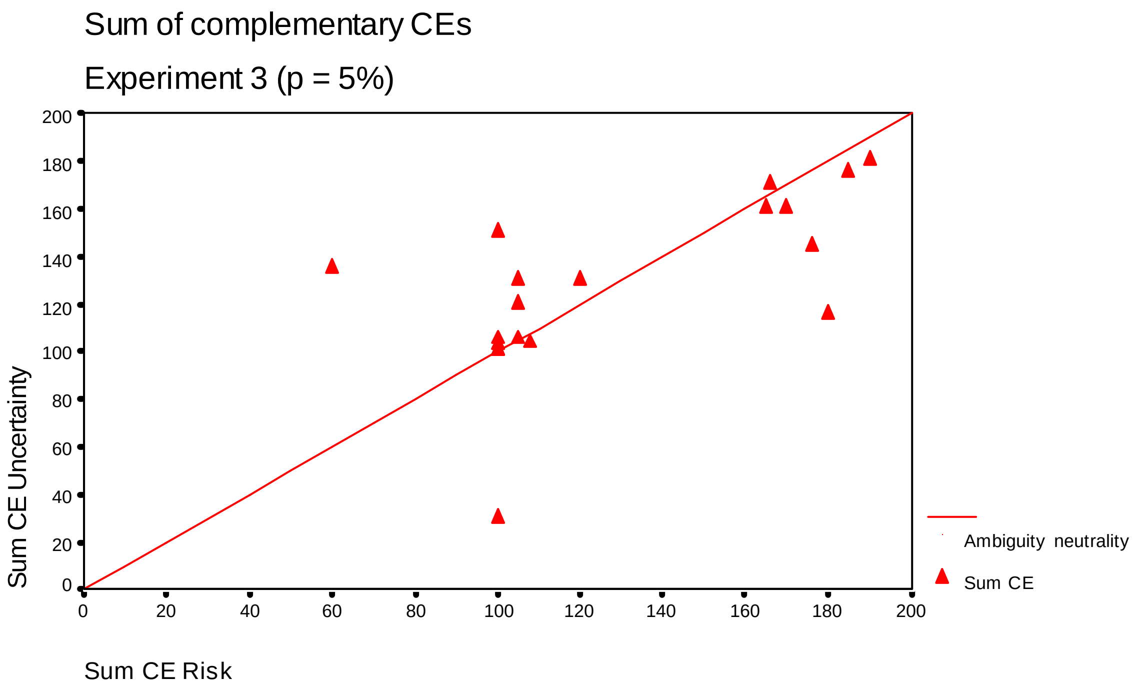


Figure 3.B

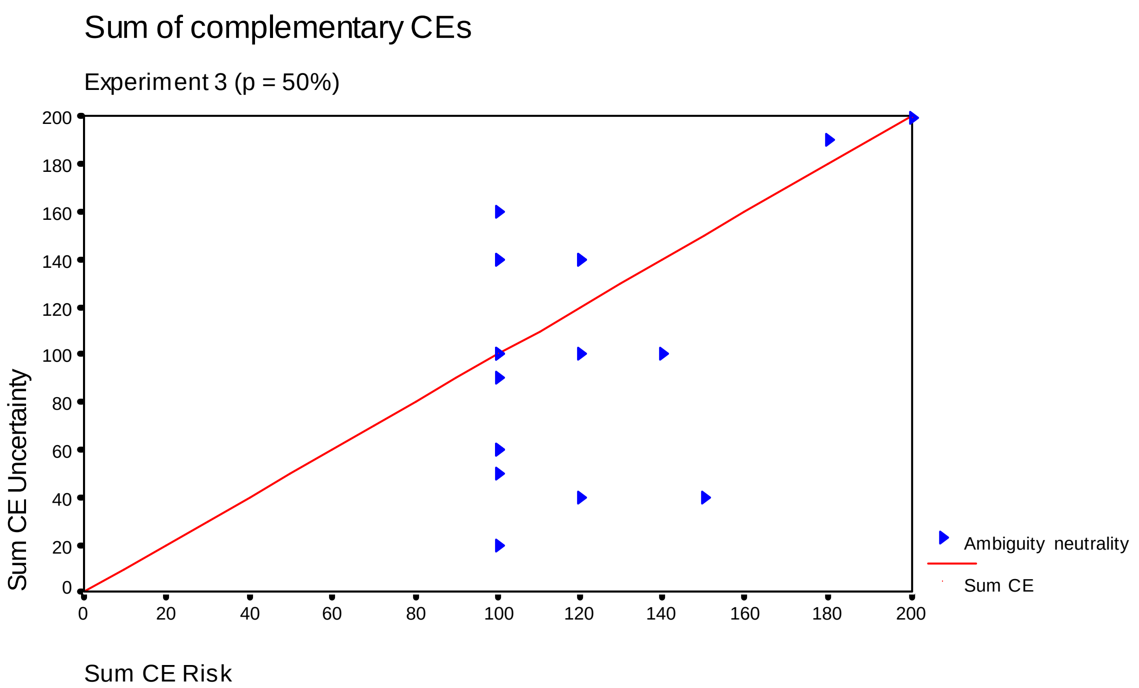


Figure 4A

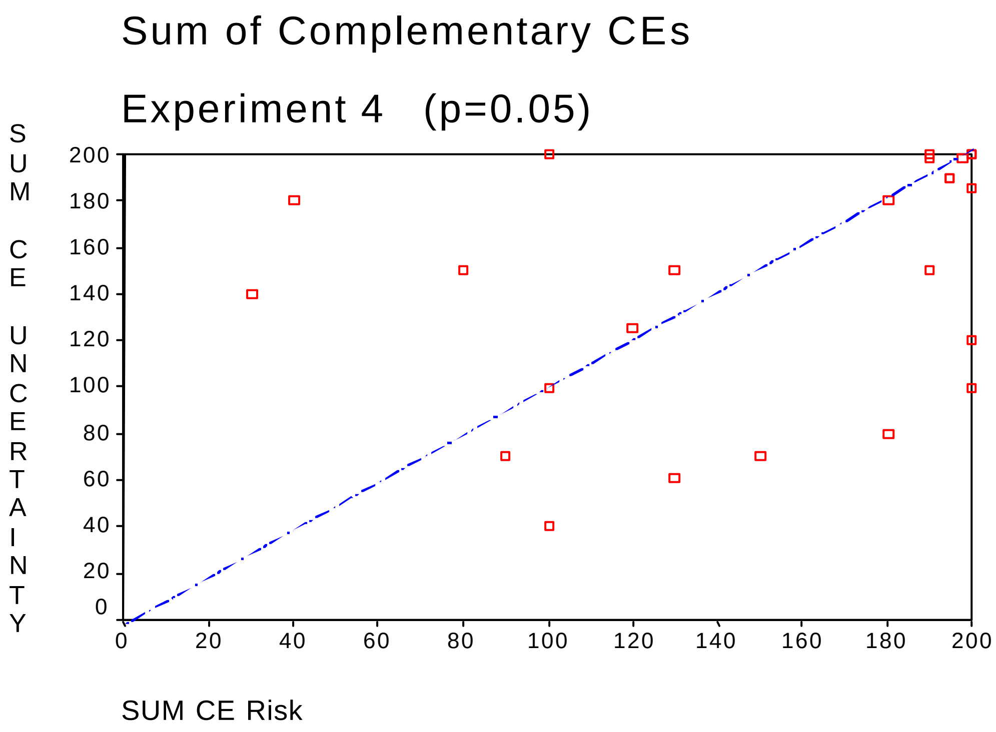
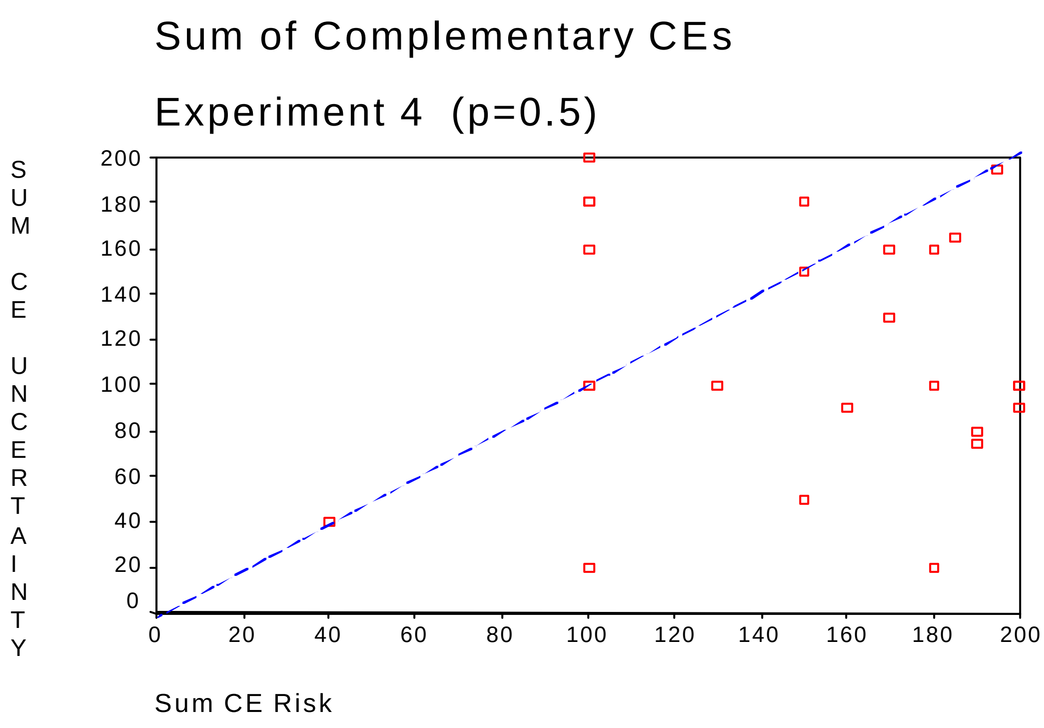


Figure 4B



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