EXPERIMENT INSTRUCTIONS

Objective

Rational expectations theory supports the hypothesis that information aggregation is possible through markets, and provides a scientific framework for interpreting the equilibria in these markets. The motivation of this experiment is to evaluate whether rational expectations theory accurately predicts equilibrium prices of binary contracts[1] in a controlled laboratory experiment.

System Requirements

A web browser with Java 1.5 or newer version installed. If you do not have Java installed, direct your browser to:

http://www.java.com/en/download/manual.jsp

Download the file most appropriate for your operating system. *Also, I think the software works best with Internet Explorer.*

Software/Platform

JMarkets version 1.5 is the software you will be using for this experiment. It has been deployed onto an online remote server. The web address is:

www.binarycontracts.com/jMarkets15

User Signup and Login

The first step (after verifying that you have Java 1.5 or a newer version installed) is to go to the above website and signup. From the Main Menu select the option that says "Subject Signup" and fill in the open fields labeled: Email, First Name, Last Name, Phone Number, and Choose a Password for Use in the Experiment. Then click Submit to continue. At this stage you have registered to participate in the experiment.

On the day of the experiment you will direct your browser to the same page, but this time since you have already signed up click on the link that says If You Have Already Signed Up, Click Here to Participate. Enter your Email address and Password. Upon validating your identity, a Java Applet Window should appear titled JMarkets Session Selector. Click on the session tab (there will be just one open session). When asked to join, click Yes. **You will also see a blank white Internet Explorer window. Do not close this window!** As soon as everyone has joined I will Start the Experiment from my experimenter panel.

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[1] The assets traded in information markets are binary contracts. These are Arrow-Debreu securities that pay the holder of the contract $1 if the event specified by the contract occurs and $0 otherwise.

Experiment Overview

The experiment features an information market for two complimentary Arrow securities, namely Heads and Tails. The event is whether a fictitious biased coin lands heads or tails. **The probability that the coin lands heads, θ, is drawn randomly from a uniform distribution over the open unit interval, (0,1).** As soon as I start the experiment each individual is endowed with 100 units of currency and a private signal. The private signal, s^i, consists of t_i private observations of the true coin toss process, where t_i is randomly drawn from the discrete distribution shown below.

t_i	Probability
3	2/36
4	3/36
5	4/36
6	4/36
7	6/36
8	5/36
9	4/36
10	2/36
11	2/36
12	1/36
16	1/36
20	1/36
24	1/36

An example of a private signal is the sequence {H,T,T,H,H,H}, where $t_i = 6$ (4 heads; 2 tails). Your private signal will be displayed on your screen throughout the experiment. This is the only private information you will have. Note that your signal will most likely differ from everyone else's signal.

At the start of the experiment, as you receive your signal you are asked to report your true belief regarding θ**, the probability that the coin lands <u>HEADS</u>.** Your beliefs are probability assessments for the coin to land <u>HEADS</u>. Therefore, you will be reporting a number between 0 and 1 (excluding 0 and 1), say 0.57, which indicates your true belief regarding the probability that the coin lands <u>HEADS</u>. You will report your beliefs four times (in 15 minute intervals) throughout the experiment. Please keep in mind the following:

(1) You are reporting your beliefs for the probability that the coin lands <u>HEADS</u>.
(2) You are not allowed to report 0 or 1.[2] The minimum allowable report is 0.01 and the maximum is 0.99.
(3) You are encouraged to report truthfully, as your belief reports will be evaluated using a <u>proper scoring rule</u>[3].

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[2] You are being told that θ will not be 0 or 1 since it will be drawn from the *open* interval, (0,1). Therefore, you must not report 0 or 1.

At the start of the experiment, after you get your private signal and submit your belief input for the first time, the market for trading HEADS and TAILS securities will open. The supply of securities is unlimited. There are no short sales constraints or bankruptcy constraints. There is, however, a cash-in-advance constraint. So, for instance, if you have $10 cash and $9 in outstanding buy orders you will be restricted from placing additional buy orders in excess of $1. If you choose to do so, you will be asked to cancel some of your previous orders, otherwise you will violate the cash-in-advance constraint.

The market will remain open for 45 minutes. The trading screen will display menus of prices (in 1 cent increments) for the two securities. To submit an order or cancel previous orders you simply click on the price and enter the quantity you want to buy, sell, or cancel. There is a panel on the right hand side displaying YOUR open orders (i.e. orders that have not been matched). There is no ORDER BOOK to show you the bids and asks for the two assets. You need to scroll down the menu of prices to look for offers. By clicking on CENTER above the price menus you will be directed to the center of the bid/ask spread.

As I mentioned before, throughout trading you will be interrupted by a small Java screen which will ask you to input your belief for the probability that the coin lands HEADS. You will not receive a new signal! Beliefs will be elicited at the 15 minute and 30 minute marks and once more at the conclusion of trading.

Your goal in this experiment is to establish a portfolio of HEADS, TAILS, and CASH holdings with the highest expected value, where expectations are taken with respect to the true (unknown) probabilities. At the conclusion of trading, players are assigned payoffs in accordance to the accuracy of their belief reports[4] and the value of their portfolio holdings. You will begin with {0 HEADS; 0 TAILS; 100 CASH}; that is, 0 of each security and 100 units of cash. The value of a portfolio, *V*, is given by:

$$V = \theta H + (1-\theta)T + C$$

Thus, the value of your beginning portfolio is 100. After trading your portfolio *might* be {147; -32; 56.43}. The value of this portfolio (assuming say θ=0.56) is:

$$V = 0.56(147) + 0.44(-32) + 56.43$$

$$V = 124.67$$

Your actual payoff in this case would be $12.47. **To be eligible for cash prizes you must trade at least once!** That is, you cannot participate and take home your endowment ($10).

If you are interested in learning about the exact calculation of payoffs please read the sections below. I have included a numerical example illustrating the procedures step by step.

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[3] A proper scoring rule is incentive compatible. This means truth-telling is your optimal strategy. The goal is to elicit true reports.

[4] Lottery tickets in direct proportion to points earned by inputting beliefs are assigned to each individual. A ticket is drawn randomly and the holder of the ticket wins $100. More information regarding the lottery is available in the *Payoff Functions* section below.

Payoff Functions

I. Beliefs Evaluation

The belief report evaluation procedure will consist of the following five steps:

1. Determination of cumulative rewards, CR_i, for all *i*
2. *T* imaginary lottery tickets printed
3. Assignment of lottery tickets
4. Lottery result – selection of winner
5. Determination of Payoffs

Step 1: The reward to client *i* for the j^{th} belief report, ρ_{ij}, is given by:

$$\rho_{ij} = \theta\left[100LN\left(100\mu_{ij}\right)\right] + (1-\theta)\left[100LN\left(100\left(1-\mu_{ij}\right)\right)\right]$$

where

$\theta = true\ coin\ parameter$

$\mu_{ij} = client\ i's\ j^{th}\ belief\ report$; $j = 1,2,3,4$ and $i = 1,2,\ldots N$

Since beliefs are elicited four times, the cumulative reward for client *i*, CR_i, is given by:

$$CR_i = \sum_{j=1}^{4} \rho_{ij}$$

For each *i*, CR_i is computed and rounded to the nearest whole number.

Step 2: Print *T* tickets:

$$T = 4N\left[\theta\left[100LN(100\theta)\right] + (1-\theta)\left[100LN\left(100(1-\theta)\right)\right]\right]$$

(Note: T is rounded *up* to the nearest whole number)

Basically, *T* is the maximum cumulative rewards possible by all clients. This is obtained if each client correctly reports the true theta four times.

Step 3: Assignment of lottery tickets

Each client is assigned an ID # at the start of the experiment. Beginning with the client with ID #0, raffle tickets are assigned to all clients in equal proportion to their respective rounded cumulative rewards. In all likelihood, the number of printed tickets will exceed the total number of assigned tickets. The unassigned tickets are not deleted, as they will also be part of the lottery. In the event that an unassigned ticket is drawn nobody wins the lottery.

Step 4: Lottery

A ticket number between 1 and *T* is drawn. The client assigned the drawn ticket wins \$100. In the event that the drawn ticket number is unassigned, nobody wins the \$100 prize.

Step 5: Payoffs

$\alpha_i = \$0$ for all *i=1,2,…,N* except the client, say *j*, holding the drawn lottery ticket (if any); then $\alpha_j = \$100$.

II. Trading Payoffs

For each client the value of their portfolio, V_i, is determined and they are assigned payoff $\beta_i = \frac{1}{10} V_i$.

$$V_i = \theta H_i + (1-\theta) T_i + C_i$$

where

$H_i = quantity\ of\ heads\ contracts\ held\ by\ i$

$T_i = quantity\ of\ tails\ contracts\ held\ by\ i$

$C_i = cash\ holdings$

Final payoff = $\prod_i = \alpha_i + \beta_i$

Example illustrating the calculation of payoffs

Preliminary data:

$\theta = 0.62$

$N = 2$

$\Rightarrow T = 3152.884848$; after rounding we get $T = 3153$

Therefore, 3,153 imaginary tickets will be printed.

Matrix of Belief reports, μ_{ij} for *i=1,2* and *j=1,2,3,4*

	1	2	3	4
Client 1	0.56	0.65	0.60	0.61
Client 2	0.44	0.48	0.55	0.60

Matrix of Rewards, ρ_{ij} for *i=1,2* and *j=1,2,3,4*

	1	2	3	4
Client 1	393.37	393.92	394.03	394.09
Client 2	387.58	390.16	393.11	394.03

Rounded cumulative rewards

$$CR_1 = 1575$$
$$CR_2 = 1565$$

Raffle ticket assignments

Client	Ticket numbers assigned
1	#0001 - #1575
2	#1576 - #3140
Unassigned	#3141 - #3153

Ticket drawn: #2005

Client 2 wins the lottery $\Rightarrow \alpha_1 = \$0;\ \alpha_2 = \$100$

Now for calculating the trading payoffs assume the following portfolios:

$$P_1 = \{85; -15; \$55.00\}$$
$$P_2 = \{-85; 15; \$145.00\}$$

The expected values of the portfolios are:

$$V_1 = 0.62(85) + 0.38(-15) + 55 = 102$$
$$V_2 = 0.62(-85) + 0.38(15) + 145 = 98$$

$\Rightarrow$

$$\beta_1 = \$10.20$$
$$\beta_2 = \$9.80$$

$\Rightarrow$

$$\Pi_1 = \$10.20$$
$$\Pi_2 = \$109.80$$