Sunspots, Animal Spirits and Business Cycles: an Experimental Research

Chandana Boteju
South Eastern University of Sri Lanka

Abstract
Due to difficulties associated with measuring expectations and observing random coordination devices, the models that posit the idea that business cycles being driven by expectations are hard to test empirically. The paper proposes an experiment to capture features of an expectation driven business cycles model and investigate whether such cycles arise in an experimental setting. Externalities, uncertainty and an extrinsic random variable to mimic the crucial features of the model are introduced. The results provide preliminary support for the hypothesis that given the right incentives for coordination, expectations-driven cycles do occur.

Key Words: Business Cycles, Sunspots, Animal Spirits, Multi-player Game, Experimental Economics.

Introduction

Since the economic crisis of 2008 and the subsequent world economic recession, there is a renewed interest in the Schumpeterian theory of business cycles. In particular, a great emphasis is made on the nature and causes of business cycles. However, few subjects in economics are as contentious as the business cycles-the fluctuations of output and unemployment around the long run upward trend (Sloman, 2003). A generation ago, majority of economists agreed on what caused business cycles. Then, partly as a result of "stagflation" - the unexpected and unpleasant combination of inflation and unemployment- economists studying business cycles divided into rival factions (Krugman, 2010)**.**

The dominant view in this regard until recently was that Business Cycles are the result of exogenous shocks to the fundamental conditions of a dynamically stable economic system (Lucas, 1975).According to this view, the fluctuations in the economy, recessions and depressions, are the result of random changes in the variables such as availability of profitable investment opportunities in the economy, the propensity to save, the macroeconomic policy framework, population, international terms of trade etc (Freeman & Perez, 1988). The competing view of business cycles has that fluctuations would occur even if fundamental conditions to remain unaltered over time. This view has two variants.

The first sees the fluctuations, the booms and busts, as created by internal factors resulting from the failure of the economic system to settle down to a stationary state even in the absence of shocks. This variant has been formalized as nonlinear systems exhibiting either periodic equilibria or chaos (Howitte and Macafee, 1992). The second variant of the competing view attributes the fluctuations to random waves of optimism and pessimism that are unrelated to fundamental conditions.Arguing on behalf of this phenomenon, Keynes in his *General Theory* questionedthe role of business expectations or business confidence, or what Keynes called the 'animal spirits', in determining business cycles (Keynes, 1936). Of course, before him, his teacher in Cambridge, Arthur Pigou, has also remarked that it is "the varying expectations of business men... and nothing else constitute the *immediate cause and direct causes* or antecedents of industrial fluctuations" (Collard, 1996).

However, with the onset of a period of "great moderation", unprecedented technological

change and globalization, in US and Europe during the final decade of twentieth century, the Keynesian explanation of business cycles fell out of grace with neo classical theories of market clearing and rational expectation embraced as the key elements in determining business cycles (Farmer and Guo, 1994). But, ironically, the ensuing crisis that gripped the US and Europe after 2008 turned the tables around. Again, there is a renewed emphasis on both economicfundamentals that causes cycles as well as other factors that affect cycles that do not have an elemental relation with economic fundamentals (Akerlof and Shiller, 2010).

In the light of the above discussion, the primary objective of this research is to inquire into a facet of the relationship between animal spirits or sunspots and the economic fluctuations. The words "sunspots" or "animal spirits" are understood as self-fulfilling beliefs or waves of optimism and pessimism that are not related to economic fundamentals such as technology, preferences and endowments (Chauvet & Guo, 2003). In other words, the words "sunspots" or "animal spirits" usually refer to an exogenous random variable that does not directly affect economic fundamentals but affects the investment and business decisions of a business community. In short, it is an extrinsic uncertainty that does not come from variation in economic fundamentals but affects the mood of the investors (Cass & Shell, 1983).

There is only a very limited amount of empirical research done to test the validity of the hypothesis that consumers' sunspots and investors' animal spirits have important independent influence on aggregate fluctuations. A notable exception is the research by Chauvet & Guo (2003) who find that the innovations to consumer sentiment and business formation continue to show the same observed cyclical patterns around turning points. One reason for this is the difficulty of the sunspot variable used by agents to coordinate their beliefs. Therefore, real world empirical evidence for expectationally driven randomness at work is scarce. Consequently, in order to achieve the primary objective of this research, the researcher works out an experiment to attempt to answer this question regarding the relationship between business cycles and sunspots or animal spirits.

Experiments are a special form of games and everyone play games for the fun of it. Games are also adaptive and serve to help us learn. An experiment actively engages some small piece of the world. A researcher designs and run an experiment and records the results in order to learn about a particular phenomenon. This form of learning is the essence of science (Cassar and Friedman, 2004).Experimental economics is relatively a young tradition in economics. For instance, economics theory before 1960s hardly had any room for laboratory experiments. Macroeconomics referred to exorbitantly large scale events, and seldom had connections with microeconomics. However, the microeconomics at that time referred primarily to equilibrium mainly under varying conditions of competition. Therefore, economics was chiefly interested in the consequences of assumptions that all agents (firms and households) are rational and they choose optimally to result in equilibrium prices that ensure consistency of choices (Friedman, 1952). Till experimental economics emerged as a separate tradition shortly afterwards, no economists bothered to test the validity of these underlying assumptions.

Meaningful economic experiments became possible with the emergence of new theories in the 1960s. Game theory, industrial organization, social choice theory and search theory, etc. offered competing ways to understand microeconomics data. And sometimes, multiple economic equilibria emerged from a single theory. By the early 1970s, many economists began to recognize the potential of experiments to distinguish among the many alternatives. Experimental economics really took off in the 1980s. Financial markets, auctions, asymmetric information models, institutional engineering, voting, and dozens of other new applications opened to the new methodology. The 1990s saw continued rapid growth up to and until now that

is powered by the new computational techniques (Friedman and Cassar, 2004).

However, it is of paramount importance to understand the rational for a separate tradition of experimental economics in contrast to traditional econometrics (Friedman and Cassar, 2004). On one hand, traditional econometrics works with happenstance data, which occur naturally, as opposed to laboratory data, which are created in an artificial environment to inform the investigator. On the other hand, traditional econometrics works with uncontrolled processes, as opposed to the controlled process that are the hallmark of experimental science.

Nowadays experimental methods are widely accepted by economists, but whether the data representative of the real world or not is a matter for the good laboratory technique and experiment design. The issue here is generally called external validity. It is a fundamental issue for any laboratory science. It goes back at least to Galileo and Newton, whose critics did not believe that the behaviour of balls on inclined planes had any relation to planetary motion. Formal models often omit crucial details regarding the complex reality, and sometimes include behavioral assumptions that the research would like to test rather than induce. Therefore, the contrast between the laboratory and "real world" is often exaggerated. Laboratory experiments feature real people operating under real rules for real states (Plott, cited in Friedman and Cassar 2004). They differ mainly in that they are simple than naturally occurring process. The real world is often too complex to approximate closely in the laboratory, and futile attempts to do so would decrease the scientific validity of the experiment.

Keeping the above discussion in mind, the challenge is to design cycles that are expectationally driven and that occur if there are significant complementarities in some aspect of firms' decision making, creating an incentive for coordination. Thus, following the experimental economic methods pioneered in Marimon *et al*. (1993) who examined the role of animal spirits or sunspots in an experimental settings finding that sunspots can matter if they are expected to; the present research attempts to analyze the interrelationship between business cycles and animal spirits emphasizing the role of expectations and coordination on causing the same. A particularly simple model of this kind was proposed by Howitt and Mcafee (1992). Using this model, Hwang (2004) conducted a pilot session with pairs of individuals that validate the model. However, a major limitation of the above study was the use of pairs that made it easier for coordination.

Therefore, this research proposes an experiment that captures the relevant features of Howitt and McAfee's theoretical environment with larger groups and investigates whether expectationally driven cycles occur in an experimental setting. In doing so, the remainder of this paper is organized as follows. Section II describes the model and section III the experimental design. Section IV presents the experimental results and section V concludes with areas for further research.

Model

The following simple setup conveys the main idea behind Howeitt and McAfee's model. There is a continuum of identical, infinitely lived firms who decide whether to hire each period. A firm's decision is denoted by h_t, which takes on the value 1 if the firm hires and 0 if it does not. Letting Y_t represent the proportion of firms who decide to hire, a firm's profits are given by

$$\pi_t = f(Y_t) - C_t$$

If: $H_t=1$, $H_t=0$

Where $f(Y_t)$ is the firm's revenue. Crucially, the model assumes that $f' > 0$ so that each firm's hiring decisions carry externalities for other firms.It is clear that this setup must generate multiple equilibria. Since, with

appropriate conditions on costs, all the firms will find it optimal to coordinate their actions by either hiring together or not hiring. Assuming that costs can be either high, C^H, or low, C^L, and these costs are observed after firms have made their hiring decisions, the sufficient condition for coordination is:

$f(0) < C^L < f\frac{1}{2} < C^H < f(1)$

Whichsays that when no firm is hiring, the revenue from hiring will never justify the cost, while if every other firm is hiring, then the remaining firm will also want to hire, since the benefits from externalities are large enough to swamp even high costs.

At this point, before, turning to cycles, it is useful to establish some benchmark results under the assumption of deterministic costs; that is, costs are either always high or always low. These assumptions are based on the fact that since firms make hiring decisions repeatedly, observing costs after they decide each period, it follows that they will learn to base their decisions on their increasingly confident-and correct- forecast of costs for the next period. Two possible equilibria in the case of deterministic costs are the "optimistic" and "pessimistic" paths in which all firms choose either to hire or not.

Assuming instead that costs are stochastic yields the main result of the model. To consider the possibility of animal-spirits equilibria, assume that in addition to randomly shifting costs, there is a random variable, extrinsic to the economy, which changes between two states, high and low, and is observed before firms make hiring decisions. Under these assumptions, optimistic and pessimistic paths remain as possible equilibria, along with a third possibility: a cycle where all firms hire if animal spirits, the extrinsic random variable, are high and not hire if spirits are low. Howitt and McAfee (1992) show that such an animal spirits cycle can be rational-expectations equilibrium if agents update their beliefs regarding relevant probabilities according to Bayesian learning.

The intuition for this is straightforward. Suppose that firms experience a period of spurious correlation between spirits and costs. During this period, firms will learn to base their decisions on the publicly observed animal spirits or sunspots, which turn out, temporarily, to be a perfect forecast of costs. Eventually, the correlation disappears and spirits can no longer be used to forecast costs but firms will have learned that they are made better off by coordinating, regardless of whether costs are high or low, due to output externalities. If this incentive for coordination induces some firms to use animal spirit or sunspots as a device for coordination, then the externalities reinforce theirbehaviour, eventually producing a cyclical equilibrium.

Experimental Design

The model contains four crucial features that an experiment testing its predictions must capture in some way:1) the presence of externalities, 2) uncertainty regarding costs, 3) an extrinsic random variable, and 4) the timing of events. The research presents a variant on a two-player coordination game which is likely the simplest setup with these features.

Consider a four player game with the following payoff matrices:

	Hiring	Not	
Hiring	10,	0, 0	Hiring
Not	0, 0	6, 6	Not
	Hiring	Not	

Low Cost

	Hiring	Not	
Hiring	1, 1	0, 0	Hiring
Not	0, 0	5, 5	Not
	Hiring	Not	

High Cost

Each player chooses hiring or not hiring without observing a random event that determines the payoffs as shown above. The researcher has chosen to make presentation of the game to the subjects context-free and therefore uses neutral labels in place of hiring and not hiring as A and B. Here choice of hiring can be thought as A, not hiring as B, and low cost as a random event X and high costs as random event Y. Note that the pure strategy equilibria of the game require coordination, with the exact payoffs depending on which random event has occurred. This introduces the first two required elements of the model into the experiment: externalities and uncertainty. As in the model where a firm would like to follow the actions of the others, here a player would like to make the same choice as the other player. Also following the model, coordination is always better than not coordinating but whether coordination on A or B is more profitable depends on an unobserved random event.

The researcher introduces animal spirits by showing at the beginning of each round either one of two pictures, one depicting a sunrise and another depicting a storm. Below in Table 1 the pictures are referred to as "Optimistic" and "pessimistic" respectively. The previous section noted that Bayesian learning is consistent with the animal spirits equilibrium if there is a period of spurious correlation between spirits and costs, during which firms learn that no matter what the costs are coordination will always be profitable. The researcher introduces a "spurious" correlation by correlating the pictures perfectly with the random events during the first ten round of the game. For the remaining twenty rounds, the realizations of pictures and random events are determined independently by separate coin tosses done prior to the experiment. Also the process of learning described in the model presumes that firms do not have ex ante knowledge that coordinating with other firms will make them better off-this must be "learned" during the period of spurious correlation. Therefore, I choose not to reveal the payoff matrix to the subjects, in contrast to the standard approach in coordination experiments where payoffs are typically known in advance.

All subjects observe sunspotsSubjects make choice A or B (representing to hire or not) and hands over the paper to researcherThe researcher gives feedback on realized random event, partners' choices and payoff for the round and had over the paper back for the next round.

Picture 1 **Timeline for each round**

Figure 1 shows the timeline for a single round of the experiment. At the beginning, either an optimistic or pessimistic picture is shown. The subjects are then asked to write down their choice of A or B. The experimenter then collects the record sheets and fills in the following information as feedback: the partners' choices, the realization of the random event and the profit the subject made. The feedback gives the subject a chance to learn, and use to their advantage, the correlation between pictures and random events in the first ten rounds. Further, if learning takes place as the model describes, then the first ten rounds should also teach the subjects that coordination makes them better off and lead, at least in some pairs, to animal-spirits cycles. Twenty Engineering undergraduate students at the South Eastern University of Sri Lanka were recruited as subjects for this economics experiment. See the Appendix 1 for the instructions.

Results

Table 1 reports the data from the last twenty rounds of the experiment. The researcher focuses on them since the research is mainly interested in behavior observed sufficiently after the initial period of correlation so that the subjects have had a chance to reach any equilibrium. The first two columns show the realizations of pictures and random events. The remaining columns show the choices made by each subject. The subjects' labels indicate the groups. The second row from the bottom records the number of time changes in a subject's choices coincided with changes in the pictures in a consistent manner. The last row indicates the type of equilibrium reached.

The second group (S2-1, S2-2, S2-3, and S2-4) clearly appears to have reached an animal spirits cycle. All the subjects choose A when the picture is bright and B when the picture is dark for the entire duration of the last twenty rounds with only one deviation by the third participant (S2-3) at only the beginning of final rounds. The fourth group (S4-1, S4-2, S4-3, and S4-4) appears to be converging on to the same animal spirits equilibrium. All the participants in the group switched their choices with the picture at least fifteen out of twenty times. And the third participant did so sixteen out of twenty times. The last group too appears to exhibit somewhat similar pattern at the beginning of their last rounds. Had the game been played a little longer, it seems likely that the fourth group would also have converged to perfect animal spirits equilibrium.

Having settled to an animal spirits equilibrium during the first half of their final rounds, deviating from it only once in the beginning in eleventh round, and by third participant in the fourteenth round, they suddenly start deviating from the equilibrium animal spirits cycle in the twentieth round and emerge to be converging on a "reverse" animal spirits equilibrium where the participants choose A when the picture is dark and B when bright. There is consistent evidence for this during the last six rounds.

The remaining two groups behave very differently from the three already discussed. The participants of the first group behave the more puzzling of the two as there appear to be some erratic behaviour by one member or the other in majority of rounds. The evidence to the possibility that they are converging to"reverse" animal spirit equilibrium is also quite weak; the participants only converge to this strategy four times in the last ten rounds. The third group appears equally puzzling, with the first participant choosing A for the entire duration and the third participant choosing B for the same duration in Table 1. This virtually eliminates the possibility of any equilibrium. However, the model may yield both optimistic and pessimistic paths as valid equilibria under stochastic costs. But due to the diametrically opposite choices of the above participants, there is no room for such equilibria either.

So far, inspection of individual behaviour indicates that animal spirits cycles may arise. It is also instructive however to look at the entire pool of subjects. Figure 2 shows for each round the number of groups that succeeded in coordinating.

At the outset, the pictures are not correlated with random events. But, the frequency coordination rises as participants "learn" that pictures can be utilized to guess random events. Therefore, the subjects learn through the feedback of the profits and realized random events that they may use the pictures to forecast random events and at the same time that coordination is profitable. In the eleventh round, pictures are no longer correlated with random events and the frequency of coordination drops. But it increases again, with at least three of the five groups coordinating in the ten out of twelve rounds. This is indicative of the type of learning the model describes. Once the initial period of correlation ends, the subjects use the pictures no longer as a forecast for random events but now as a coordination device since they discover that regardless of the costs, coordination increases profits. This naturally explains the finding that some type of coordination equilibrium was reached for three of the five groups by the end of the experiment.

Conclusion

Thus, the results the researcher reported above corroborate the finding that some type of conditioning can induce agents to base decisions on extrinsic random events. They also support the theoretical result that, with right incentive for coordination, animal spirits cycles arise with positive probability. The results are also consistent with Bayesian learning, which show to be able to generate beliefs that converge to animal spirits cycle equilibrium (Howitt and McAfee, 1993).

The results presented here are preliminary but provide initial support for the empirical validly of Howitt and McAfee's model of animal spirits

cycles. Further, they corroborate the finding that a period of correlation between a sunspot and a fundamental of an economy can condition agents into basing their future decisions on the sunspot even in the absence of any correlation (Marimon *et al*, 1992). In addition, the findings strengthen the hypothesis that given the right incentives for coordination, expectations-driven cycles do occur (Hwang, 2004).

Future work can build on the simple experimental design used in this research paper in several directions.In order to bring out the importance of initial correlation and stochastic costs more clearly, a more formal 2x2 design may be used, with the nature of costs (fixed or stochastic) and correlation (with and without) as treatment variables. Rematching of subjects and expanding feedback to include the concurrent behaviour of other groups may also be considered.

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Appendix

General Instruction to participants

Round	A.S	Costs	S1-1	S1-2	S1-3	S1-4	**S2-1**	**S2-2**	**S2-3**	**S2-4**	S3-1	S3-2	S3-3	S3-4	S4-1	S4-2	S4-3	S4-4	S5-1	S5-2	S5-3	S5-4
11	D	Y	A	B	B	B	**B**	**B**	**A**	**B**	A	A	B	A	B	B	B	B	A	B	A	A
12	B	X	B	A	A	A	**A**	**A**	**A**	**A**	A	B	B	A	A	A	B	B	A	A	A	A
13	B	X	A	A	B	A	**A**	**A**	**A**	**A**	A	A	B	A	A	A	A	A	A	A	A	A
14	D	Y	B	B	B	B	**B**	**B**	**B**	**B**	A	A	B	A	B	B	B	B	B	B	A	B
15	B	X	A	A	A	A	**A**	**A**	**A**	**A**	A	A	B	A	A	A	A	A	A	A	A	A
16	B	X	A	A	A	A	**A**	**A**	**A**	**A**	A	B	B	B	A	A	A	A	A	A	A	A
17	D	Y	B	B	B	B	**B**	**B**	**B**	**B**	A	A	B	A	B	B	B	B	B	B	B	B
18	D	X	A	B	B	B	**B**	**B**	**B**	**B**	A	A	B	B	B	B	B	B	B	B	B	B
19	B	X	A	B	A	A	**A**	**A**	**A**	**A**	A	B	B	B	A	A	A	A	A	A	A	A
20	B	X	A	A	A	A	**A**	**A**	**A**	**A**	A	B	B	A	A	A	B	A	A	A	A	A
21	B	Y	A	A	A	A	**A**	**A**	**A**	**A**	A	A	B	A	A	A	A	A	A	A	A	A
22	D	X	B	A	B	B	**B**	**B**	**B**	**B**	A	B	B	B	B	B	B	B	A	A	A	A
23	B	Y	B	B	A	A	**A**	**A**	**A**	**A**	A	A	B	A	B	B	A	A	B	B	A	A
24	B	Y	B	B	B	A	**A**	**A**	**A**	**A**	A	A	B	A	B	B	B	A	B	B	B	B
25	B	Y	B	B	B	B	**A**	**A**	**A**	**A**	A	B	B	B	B	B	B	B	B	B	B	B
26	D	Y	A	A	A	A	**B**	**B**	**B**	**B**	A	A	B	A	A	A	A	A	A	A	A	A
27	B	Y	B	A	B	B	**A**	**A**	**A**	**A**	A	B	B	B	B	B	B	B	A	A	A	A
28	B	X	B	B	B	B	**A**	**A**	**A**	**A**	A	B	B	B	A	A	A	A	B	B	B	B
29	D	X	A	A	A	A	**B**	**B**	**B**	**B**	A	A	B	A	B	B	B	B	A	A	B	A
30	B	Y	B	B	B	A	**A**	**A**	**A**	**A**	A	B	B	B	A	A	A	A	A	A	A	B
Switched with A.S			N A	N A	N A	N A	**2 0**	**2 0**	**1 9**	**2 0**	N A	N A	N A	N A	1 5	1 5	1 5	1 6	1 2	1 3	1 3	1 2
Type of Equilibrium			NA				**ASC**				NA				ASC				ASC			

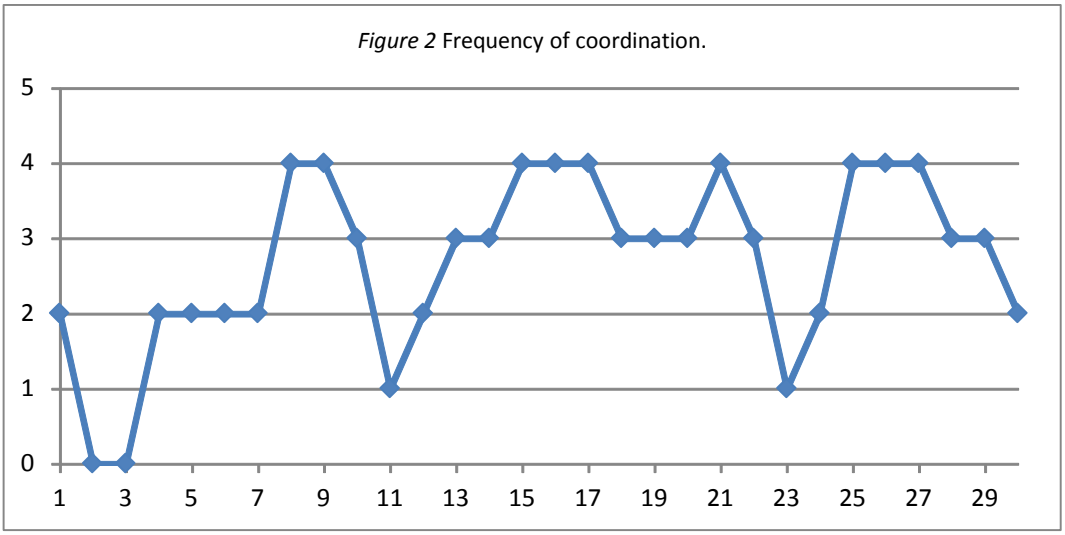

Figure 2 Frequency of coordination.

You are about to participate in an economic experiment in which you will play a game with 3unknown participant for 30 rounds.

In each round, you have to choose A or B. The other participants will also choose A or B. Your profit for that round depends on three things:

1. Your choice
2. The other participants choices
3. A random event

The following table shows how your profits are calculated

Table -01

Your choice	*Other Participant's Choice*	*Other Participant's choice*	*Other Participant's choice*	*Your profit*
A	A	A	A	*k*
A	A	A	B	*l*
A	A	B	B	*m*
A	B	B	B	*n*
B	B	B	B	*o*
B	B	B	A	*p*
B	B	A	A	*q*
B	A	A	A	*r*
A	A	A	A	*s*
A	A	A	B	*t*
A	A	B	B	*u*
A	B	B	B	*v*
B	B	B	B	*w*
B	B	B	A	*x*
B	B	A	A	*y*
B	A	A	A	*z*

Each round, either one of two random events occurs: X or Y. If random event X occurs, for instance, and you choose A and the other three participants B, then you will get *n* number of points. If random event Y occurs and both you and the other participant choose B, then you will receive *w* points for that round.Some combinations of choices by you and the other participants will yield more profits than other choices, although you will not know in advance which choices are more profitable.

Finally, for each round before you make your choice, the researcher will show one of the following two pictures:

Picture 1

Picture 2

These pictures may or may not be related to or be relevant in the game. You may choose to ignore these pictures or to use them in some way.

Filling the sheet

On the record sheet, please fill out the first two columns each round.

- In the first column, "Pictures," write in whether picture 1 or picture 2 is shown.
- In the second column, "your choice", write your choice for that round: A or B.

Do not fill out the rest of the form. When you have filled out the first two columns, the researcher will take the sheet and fill out the other participant's choice, the random event and your profit for the round.

Remember that your profits depend only on three things: your choice, the other participant's choices, and the random event.