

ASSIGNMENT 4 (9 points)

(Due Sunday November 16)

Answer key

There are three multipart questions and three experiments.

Question 1 (3 points)

This question is based on the Ware National case study. Both companies are deciding whether to try to develop FR 8420 as dental material or not. Extract from the reading material the key elements that characterize the strategic situation described in the case study to answer the following questions.

- (a) Who are the main players?
Ware Medical Corporation (“Ware”) and National Dental Corporation (“National”)
- (b) In this case study, what actions (moves) can each company take (make)?
Both Ware and National have an option to develop a new composite using FR 8420 or not.
- (c) What are the sources of uncertainty for the players in this scenario? In other words what is the role of nature in determining the outcomes?
The experiment for developing a new material might not be feasible (“50% chance that an acceptable translucent composite is feasible using fibers with FR 8420”).
When both Ware and National experiment, there is uncertainty to which firm wins the patent race. For simplicity, let’s give the probability 50%.
- (d) Provide estimates of the probabilities for the contingencies that might occur.
Let (A, B, C, D) be a tuple describing each contingency: A is the move for Ware, B is the move for National, and C is the feasibility of developing a new material (Ware and National do not know about this).
- Development is Feasible, and Ware wins the patent race when both firms experiment: 0.25
 - Development is Feasible, and National wins the patent race when both firms experiment: 0.25
 - Development is Infeasible, and both firms experiment: 0.5
 - Development is Feasible, and only one firm experiment: 0.5
 - Development is Infeasible, and only one firm experiment: 0.5
 - Development is Feasible, but no firm experiment: 0.5
 - Development is Infeasible, but no firm experiment: 0.5
- Note that the last two items are unimportant because both firms decided not to experiment with the new material; thus, the feasibility does not matter.
- (e) Explain how to calculate the change in net present value to both companies that result of their actions and the events they do not control (determined by the probability of nature’s

moves)?

Let's assume that the firm is risk-neutral. I also denote choose to experiment as "in" and choose not to experiment as "out". Given the 10% discount rate, the entry cost for each firm is:

- Ware: $0.5*(1+1/1.1) = 0.9545$ million
- National: $1*(1+1/1.1) = 1.9091$ million

Also, the present value of annual sales from year 3 to year 7 when the experiment succeeds is:

- $17.5*0.2*(1/1.1^5-1)/(1/1.1-1)*(1/1.1^2)=12.0616$ million

The net payoff for each firm for each contingency is then:

- (Feasible, In, In, Ware wins)
 - Ware: $12.0616-0.9645 = 11.0971$ million
 - National: -1.9091 million
- (Feasible, In, In, National wins)
 - Ware: -0.9645 million
 - National: $12.0616-1.9091=10.1525$ million
- (Infeasible, In, In)
 - Ware: -0.9645 million
 - National: -1.9091 million
- (Feasible, In, Out)
 - Ware: $12.0616-0.9645 = 11.0971$ million
 - National: 0 million
- (Infeasible, In, Out)
 - Ware: -0.9645 million
 - National: 0 million
- (Feasible, Out, In)
 - Ware: 0 million
 - National: $12.0616-1.9091=10.1525$ million
- (Infeasible, Out, In)
 - Ware: 0 million
 - National: -1.9091 million
- (Feasible, Out, Out)
 - Ware: 0 million
 - National: 0 million
- (Infeasible, Out, Out)
 - Ware: 0 million
 - National: 0 million

- (f) Use the data provided in the case study to quantify what happens to the net present value of each company as a function of the moves by both players.

Note that the payoffs for each contingency in item E realize with probabilities we estimated in item D. The expected net payoff for each action in the strategy form game is illustrated as below:

- (In, In)

- Ware: $0.5*(0.5*11.0971+0.5*(-0.9645))+0.5*(-0.9645)=2.0509$
- National: $0.5*(-1.9091+0.5*10.1525)+0.5*(-1.9091)=0.629025$
- (In, Out)
- Ware: $0.5*11.0971+0.5*(-0.9645)=5.0663$
- National: 0 million
- (Out, In)
- Ware: 0 million
- National: $(0.5*10.1525-0.5*1.9091)=4.1217$
- (Out, Out)
- Ware: 0 million
- National: 0 million

		National	
		In	Out
Ware	In	(2.0509, 0.629025)	(5.0663, 0)
	Out	(0, 4.1217)	(0, 0)

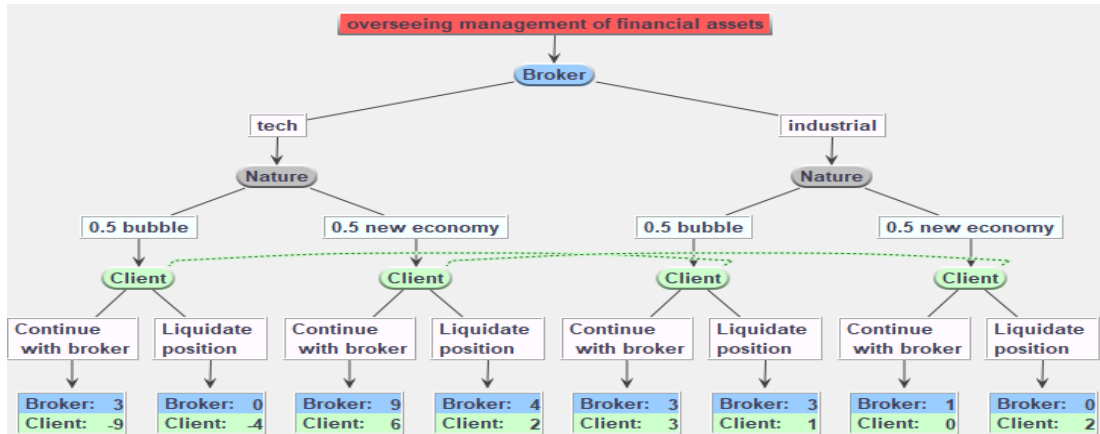
(g) Is it reasonable to assume that the players move at the same time, in which case neither knows what the other has done until later? Alternatively, can one player move first, and also convince the other one it has done so, without giving any company specific technological secrets away? Give me your team's considered opinion in a sentence or two.

It is reasonable to assume that players move at the same time, as communication between managers at the firm is held in secret. The managers do not know the competitor's action. In this situation, choosing to experiment is the dominant strategy for both firms. Thus, revealing the firm's action to the competitor would not affect the competitor's action.

Question 2 (3 points) . . . *overseeing financial asset management*

The timeline for this game is:

1. A broker buys tech or industrial stocks on behalf of a client.
2. The economy determines whether there is a shift towards new technology or not
3. The client decides to continue with her broker or not.



The client has two information sets. She cannot tell how the broker has managed her stocks. However, she can distinguish between:

- The (old) economy has a bubble.
- There is a new economy.

- (a) Save this game from the course website, and run it amongst your **experimental group** four or more times, and take a snapshot to show the outcome of this experiment. As usual I will not grade you on these outcomes; just do the best you can.
- (b) What is the probability distribution of the empirical moves (by player)?
- (c) What is the best reply (by player) to the empirical distribution?
- (d) Write down the set of strategies for each of the two players. (*HINT: One strategy of the client is to continue with the broker if there is a bubble and to liquidate her position if there is a new economy. She has three other strategies. The broker has two strategies.*)

Client:

- [1] continue with the broker if there is a bubble and liquidate her position if there is a new economy.
- [2] continue with the broker if there is a new economy and liquidate her position if there is a bubble.
- [3] always continue with the broker.
- [4] always liquidate her position.

Broker

- [1] choose tech.
- [2] choose industrial.

- (e) Use the matrix representation developed in Lecture 1 to lay out the strategic form of this game, using comlabgames.

	tech	industrial
continue if bubble, continue if new economy	$0.5 \cdot (3+9)=6$ $0.5 \cdot (-9+6)=-1.5$	$0.5 \cdot (3+0)=1.5$ $0.5 \cdot (3+1)=2$
continue if bubble, liquidate if new economy	$0.5 \cdot (3+4)=3.5$ $0.5 \cdot (-9+2)=-3.5$	$0.5 \cdot (3+2)=2.5$ $0.5 \cdot (3+0)=1.5$
liquidate if bubble, liquidate if new economy	$0.5 \cdot (0+4)=2$ $0.5 \cdot (-4+2)=-1$	$0.5 \cdot (1+2)=1.5$ $0.5 \cdot (3+0)=1.5$
liquidate if bubble, continue if new economy	$0.5 \cdot (0+9)=4.5$ $0.5 \cdot (-4+6)=1$	$0.5 \cdot (1+0)=0.5$ $0.5 \cdot (3+1)=2$

- (f) Solve for the strategic form using arrows drawn on the matrix. Play the strategic form from game four times among your **experimental group** and take a snapshot of the results for inclusion in your answers.

The unique Nash equilibrium is that the broker chooses tech, and the client chooses to liquidate if there is a bubble and to continue if there is a new economy.

	tech	industrial
continue if bubble, continue if new economy	6 -1.5	1.5 2
continue if bubble, liquidate if new economy	3.5 -3.5	2.5 1.5
liquidate if bubble, liquidate if new economy	2 -1	1.5 1.5
liquidate if bubble, continue if new economy	4.5 1	0.5 2

- (g) Compare the empirical distribution of the outcomes of the extensive and strategic forms and provide a few sentences of explanation.
 (h) Does dominance play a role in solving this game? If so, what role?

Yes. The broker has a dominant strategy which is to choose tech. For all four strategies of the client, the broker's expected payoff from tech is always higher than that from industrial. Therefore, we can eliminate industrial from the broker's choice set.

- (i) Now suppose we change the game so that the client can see what the broker does but cannot see the state of the aggregate economy when she makes her move. First the broker moves, then the client sees what the broker has done, and then decides to continue with the broker or not (that is after this year's financial results are in), and finally the state of the economy is revealed. What are the strategies for the client now?

The client will have four strategies.

[1'] continue with broker if broker chooses tech and liquidate position if broker chooses industrial. [2'] continue with broker if broker chooses industrial and liquidate position if broker chooses tech. [3'] always continue with broker. [4'] always liquidate position.

(j) Write down the strategic form of this new game.

	tech	industrial
continue if tech, continue if industrial	$0.5 \cdot (-9+6) = -1.5$ $0.5 \cdot (3+9) = 6$	$0.5 \cdot (3+0) = 1.5$ $0.5 \cdot (3+1) = 2$
continue if tech, liquidate if industrial	$0.5 \cdot (-9+6) = -1.5$ $0.5 \cdot (3+9) = 6$	$0.5 \cdot (1+2) = 1.5$ $0.5 \cdot (3+0) = 1.5$
liquidate if tech, liquidate if industrial	$0.5 \cdot (-4+2) = -1$ $0.5 \cdot (0+4) = 2$	$0.5 \cdot (1+2) = 1.5$ $0.5 \cdot (3+0) = 1.5$
liquidate if tech, continue if industrial	$0.5 \cdot (-4+2) = -1$ $0.5 \cdot (0+4) = 2$	$0.5 \cdot (3+0) = 1.5$ $0.5 \cdot (3+1) = 2$

Payoffs: Broker Client | Inactive | Nature

(k) Solve the strategic form of the new game.

	tech	industrial
continue if tech, continue if industrial	-1.5 6	1.5 2
continue if tech, liquidate if industrial	-1.5 6	1.5 1.5
liquidate if tech, liquidate if industrial	-1 2	1.5 1.5
liquidate if tech, continue if industrial	-1 2	1.5 2

Payoffs: Broker Client | Inactive | Nature

There are three Nash equilibria marked by stars in the graph.

[NE1']

Broker: tech

Client: liquidate if tech, liquidate if industrial

[NE2']

Broker: tech

Client: liquidate if tech, continue if industrial

[NE3']

Broker: industrial

Client: liquidate if tech, continue if industrial

This is not required in the answer: Note that although tech weakly dominates industrial for the broker, this does not eliminate industrial from the choice set of the broker. In fact, in the third NE above, the broker chooses industrial and he does not want to deviate to tech when the client chooses to liquidate if tech, and to continue if industrial.

- (l) What would the client prefer to know before she makes her investment decision: the state of the economy, or what her broker is doing? Briefly explain why, and report the difference in expected value to her, and to the broker.

When the client knows the state of the economy, her expected payoff is 1 in the unique Nash equilibrium.

When the client knows the broker's choice, because there are three possible Nash equilibria, the client's payoff depends on which NE is played.

Suppose NE1' or NE2' is played, the client's expected payoff is -1. The difference in client's payoff from knowing the broker's choice to that from knowing the state of the economy is $(-1) - 1 = -2$, which is negative.

Suppose NE3' is played, the client's expected payoff is 1.5. The difference in client's payoff is $1.5 - 1 = 0.5$, which is positive.

If the client believes that the likelihood of the broker choosing tech exceeds 0.2, then the client would prefer to know the state of the economy.

Regardless of which NE is played, the difference in broker's expected payoff compared to that in the case when the client knows the state of the economy, is $2 - 4.5 = -2.5$.

Question 3 (3 points) . . . a simple acquisition game

Kraft values Cadburys at 5 while Hershey's values Cadburys at 3. Consider a first price sealed bid auction in which Kraft and Hershey's tender their respective sealed bid offers, which for simplicity are restricted to whole numbers between 1 and 6. (That is, each bidder can submit one, two, three, four, five or six.) In a first price sealed bid auction, bidders submit their bids simultaneously and the winner pays the price they submit. For example, Kraft might bid 6 and Hershey's might bid 2 in which case Cadburys is sold for 2 to Kraft, who then makes a net loss of 1. If there is a tie, both potential acquirers bidding the same number, a fair coin toss determines the winner of the auction. This is how the expected payoff in the top left cell is calculated.

		Hershey's					
		1	2	3	4	5	6
Kraft	1	1					
	2						
	3						
	4						
	5						
	6			-1			

- (a) Complete the bi-matrix on the comlabgames module to depict this simple competitive acquisition game.

		Hershey's					
		1	2	3	4	5	6
Kraft	1	1	1	0	-1	-2	-3
	2	0	0.5	0	-1	-2	-3
	3	0	0	0	-1	-2	-3
	4	0	0	0	-0.5	-2	-3
	5	0	0	0	0	-1	-3
	6	-1	-1	-1	-1	0	-1.5

- (b) Play through the auction five times with your **experimental group** and record the result by taking a snapshot.
(c) What is the empirical distribution of responses?
(d) What is the best response to the empirical distribution?
(e) Use arrows to show the best responses.

(f) Solve the simultaneous move game you have written down.



(g) How close are the best responses to the empirical distribution reported in (d) to the solution reported in (f)?

(h) As a stand-alone company, Cadbury's is valued at 2. Cadbury's has the option of setting a reserve price for this auction. That is, unless someone bids higher than the reserve price Cadbury's sets, no one takes it over. What reserve price should Cadbury's set?

If Cadbury knows the valuations, it should set a reserve price of 5, leading Kraft to acquire the company for 0 return. (If this is too risky, since Kraft could not bid for the same payoff, a reserve price of 4 would guarantee Kraft participates.)

Otherwise, it should set a reserve price of 2.