



Keio Business School

Constructing a Strategy in a Management Game: When to Invest, How Many to Produce

Abstract

The purpose of this material is to learn the multi-faceted recognition of a situation and the multi-layered reasoning in strategic thinking by examining the data taken from a management game that was actually played. In the strategic situation considered here, each decision influences one another, resulting in interdependent decision-making or bargaining among decision-makers. Namely, there are multiple decision-makers. Non-cooperative games are suitable for describing and analyzing those situations. This material intends to be an introduction to the theory of non-cooperative games. In this management game, participants were assigned to companies and consumers, and those assigned to the companies determined the timing of investment in their own production equipment as well as the production volume of an identical commodity. The entrance door of game-theoretic analysis is understanding the difference between “plan” in management and “strategy” in game theory.

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Questions

Section 2 of this material describes the instructions that were distributed to the participants in a management game. Participants were assigned to a consumer side and a corporate side. Those assigned to a corporate side managed companies and determined the timing of capital investment and the production volume, competing with one another in the market of their product.

1. Read the instructions of the management game carefully, which are described in Section 1.

Suppose that you were the manager of a company in this management game. What strategy would you build for maximizing the total profit of the company? This management game consists of 7 terms, and you do not need introduce discount rates (time preferences) into your consideration.

2. This management game was already played by college students. The data of managers decisions are attached in the Appendices. Complete the tasks provided in Section 3, using the data.

Choose a company and review the actions taken by the company in each term. Was the timing of capital investment best? Was the production volume most appropriate? If you could change the strategies of the company, how would you infer the rival companies' reactions to the change?

- If you think there are logical errors in the data, you may modify them. Explain the reasons of any corrections you make.

3. Review the strategy you build in Question 1, referring to the results of your data analysis conducted in Question 2. Are there are changes that should be made? Explain how you elaborate and revise your strategy.

1 Introduction

It is difficult to remove mechanical equipment once installed at manufacturing sites, but the equipment becomes obsolete as time elapses. Commodities that go unsold at retail stores will be returned to the manufacturer to be stored as inventory, which incurs management costs. Consider a situation in which the unit cost of production of a commodity is reduced for some terms after such equipment is installed, but the price of the commodity will decrease. If you produce and sell more products in order to recover the capital investment. Furthermore, the rival companies who produce and sell an identical commodity are faced with the same situation. The price of the commodity will drop when those companies invest in production equipment and supply more units of the product in the market. If you were a manager of one of those companies, then how would you analyze this situation for a better decision on the timing of the capital investment and production volume? In this material, let us consider this strategic situation, examining the data taken from a management game actually played.

The remainder of this material is organized as follows. Section 2 describes the rules of a management game. The instructions are presented there for both a corporate side and a consumer side. This management game was already played by college students. The data are attached in the Appendices. Section 3 provides some tasks for analyzing the data from the viewpoints of macroeconomics and microeconomics. A handy calculator can deal with the data but a software such as Excel is better for visualizing the results. Answer the questions posted to readers at the beginning of this material.

2 Instructions

In this management game, 8 companies produce an identical fictitious commodity and sell it directly to 32 consumers, competing with one another in the market in 7 terms. In each company, managers make their decision on “when to invest” in a production equipment (a machine) and “how many to produce” the commodity under the following constraints. (1) The machine can be used in 2 consecutive terms immediately after the installation. (2) Inventory management costs are extremely high, so that all unsold commodities must be disposed of free of charge. The participants in this management game are randomly assigned to a consumer side and a corporate side. Those assigned to the corporate side are divided into 8 companies of 4 participants. The consumers and companies enter in separate rooms, which we call the Consumer Room and the Corporate Room.

Each term has a Production Period (4 minutes) and a Trading Period (3 minutes). In the Production Period, the first 3 minutes are dedicated to Strategic Meetings held by the members in each company, and the remaining 1 minute is spent for Production in which those members decide whether to invest in a production equipment and the number of the commodity for sale. White cards are used for the fictitious product. During this period, consumers can refer to the transaction history up to that term

and consider strategies for purchasing products at a lower price in price negotiations with companies. Each consumer may purchase at most one unit of the commodity. The Trading Period is literally the time for freely negotiating prices with companies and trading the commodity. The trades start when all consumers enter the Corporate Room in which companies wait for them. Negotiations may be conducted with any number of companies simultaneously at any time during the Trading Period.

In playing this management game, participants assigned to a corporate side are required to understand not only the rules for the companies but also the rules for the consumers. Similarly, participants assigned to a consumer side are required to understand not only the rules for consumers but also the rules for companies. Each subject is provided with written instructions upon arrival and then the instructor reads a copy of these instructions aloud. Subjects are allowed to ask general questions regarding the instructions and are given answers. One practice term is played before proceeding to the first term, in order for participants to review the procedure of this management game.

2.1 Rules for Companies

Each company can produce up to 5 units of product. It is allowed not to produce any units. The production costs are 100 per unit. Companies may introduce a machine that reduces the unit cost of production. This is called “investment.” The production costs for companies with such a machine are 30 per unit, and the price of the machine itself is 540. Furthermore, the service life of the machine is 2 terms; that is, the machine breaks down promptly after 2 terms elapses. Companies that wish to continue using the machine after the end of its useful life will need to purchase them again at a price of 540. There is no benefit to owning more than one machinery; that is, the production cost is the same with two machines as with one machine. The machine cannot be resold to any other companies. Note that production costs vary depending on the unit of production, as shown in the following example.

Example: To produce 5 units per term for 2 terms without a machine would cost a total of $10 \times 100 = 1,000$, but with a machine, it would only be $540 + 10 \times 30 = 840$. In comparison, whereas producing only 2 units per term for 2 terms without a machine would cost a total of $4 \times 100 = 400$, to do so with a machine would end up costing a total of $540 + 2 \times 2 \times 30 = 660$.

Prior to this management game, each company is asked for the registration. Name your company. Then, go to the supervisor (an instructor) in charge of companies and register the name of the company and the names of the managers. In each term, you are asked to play the management game according to following the steps.

- (1) In each Production Period, hold a strategy meeting and then, as managers, decide whether to purchase (invest in) a machine and how many units of product to produce. Enter this information

on a separate Experiment Record Sheet. Next, show your Experiment Record Sheets to the supervisor in charge of companies to receive product cards for the number of units to be produced. Product cards are white pieces of paper on which nothing is written. After distributing product cards to all companies, another supervisor (a chief instructor) reveals which companies have the machine to all consumers as well as all companies.

- (2) Consumers come into the Corporate Room to purchase the products. There are 32 consumers, each of whom can purchase at most one unit of the product. The Corporate Room thus becomes a marketplace. In groups of four, split up to sell your products (the product cards) as you like. Whenever you conclude a sales contract with a consumer, give a product card to that consumer.

A Trading Rule: This rule imitates a transaction known as a “continuous trading session” (zaraba in Japanese) on stock exchanges. The seller may shout out the selling price, and look for a buyer. The buyer can also shout out a buying price, and look for a seller. Negotiations have a time limit of 3 minutes. You are free to find trading partners and negotiate prices as you like. You are also free to choose a negotiating partner. You may also negotiate with any number of partners simultaneously. If negotiations have not been finalized, you can switch partners to negotiate elsewhere. When the chief instructor signals that time is up, you must cease all negotiations.

Once a sales contract has been concluded with a consumer, go over to the supervisor in charge of companies with the consumer and report the company name, transaction price, and the number written on the card that the consumer carries (consumer card). The supervisor records these on the supervisor’s copy of Experiment Record Sheet. When the record was completed, the sales contract will be regarded as having been formally established. Also, be sure to record the sale (transaction) price on your own Experiment Record Sheet for later use at the Strategic Meeting.

NB: Unsold products cannot be carried over to the next term. Moreover, the costs expended on production are non-refundable. Accordingly, anything likely to remain on the shelf would be better off being sold off at a discount.

- (3) Working with the other three managers in your company group, refer to the Experiment Record Sheets that you each filled out and share the number of products sold and the prices realized for each. Make sure that the same number is written on the Experiment Record Sheet. Next, calculate the total sales, current profit for the term, and the cumulative profit. Supervisors will do the same thing. Once the calculations have been completed, the current profit for the term will be disclosed to all consumers and all companies. This corresponds to the quarterly disclosure of securities reports in the real economy.) This concludes the trading for the term.

... Return to step (1). The transactions are repeated for 7 terms. Read the rules for consumers. Practice for about one term to get used to filling out the recording forms and the overall flow. The results of the practice are not used to calculate the cumulative profit.

2.2 Rules for Consumers

(A) (Consumers Room) At the beginning of each term, each consumer draws a card on which a number is written. For each consumer, the number represents the willingness to pay for the product or the degree of satisfaction (utility) that he or she obtains by consuming it. This card is called a consumer card. The numbers are distributed in increments of 10 from 110 to 210 so that there are 3 cards for each number except 110 and 210. The average is thus about 160. The number written on the card is your private information and should not be shown to the other participants (either consumers or companies) until the completion of the transaction. When you receive the consumer card, fill in the number on the card in the corresponding space on your Experiment Record Sheet.

(B) (Corporate Room: Marketplace) Bring your consumer card into the Corporate Room. That will be the marketplace. Feel free to buy products from the companies as you like. However, you may only purchase one unit of the product. After the game supervisor signals the start of trading, you are free to find trading partners and negotiate prices as you like. You are also free to choose a negotiating partner. You may also negotiate with multiple partners simultaneously.

- The seller will shout out the selling price, and look for a buyer. The buyer will also shout out a buying price, and look for a seller. Negotiations have a time limit of 3 minutes.
- If negotiations have not been finalized, you can switch partners to negotiate elsewhere. When the instructor signals that time is up, you must cease all negotiations. Once a sales contract has been concluded with a seller, receive the product card and go over to the supervisor in charge of companies with the seller and report the company name, transaction price, and the number written on the card that the you carry.

When the chief instructor signals that time is up, you must cease all negotiations. The supervisor will record these on the supervisor's copy of the Experiment Record Sheet. When the record is completed, the sales contract will be regarded as having been formally established. Also, be sure to record the purchase (transaction) price on your own Experiment Record Sheet.

Return your numbered card and the product card given by the company to the supervisor. Then, return to the Consumer Room. If you would like to hear reports of the current profit for each company, you can see the reports at the Consumer Room.

(C) (Consumer Room) When the companies' next Production Period begins, consumers are to return to the Consumer Room, where each consumer will calculate the difference between the value on his or her consumer card and the purchase price (benefit). This concludes the trading for the term.

... Return to step (A). These transactions are repeated for 7 terms. Read the rule for companies. Practice for about one term to get used to filling out the recording forms and the overall flow. The results of the practice are not used to calculate the cumulative profit.

2.3 Announcements

Some reward is given to the managers of the top company that have the highest cumulative profits and the top three consumers who have accrued the highest total benefits at the end of all terms. After a break time, the roles of companies and consumers are switched, and the management game is played again.

3 Analysis of the Data

According to the rules described in Section 2, the management game was played twice, in the first half and the second half. Participants assigned to companies in the first half played the role of consumers in the second half, and participants assigned to consumers in the first half played the role of companies in the second half. The data on the decisions made by companies in the first half are presented in Appendix 2a, and those in the second half are presented in Appendix 2b. Appendix 1 is a list that summarizes the timing of capital investment made by each company. Consider the tasks provided below and then answer the questions posed at the beginning of this material.

Task 1: Macroeconomic Viewpoint

(1) Calculate the nominal GDP, the average price, and real GDP for each term, referring to the data in Appendices 2a and 2b. The nominal GDP is defined as the sum of the profits of all companies and the amount of capital investment, and the real GDP is defined as

$$\text{nominal GDP/average price.}$$

(2) Draw the graphs of the real GDPs for the first half and the second half, respectively. Take term in the horizontal axis and real GDP in the vertical axis in the graphs.

(3) Describe the characteristics of the transition of the real GDP for each of the first half and the second half in reference to the graphs drawn in (2.). Consider what the causes of the appearance were.

Task 2: Microeconomic Viewpoint

Select one of the companies. Suppose that you were the manager of that company. Evaluate the timing of capital investment and the production volume that were determined in this management game, referring not only to the data of the company you chose but also to the data of other companies.

Appendix 1: The Timing of Capital Investment

Table 1 shows the term when the machine was used by company i (com i , $i = 1, 2, \dots, 8$).
 10 The cumulative profit (cum profit) of each company is also shown at the bottom of each small table.

Table 1: Use of the Machine and Cumulative Profits

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first half		com 1	com 2	com 3	com 4	com 5	com 6	com 7	com 8
term									
1		1	1	1	1	0	1	1	1
2		1	1	1	1	0	1	1	1
3		1	1	0	1	1	1	1	0
4		1	1	0	1	1	1	1	0
5		0	0	0	0	0	1	0	1
6		1	1	0	0	0	1	1	1
7		1	1	0	0	0	0	1	1
cum profit		-119	-102	-283	-97	31	-130	-14	-120

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second half		com 1	com 2	com 3	com 4	com 5	com 6	com 7	com 8
term									
1		0	1	1	0	1	0	0	0
2		0	1	1	1	1	0	0	0
3		0	0	0	1	1	1	1	0
4		0	1	1	0	1	1	1	0
5		0	1	1	0	1	0	1	0
6		0	1	1	0	1	1	1	0
7		0	1	1	0	0	1	0	0
cum profit		277	437	343	144	455	170	383	280

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Note: A value of 1 indicates that the machine was used in the term.

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Appendix 2a: Decisions Made in the 1st Half

In Tables 2-10, for each company that made decisions in the first half, the following data are listed: how many were produced (quant), how much was the unit cost of production (unit cost), the amount of investment (invest), how much was the total cost (total cost), how much was the product sold for each unit (p_1, \dots, p_5), sales, the current profit and cumulative profit. In the column for invest, the amount of investment, 540, was noted only in the term when the capital investment was made. For prices (p_1, \dots, p_5), a value of 0 indicates that the product was not sold. If there is no unsold product, the cell for the price is left blank.

Table 2: company 1 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	100	100	99	90	90	479	-221	-221
2	5	30	0	150	85	75	80	71	73	384	234	23
3	5	30	540	690	75	115	115	55	60	420	-270	-247
4	5	30	0	150	45	25	70	70	73	283	133	-114
5	3	100	0	300	120	115	120			355	55	-59
6	5	30	540	690	40	80	45	85	81	331	-359	-418
7	5	30	0	150	82	90	92	90	95	449	299	-119

Table 3: company 2 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	120	85	88	0	20	570	-380	-380
2	5	30	0	150	95	80	80	80	0	510	360	-20
3	5	30	540	690	70	70	70	73	65	535	385	365
4	5	30	0	150	70	81	75	70	65	525	-425	-60
5	0	100	0	0						435	285	225
6	5	30	540	690	90	91	90	50	110	431	-259	-602
7	5	30	0	150	95	95	150	150	160	650	500	-102

Table 4: company 3 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	100	110	87	100	0	397	-293	-293
2	5	30	0	150	80	120	60	50	0	310	160	-133
3	3	100	0	300	60	75	75			210	-90	-223
4	2	100	0	200	75	65				135	-65	-288
5	1	100	0	100	85					85	80	-303
6	1	100	0	100	120					120	20	-283
7	0	100	0	0						0	0	-283

Table 5: company 4 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	90	80	85	70	0	325	-365	-365
2	5	30	0	150	85	40	40	40	0	382	232	-133
3	5	30	540	690	80	65	76	80	80	381	-309	-442
4	5	30	0	150	80	75	65	100	55	375	225	-217
5	0	100	0	0						0	0	-217
6	0	100	0	0						0	0	-217
7	3	100	0	300	100	113	115			420	120	-97

Table 6: company 5 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	4	100	0	400	110	90	90	85		375	-25	-25
2	4	100	0	400	110	105	80	75		342	-55	-80
3	5	30	540	690	95	73	85	75	80	425	-265	-345
4	5	30	0	150	84	75	65	100	55	367	217	-128
5	1	100	0	100	199					199	99	-29
6	3	100	0	300	105	105	130			340	40	11
7	3	100	0	300	100	113	115			320	12	31

Table 7: company 6 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	100	80	80	0	0	260	-430	-430
2	4	30	0	120	90	80	80	70		320	200	-230
3	5	30	540	690	60	80	75	75	75	365	-325	-555
4	3	30	0	150	75	70	65	70	65	345	195	-360
5	4	30	540	690	130	130	110	115	120	605	-85	-445
6	5	30	0	150	100	95	100	90	80	465	315	-130
7	3	100	0	300	100	100	100			300	0	-130

Table 8: company 7 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	110	100	90	100	65	465	-225	-225
2	5	30	0	150	90	81	78	60	60	369	219	-6
3	5	30	540	690	85	81	50	65	65	346	-344	-350
4	5	30	0	150	60	70	80	100	60	370	220	-130
5	0	100	0	0						0	0	-130
6	5	30	540	690	70	85	83	92	70	400	-290	-420
7	5	30	0	150	100	100	111	100	145	556	406	-14

Table 9: company 8 (first half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	90	90	91	90	90	451	-239	-239
2	5	30	0	150	85	80	0	0	0	165	15	-224
3	0	100	0	0						0	0	-224
4	0	100	0	0						0	0	-224
5	5	30	540	690	87	85	85	90	100	447	-243	-467
6	5	30	0	150	92	100	90	90	115	487	337	-130
7	1	100	0	100	110					110	10	-120

The data for the first half are downloadable at the following site.

<http://labs.kbs.keio.ac.jp/naoki50lab/TimingStrategicInvest1.xlsx>

Appendix 2b: Decisions Made in the 2nd Half

Tables 11-19 present the data on decisions made by companies in the second half.

Table 10: company 1 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	2	100	0	200	115	110				225	25	25
2	3	100	0	300	105	115	115			335	35	80
3	3	100	0	300	110	110	130			350	50	110
4	3	100	0	300	102	120	110			332	32	142
5	3	100	0	300	115	115	120			350	50	192
6	4	100	0	400	105	110	105	95		415	15	207
7	3	100	0	300	120	120	130			370	70	277

Table 11: company 2 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	4	30	540	660	97	95	91	92		375	-285	-285
2	5	30	0	150	100	100	95	93	95	483	333	48
3	0	100	0	0						0	0	48
4	5	30	540	690	95	105	100	90	100	490	-200	-152
5	5	30	0	150	100	110	101	105	101	517	367	215
6	5	30	540	690	100	103	105	103	95	506	-184	31
7	5	30	0	150	106	115	120	105	110	556	406	437

Table 12: company 3 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	90	100	127	142	112	613	-337	-337
2	5	30	0	150	90	95	110	100	100	490	340	125
3	0	100	0	0						0	0	125
4	5	30	540	690	89	95	90	85	90	365	-241	-116
5	5	30	0	150	100	100	110	120	105	535	385	269
6	5	30	540	690	104	105	100	95	0	404	-288	-17
7	5	30	0	150	105	105	95	105	100	510	360	343

Table 13: company 4 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	1	100	0	100	100					100	0	0
2	5	30	540	690	90	90	85	85	90	440	-250	-250
3	5	30	0	150	90	90	85	80	80	160	-40	55
4	1	100	0	100	105					105	5	30
5	3	100	0	300	110	110	110			330	30	60
6	4	100	0	400	105	105	120	110		440	40	100
7	3	100	0	300	105	120	119			344	44	144

Table 14: company 5 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	5	30	540	690	90	90	100	105	91	476	-214	-214
2	5	30	0	150	95	110	100	120	110	535	385	-171
3	5	30	540	690	98	110	110	125	92	535	-155	16
4	5	30	0	150	86	87	100	100	90	463	313	329
5	5	30	540	690	85	85	90	105	90	455	-235	94
6	5	30	0	150	100	90	100	100	115	490	340	434
7	1	100	0	100	121					121	21	455

Table 15: company 6 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	0	100	0	0						0	0	0
2	1	100	0	100	105					105	5	5
3	5	30	540	690	90	85	95	85	90	445	-245	-240
4	5	30	0	150	90	90	85	90	90	445	295	55
5	0	0	0	0						0	0	55
6	5	30	540	690	100	105	105	110	0	620	-270	-215
7	5	30	0	150	110	110	105	100	110	535	385	170

Table 16: company 7 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	0	100	0	0						0	0	0
2	1	100	0	100	110					110	10	10
3	5	30	540	690	100	90	100	100	100	490	-200	-190
4	5	30	0	150	95	90	100	105	100	490	340	150
5	5	30	540	690	120	105	110	120	130	585	-105	45
6	5	30	0	150	103	95	105	120	75	498	348	393
7	2	100	0	200	20	170				190	-10	383

Table 17: company 8 (second half)

term	quant	unit cost	invest	total cost	p1	p2	p3	p4	p5	sales	current profit	cum profit
1	1	100	0	100	130					130	30	30
2	2	100	0	200	110	120				230	30	60
3	4	100	0	400	120	110	110	130		470	70	130
4	2	100	0	200	110	120				230	30	160
5	3	100	0	300	120	130	105			355	55	215
6	2	100	0	200	110	120				230	30	245
7	2	100	0	200	115	120				235	35	280

The data for the second half are downloadable at the following site.

<http://labs.kbs.keio.ac.jp/naoki50lab/TimingStrategicInvest2.xlsx>

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