Developments in Business Simulation and Experiential Learning, Volume 32, 2005

A COMPARISON BETWEEN SOLUTIONS AND DECISIONS IN A BUSINESS GAME

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ABSTRACT

We use the concept of solutions in games to analyze relations between decisions and profits in a business game. When we compare the cooperative, noncooperative and competitive solutions to decisions made when the game is played we find that the noncooperative solution best describes the mean decisions in the game, but that the individual decisions of firms are dispersed. We show how the comparisons enhance understanding of relations between decisions and profits, and evaluation of performance of firms in business games.

INTRODUCTION

One common objective for firms playing a business game is to earn as much profit as possible. That is, the participants acting as firms in the game are trying to make decisions that give their firms the highest possible profit. The profits the firms earn depend on the design of the business game, for example, when the game consists of an oligopoly market, the profits depend on the decisions of the other firms competing in the same market, and when the game has dynamic properties, the profits depend on decisions in the present period and in the previous periods of the game. In this article, we will analyze the relations between decisions and profits in a business game.

Dickinson and Faria (1997) found that the strategies decided by participants in firms were systematic and that they performed better than random strategies. Neal (1999) suggested, after studying performance of winning strategies in a business game, the further studying of strategies that beat the winning strategies. Dickinson (2003) showed the importance of the decisions of the competitors in a business game. Shubik (2002) concluded that games appear to be of considerable aid for participants when learning theoretical concepts.

We use the concept of solutions in games (Shubik and Levitan, 1980; Tirole, 1988; Shubik, 2002) to study relations between decisions and profits, and to evaluate performance in a business game. The concept has not to our knowledge been used in the gaming literature before. The concept adds to the listing of learning objectives (Washbush and Gosen, 2001) and to what business games can teach (Faria, 2001). We will show how comparisons between solutions and decisions enhance the knowledge of how games are played (Keys and Wolfe, 1990; Wolfe and Crookall, 1998) and how the comparisons enhance debriefings after games have been played (Lederman Costigan, 1992).

Three main theoretical solutions are of interest. First, the cooperative solution where the total profit for all firms in the market is highest. Second, the noncooperative solution where no firm in the market can unitarily alter its decisions to improve its profit (also called Nash-equilibrium based on Nash, 1951). Third, the competitive solution where all firms in the market yield zero profits. A firm can earn even higher profit than the cooperative solution by making decisions that only maximize its own profit. These decisions are called best reply decisions. All firms in the noncooperative solution make their best reply decisions to the decisions of the other firms. As the number of competing firms in the same market increases, decisions in the noncooperative solution become closer to decisions in the competitive solution, and the profits decrease. We should point out that these theoretical solutions are used as benchmarks for comparisons to decisions actually made in markets, but they do not necessarily reflect these decisions.

In the field of economics, games are described in full detail as they are studied, and solutions are determined and compared to the decisions made by participants in experiments (Smith, 1994). The participants in experiments receive monetary rewards proportional to the profits they earn. Numerous experiments have been conducted with, for example, the models of Bertrand and Cournot (Holt, 1995). The general finding is that two and three firms make decisions between cooperative solution and noncooperative solution, and four or more firms make decisions close to the noncooperative solution (Dufwenberg and Gneezy, 2000; Huck, Normann, and Oechssler, 2004).

Compared to games in economics, business games usually have more decision variables and they also have dynamic properties. Still, the decisions in experiments in economics may be similar to decisions made in a business game. We will use the solutions in a comparatively small business game (Ståhl, 1986; Edman, 2000) for comparison to decisions made when the game is played, and for evaluation of performance in the game. The game has been played internationally for over a decade as part of courses at a number of universities and also in executive training. The goal for the firms is to maximize the equity at the end of the game. Since five firms compete in the same market, we state the hypothesis that of the three solutions, the noncooperative

solution gives the best description of the decisions the firms make when playing the game.

METHOD

Participants. Two hundred and twenty-four students played the business game in their first year at a business school. It was mandatory for the students to play the game, as they played it for educational purposes as part of a course. The participants were informally divided into eight sessions with 5 firms in each session and with 3 – 8 participants in each firm. We will analyze decisions from altogether 40 firms, where 5 firms competed in the same market at the time.

The business game. The game is described in full detail in Edman (2000). The business game deals with an oligopoly market where firms compete by producing and selling similar, but not identical, storable products in the same market. The game has dynamic properties, where the following four state variables are carried over from one period to the next: machine capacity, stocks, balance in checking account and cumulative advertising. Equity is calculated as the value of machine capacity and stocks plus the balance in the checking account. The cumulative advertising is not included in the equity. All firms start with the same amount of equity: cash in the checking account, but no machine capacities, no units in stocks and no cumulative advertising.

The firms have to decide upon the following four decision variables in each period as they produce to sell their products in the market: investments in machinery, production quantity, price and advertising. One unit of machine capacity can produce one unit of the product in each period of the game. The costs of one unit of machinery and one produced unit are fixed.

When the decisions are made, three outcome variables are calculated: interest rate, demand and sales. If the balance in the checking account is negative, for example, due to outlays on investment, production and advertising, the firms can borrow money. The interest rate depends on the size of the balance in the checking account and the equity of the firm. The business game has the characteristics of an oligopoly maret, where there is interdependence among decisions made by the firms. The demand for a firm's products is dependent not only on the price and the cumulative advertising of that firm, but also on the mean prices and the mean cumulative advertising of the other firms competing in the same market. In this connection it should be mentioned that no random factors are involved in the game, not even with regard to the demand for the products. Thus, the state variables and the decisions of the firms completely determine the outcome. The game is symmetric as all firms face the same costs and demand for their products.

The machines depreciate during each period, both physically and in accounting terms. Products not sold in one period go into stocks and can be sold in a subsequent period. Cumulative advertising consists of advertising in a period, plus a part of the cumulative advertising from the previous period, plus a factor reflecting the advertising effect of sales in the previous period. The profit is the difference between the equity at the end of a period and the equity at the start of a period. If a firm has equity below zero, it goes into bankruptcy. The firm can then receive a money grant from the government that decreases its debt and thus increases its equity. The money grant is deducted with interest from the equity of the firm at the end of the game. A firm can, therefore, have negative equity at the end of the game.

Theoretical solutions in the business game. Since the game is symmetric, that is, all firms face the same costs and the same demand function, and since the game has dynamic properties, we determined the symmetric dynamic solutions in the game. That is, all firms make the same decisions in the solutions and the solutions are determined for the number of periods the game is played. We used these theoretical solutions for comparisons to the decisions and profits when the game is played.

For the cooperative solution, equity is maximized for one single firm in the market, and since the solution is symmetric the other firms will make the same decisions. For the noncooperative solution, the best reply decisions are determined for each firm in the game. That is, equity is maximized for each one of the firms towards the decisions of the other firms in the market**.** The noncooperative solution can be verified by assigning the noncooperative solution decisions to the other firms, and then determining the best reply for a firm. Since the solution is symmetric, the best reply decisions shall then be the same as the decisions in noncooperative solution.

We used the Excel Solver (Smith and Lasdon, 1992; Fylstra, Lasdon and Watson, 1998) to find the cooperative and the noncooperative solutions. Since the results from the Solver varied somewhat depending on start values, we used different start values and ran the Solver 100 times for each solution. We used the mean values of these 100 runs as values for the solutions (values are presented with integers in Table 1). This precision is sufficient for the purpose of comparing the solutions to decisions when the game was played. Edman (2000) described how the solutions were determined in detail.

For the competitive solution, there are many decisions that yield zero profit, that is, where the equity at the start of the game is the same as the equity at the end of the game.

Procedure. In each session, the game including briefing and debriefing was played for a total of 3 – 4 hours. The game was presented at briefings of about 20 minutes. We instructed the participants on the rules, a decision form and the reports, an interest table and a demand table. We presented a numerical example of how to make decisions and also how to estimate demand in the market with a demand table. The participants were informed that the game would be played with a test period and that the game would be restarted from "scratch" and played for exactly 6 periods. As mentioned, the goal for the participants was to maximize

Table 1: Solutions, mean decisions when playing and best reply decisions to decisions when playing (standard deviation within parentheses).

	Period					
	1	2	3	4	5	6
Investment						
Cooperative	5	2	1	1	0	0
Noncooperative	10	1	2	2	2	2
Competitive	11	1	1	2	1	1
Playing	10 (4)	2 (2)	1 (2)	1 (2)	1 (2)	2 (4)
Best reply	12 (4)	1 (2)	3 (2)	2 (2)	1 (1)	0 (0)
Production						
Cooperative	5	6	6	6	5	5
Noncooperative	10	10	11	12	13	14
Competitive	11	12	12	13	13	13
Playing	10 (4)	11 (4)	12 (4)	12 (4)	12 (4)	13 (5)
Best reply	12 (4)	12 (5)	14 (5)	15 (4)	14 (3)	13 (3)
Price						
Cooperative	53	48	48	48	50	50
Noncooperative	39	39	37	35	33	30
Competitive	35	35	35	35	35	35
Playing	39 (8)	37 (8)	37 (7)	35 (6)	34 (6)	27 (8)
Best reply	40 (2)	39 (2)	37 (1)	35 (1)	32 (2)	27 (3)
Advertising						
Cooperative	73	35	28	28	11	0
Noncooperative	232	87	116	128	95	0
Competitive	172	172	172	172	172	172
Playing	189 (80)	89 (57)	101 (53)	117 (50)	116 (79)	72 (102)
Best reply	259 (56)	105 (49)	145 (44)	132 (32)	67 (33)	0 (0)
Cum. Advertising						
Cooperative	73	84	84	85	68	46
Noncooperative	232	236	268	300	287	185
Competitive	172	286	355	398	423	439
Playing	189 (79)	212 (77)	239 (68)	273 (74)	292 (92)	259 (130)
Best reply	259 (56)	273 (80)	321 (88)	338 (79)	284 (62)	185 (41)
Equity						
Cooperative	311	483	680	897	1145	1414
Noncooperative	138	236	324	416	553	787
Competitive	187	183	182	183	187	193
Playing	144 (74)	197 (111)	248 (149)	296 (195)	370 (226)	404 (323)
Best reply	162 (23)	287 (76)	413 (134)	560 (187)	751 (232)	957 (278)

the equity at the end of the game. The participants were also informed that the game sessions were played with monetary rewards (Holt, 1995). At the debriefings, one of the firms in each game session was selected by randomization to win its equity at the end of period 6 minus the 200 in cash the firms had at the start of the game (the exchange rate was about US $ 0.1 for the earned equity).

RESULTS

Decisions

Table 1 shows values on decisions, cumulative advertising and equity for the cooperative and for the noncooperative solution, and for one out of many competitive solutions where the decisions for all 5 firms in all 6 periods are 35 on price and 172 on advertising. Table 1 also shows the mean decisions, cumulative advertising and

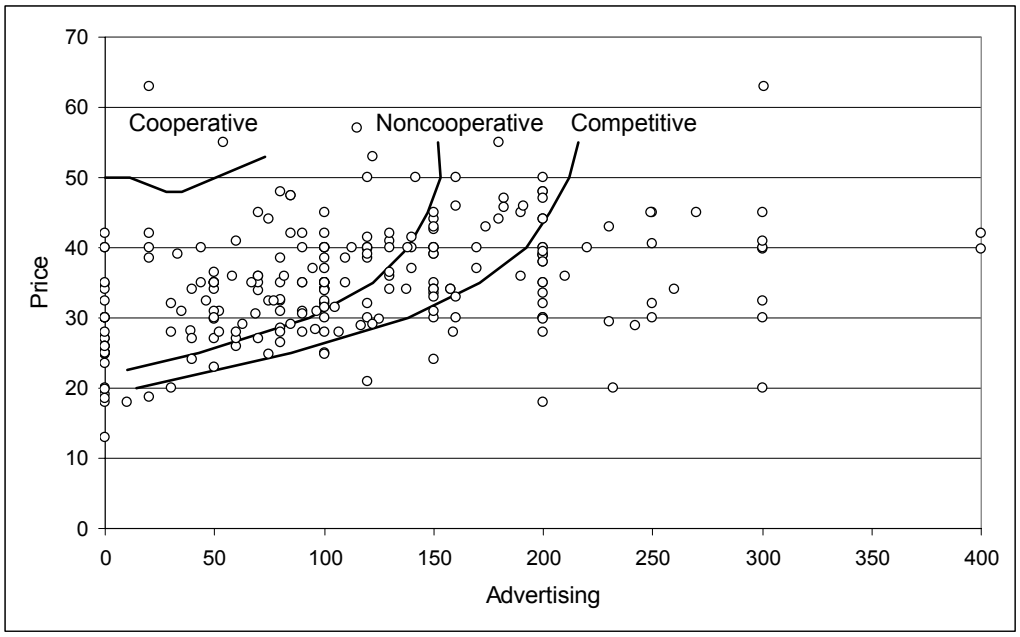

Figure 1: Curves show solution equities and rings show pairs of decisions on price and on advertising when playing the game.

equity of 40 firms when the game was played (called Playing in the table). Table 1 shows that the cooperative solution consists of lower investments, lower production, lower advertising, and higher prices than the noncooperative solution. The dynamic properties in the game make advertising higher in period 1 and lower in period 6 for both solutions, while production increase and prices decrease over time in the noncooperative solution. Although advertising is lower in the noncooperative solution compared to the competitive solution in most periods, production is about the same in the two solutions.

Figure 1 shows one curve for the cooperative solution decisions in Table 1 (equity 1414) and two curves with the same combinations of price and advertising decisions in all 6 periods that give the same equities as the noncooperative solution (787) and competitive solution (200). The rings in Figure 1 show combinations of decisions on price and on advertising when playing the game.

Out of altogether 240 pairs of decisions on price and on advertising when playing the game (40 firms in 6 periods), 2 pairs were above the cooperative equity line, 120 pairs were between the cooperative and the noncooperative equity lines, 60 pairs were between the noncooperative and the competitive equity lines, and 58 pairs were below the competitive equity line (whereof 17 pairs of decisions were in period 1, where also the noncooperative solution decisions are below the competitive equity line). Hence, most pairs of decisions are between the cooperative and the competitive equity lines. Moreover, the mean decisions for all firms in all 6 periods were 35 on price and 110 on advertising. Furthermore, since Table 1 shows that the noncooperative solution and the mean decisions when playing the game were similar, we find support for the hypothesis that the noncooperative solution gives the best description for the decisions made when the game was played.

Profits

We use equity at the end of period 6 as a measurement of profit as this equity consists of equity at the start of the game plus profits in period 1 to 6. The equity at the end of period 6 in the cooperative solution (1414) is about double the equity in noncooperative solution (787), and about seven times the equity in the competitive solution (200).

Calculations based on solution decisions in Table 1 show that one firm with a strategy of competitive solution decisions compared to cooperative solution decisions can earn much higher equity (from 1414 to 3980) and that the other four firms with a strategy of cooperative solution decisions earn less equities (from 1414 to 597). Calculations also show that a firm with a strategy of noncooperative solution decisions compared to competitive solution decisions increases its equity (from 200 to 460) and that the other four firms having strategies of competitive solution decisions also increase their equities (from 200 to 260). Furthermore, we know from the definition of the noncooperative solution, a firm can not earn higher equity than the noncooperative solution decisions when the other firms make their noncooperative solution decisions. Thus, depending on the decisions of the other firms, decisions between the noncooperative and the competitive solution give a firm maximizing only its own profit the highest profit when playing the game.

Best Reply Decisions

In order for firms to make their best reply decisions, the firms need to form expectations of the decisions of the other

firms in the same market. The dispersion among the decisions of all 40 firms is substantial (standard deviations are shown in Table 1), especially when considering that the game is symmetric. However, there were regularities between decisions from one period to the next. Table 2 shows a factor analysis (Hamilton, 1992) for decisions on price and on cumulative advertising in periods 1 – 6, of the other firms in the market and of the individual firms. The analysis shows regularities for factor 1 for price of other firms as the factor loadings in periods 1 to 4 were respectively .9, 1.0, 1.0, .7. This means that a firm facing competing firms with high prices in period 1 was likely to face high prices also in periods 2 – 4. Correspondingly for cumulative advertising, a firm which faced competing firms with high cumulative advertising in period 2 was likely to face high cumulative advertising also in periods 3 – 5. These regularities of decisions of the other firms in the same market made it easier for firms to form expectations of the decisions of the competing firms. The factors also show regularities in decisions of individual firms. The mean error when estimating demand, either as products in stock or lost sales was 3.9 (*SD*=3.9). The factor for Error in estimation in demand in Table 2 shows that firms making poor estimates of demand in period 2 also made poor estimates in periods 3 – 6.

We calculated the best reply decisions for each of the 40 firms on the assumption that the decisions of the other firms in the same market were the same decisions as when the games were played. Table 1 shows that mean decisions when playing and the mean best reply decisions were similar. The largest differences were on advertising in periods 1 and 6, resulting in somewhat higher production, cumulative advertising and equity for best reply decisions. These differences in decisions and errors in estimation of demand were the reasons for the difference between mean equity when playing (404) and best reply equity (957).

Performance

The relations between solutions and decisions are important when evaluating performance. We use two measurements on performance of firms at the end of the game: the equity of a firm and the equity of a firm divided by the equity the firm could have earned if it had made its best reply to the decisions of the other firms (here called percentage of best reply equity). If a firm has earned 100% of its best reply equity, it has made its best reply. If all firms in the same market have earned 100% of their best reply equities, they have all made noncooperative solution decisions. Although the game was exactly the same in all eight sessions, the performance of the 40 firms varied considerably: the equity range was -213 to 1035 (*M*=404) and the percentage of best reply equity range was -26% to 78% (*M*=41%).

The performance of firms can be evaluated between firms in the same game session and between firms in different game sessions. Since the mean decisions of the competing firms vary little between firms in the same game session in this game, best reply equities vary also little between firms in the same session. Comparisons between firms in the same session based on equity and based on percentage of best reply equities give the same results for 38 out of the 40 firms playing the game. Thus, when evaluating performance of firms in the same game session, equity and percentage of best reply equities give similar results.

Table 2: Factor analysis of decisions (Varimax rotation) with factors and factor loadings, and with variance and eigenvalues. Regression model of equity at the end of period 6 (adjusted R^2 is .62) based on factor loadings with coefficients (*<.05 and **<.01) and standard errors.

	Period						Variance	Eigen-	Coeff.	St.
Factors of decisions	1	2	3	4	5	6	%	value		Err.
Price other firms										
Factor 1	.9	1.0	1.0	.7			53	3.2	158**	53
Factor 2					1.0	.9	32	1.9	14	43
Cum. Adv. Other firms										
Factor 1		.5	1.0	.9	.8		48	3.1	-57*	44
Factor 2	.9	.8					38	2.1	-46	55
Price										
Factor 1	.9	.9	.9	.5			46	3.2	64*	50
Factor 2				.6	.9	.7	29	1.3	28	49
Cum Adv										
Factor 1	.8	.9	.7				50	3	2	46
Factor 2			.5	.7	.9	.7	24	1.4	-46	60
Error in est. demand										
Factor 1		.6	.9	.9	.8	.8	53	3.2	-148**	37

However, comparisons of performance of firms between sessions show important differences. For example, a firm with the highest performance in its session had only rank 20 out of 40 firms on equity (rank 1 is highest of 40 firms) and another firm with highest performance in its session ranked only 15 on percentage of best reply equities, while a firm with lowest performance in its session ranked 11 on equity and rank 15 on percentage of best reply equity. In fact, some of the firms with lowest performance in their sessions had higher performance than firms with highest performance in other sessions. Table 2 shows a regression model for equity at the end of period 6 based on factor loadings (Hamilton, 1992) of decisions when playing the game (columns Coeff. and St. Err.). The model shows that relatively higher prices (Factor 1 Coeff. 158) and relatively lower cumulative advertising (Factor 1 Coeff. -57, Factor 2 Coeff. -46) of the other firms in a session are related to higher equity. That is, when all firms in a session make decisions closer to the cooperative solution, a firm with lowest equity in this session can earn higher equity than firms with highest equities in other sessions. The regression model also shows that the best reply decisions consist of relatively higher prices (Factor 1 Coeff. 64), lower cumulative advertising (Factor 2 Coeff. -46) and lower errors in estimation of demand (Factor 1 Coeff. -148). While the equities of firms reflect decisions of all firms in the same game session, the percentages of best reply decisions show the ability of firms to make their decisions with respect to decisions of the other firms in the same session. The percentage of best reply decisions can therefore be seen as more appropriate than equity when evaluating performance. However, the two measurements of performance and comparisons between firms in different sessions enhance understanding of relations between decisions and profits.

DISCUSSION

We have used the concept of solutions to analyze relations between decisions and profits in a business game. Theoretically, the cooperative solution gives all firms the highest profits in the business game, but competitive solution decisions give a firm even higher profit when the other firms make cooperative solution decisions. Since almost no decisions when playing the game were cooperative solution decisions, the decisions that gave the highest profits in the game were decisions between the noncooperative and the competitive solution. Firms playing the game made most of their decisions between the cooperative and the competitive solution. In fact, the noncooperative solution, the mean decisions when the game was played and the mean best reply decisions were similar. Hence, the hypothesis that of the three solutions the noncooperative solution gives the best description for the decision the firms made when playing the game was supported**.** However, although the game was symmetric for all firms, the decisions among the firms were dispersed. These results correspond to conclusions from experiments with static models in economics (Rassenti, Reynolds, Smith and Szidarovszky, 2000), where mean decisions of firms were close to the noncooperative solution, but individually dispersed.

We also used the concept of solutions to evaluate performance of firms playing the game. The two measurements, equity and percentage of best reply equity, showed that firms with lowest performance in one session can have higher performance than firms with highest performance in other sessions. It could be argued that since the objective for playing the game was to maximize the equity at the end of the game, equity should be used to evaluate performance. However, the measurement percentage of best reply equity shows the ability of the firms to make decisions that maximizes their equities with respect to decisions of the other firms in the same session. It can also be argued that this measurement does not take into account that the other firms could have adjusted their decisions when receiving information about a firm making its best reply decisions. It should be pointed out that firms may not have adjusted their decisions in response to the best reply decisions of a firm since the mean decisions when playing the game were similar to mean best reply decisions. Furthermore, there were regularities among decisions of the individual firms from one period to the next, suggesting that firms may be reluctant to adjust their decisions. Both measurements of performance have their merits, but what is most important is to be clear about what measurement will be used for evaluation and the reason for it.

The smallness of the business game we analyzed and the fact that the game does not have any random factors have allowed us to determine its solutions, but this may not be possible for more complex business games. Still, the solution concept is useful when analyzing strategies and evaluating performance in business games with interdependence among decisions of firms. For example, if all firms in a session earned either very high or very low profits compared to other sessions, their decisions were probably not close to their best reply decisions. Comparisons between decisions and performance in different game sessions enhance the understanding of relations between decisions and profits, and the effect the decisions of competing firms has on performance. Depending on pedagogical approach, the concept of solutions could be introduced at briefings before playing a game or at the debriefings after playing a game (Peters and Vissers, 2004). Business games capture the essence of how reality is related to the purpose of playing them (Feinstein and Cannon, 2003). To this we add that solutions and decisions made when playing games also should capture the essence of how reality is related to the purpose of playing a game. That is, discussions of external validity of business games should be extended to external validity of the solutions and decisions made when games are played. Furthermore, we should consider how solutions and decisions made when playing games correspond to the decisions we would like to teach (Shubik, 2001). In the

game we analyzed, participants presumably learn to make noncooperative solution decisions, since firms making these decisions had the highest performance.

For future research, it is of interest to use the concept of solutions to compare relations between decisions and performance in this game to other business games. Another question of interest is to study how the solutions relate to strategic decision making (Segev, 1987; Dutton and Stumpf, 1991). Furthermore, the relation between solutions and decisions can be studied after altering the number of firms competing in the same market, the parameters in the games, the information conditions (Edman, 2004) and the objectives when playing business games.

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