SIMULATION ANALYSIS OF EXPERT POWER IN JOINT DECISION MAKING AGAINST COMPETITION

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ABSTRACT

A simulation model was utilized to investigate the influence of "expert power" when cooperating decision makers attempt to make optimal decisions of a strategic nature against competition. The simulation model is a modified version of one used previously to study the effects of conflicts in perceptions [1] and employs empirically derived utility functions, alternative game theoretic structures, and a "Group Bayesian" interpretation of joint decision making. The simulation results showed no effect of expert power when the criterion was market share (constant sum game) but some effects when the criterion was profit (nonconstant sum game) and the level of variability in the environment was high. As expected the results showed that competition was more intense when the criterion was market share.

INTRODUCTION

The process of normative decision making through which a set of cooperating decision makers reach joint strategic decisions for dealing with adversaries in competitive situations is not well understood. The complexity and dynamic nature of the situation makes computer simulation experiments a logical approach for modeling both the interactions of cooperating units and the competitive interaction among different sets of such units, as illustrated by joint decisions on marketing strategy by manufacturer-distributor dyads competing with similar dyads consisting of different manufacturers and distributors. Previous work by the authors used similation experiments to study the effects of different risk attitudes of two competing teams on the profits obtained by each team [1]. In that study, it was assumed that the cooperating units had agreed in advance on how profits were to be shared between them. The present study relaxes this assumption and deals with the role of "expert power" in establishing a group marketing information system on which competitive actions are based.

Expertness in this context is the ability to absorb uncertainty or predict outcomes. This can be illustrated by the possession by one of the cooperating units of a better management information and forecasting system. All measures of power are relative and all units have some degree of power. Expert power is treated within a "Group Bayesian" framework as a dynamic construct which can change over time to reflect the relative past accuracy of the decision makers. A formal method is used for combining different perceptions of uncertainty into a group perception.

RESEARCH METHOD

A competitive decision making model with repetitive decisions will be used in this study. Each team, consisting of manufacturer and distributor will face 2 x 2 payoff tables as illustrated in Figure 1 and Figure 2.

FIGURE 1

Nonconstant Sum Game

Team I	Team II	b_1	b_2
	a_1	A,A	B,C
	a_2	C,B	D,D

FIGURE 2

Constant Sum Game

Team I	Team II	b_1	b_2
	a_1	E	F
	a_2	G	H

The alternative courses of action available to Team I and II are represented by a_1, a_2 and b_1, b_2 respectively. These actions can be thought of as strategic decisions such as profit skimming or long term penetration of the market with a new product or coming out with a new promotional campaign versus keeping the status-quo.

The entries in the payoff table of Figure 1 represent the true means of profit probability distributions which result from different combinations of decisions. Thus, the pair C,B for example, means that the profit to Team I will be drawn from a probability distribution with mean equal to C and from a probability distribution with mean B for Team II, when Team I decides on a_2 and Team II decides on b_1.

The entries in the payoff table of Figure 2 represent the true means of the market share probability distributions to Team I. When Team I decides on a_1 and Team II decides on b_1, a market share of S_1 will be drawn to Team I from a probability distribution with mean E and this will determine the market share to Team II, S_2, which will be set equal to $1-S_1$.

Using game theory terminology, Figure 1 represents a nonconstant-sum game and Figure 3 represents a constant-sum game. These two games characterize two different degrees of competition which will be used as an experimental variable in this research. As discussed by many writers in game theory [e.g., 4], a constant-sum game represents a competitive situation in which the competitors interests are strictly opposing. A nonconstant-sum game in which cooperation is assumed to be prohibited belongs to the class of non-strictly competitive situations. These two types of competition are utilized as an experimental variable to represent two different states of the competitive environment of the distribution systems. Their impact on the internal relative power within the teams and on the performance of the competing teams will be explored. The simulated decision makers on each team will have their own perceptions of the consequences associated with their decisions and the competitor's response, depending on their expertise and experience in the field. These perceptions will be represented in the model by draws from each decision maker's prior probability distribution over the true parameters. When there are different perceptions of the payoff table within a team, the two decision makers may be expected to make different estimates of the competitor's decision and reach different conclusions about the appropriate decision. The different perceptions are converted into one joint team perception which is used to make a common decision. Since the basic decision situation is repeated over time, the decision makers have an opportunity to learn about the true parameters of the probability distributions of consequences and about the competitor's behavior. A diagram of the competitive situation is given in Figure 3.

SIMULATION MODEL

Following is a brief discussion of the general structure of the simulation model and the major assumptions on which it will be built:

(1) The profits to the teams will be generated from normal distributions whose means are unknown to the decision makers but whose variances are known.

(2) The competitor's behavior is regarded by each team as a stochastic process. Since neither of them obtains specific information on the competitor's realized profit, and collusion is not permitted, their best estimate of each other's strategy can be obtained by assuming a stochastic decision progress. The simulated teams assume that the competitor's behavior can be described by a Bernoulli process whose parameter p is initially unknown and is learned over time.

(3) It is assumed that the decision makers behave in an optimum seeking manner and select that strategy which is expected to yield the highest utility to the team, given their perceptions of the environment. They revise their perceptions in the light of new information, using Bayes' theorem. The overall perception of the team is determined by a weighting scheme which is revised over time, and can reflect the relative accuracy in making predictions by each of the two decision makers.

(4) It is assumed that exponential utility functions reflect the decision makers attitude toward risk. This family of curves can accommodate and approximate a large number of risk taking styles.

(5) In combining the individual decision makers' utility functions into the team utility function, we assume the following two conditions suggested by Harsanyi [2]:

(i) Whenever the two individuals (firms) in the team are indifferent between two prospects X_1 and X_2, the team preference system should also be indifferent between these two.

(ii) Whenever one of the two firms prefers X_1 to X_2 and the other does not prefer X_2 to X_1 the team should prefer X_1 to X_2.

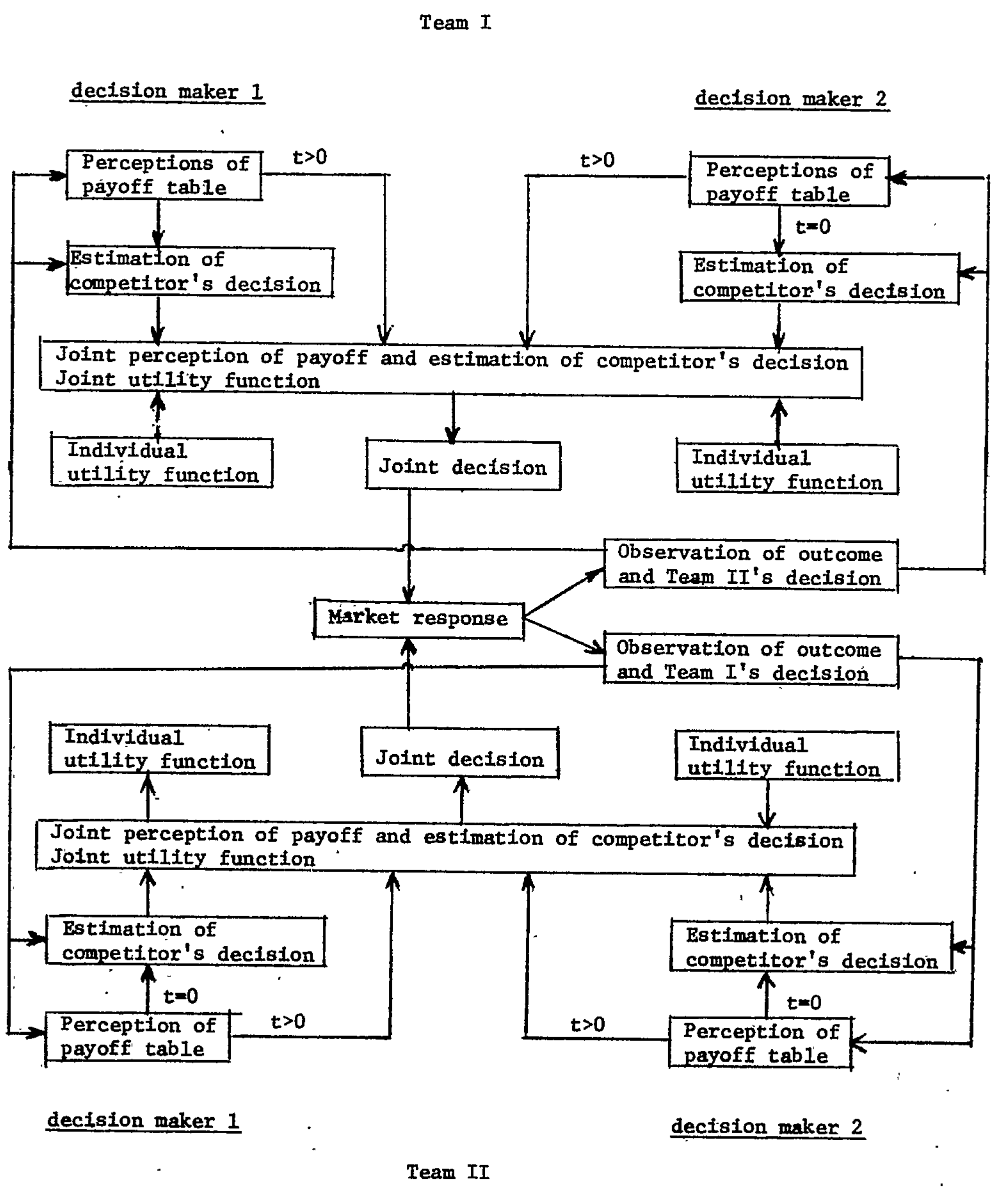
Harsanyi showed that under these conditions the team's utility function should be a linear combination of the individual utility function with positive weights.

When market share is used by both teams as the objective to be maximized, the data are assumed to be generated from normal probability distributions with small but different known variances so that inadmissible draws of actual outcomes such as negative values or values greater than one will not be generated. The means of the market share probability distributions will represent responses to the same market behavior as the profit probability distributions. When competing on market share, only one draw from the distribution of the consequences will be made in order to determine the actual market share for both teams.

Each decision maker faces the decision tree and payoff table shown in Figure 4. The following indices will be used:

FIGURE 3

Diagram of the Competitive Situation

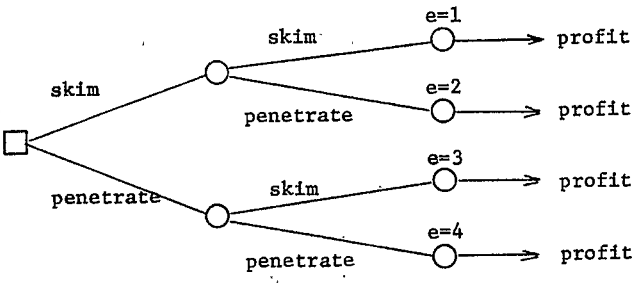


Note: t = 0 represents the time at which a particular set of simulated decision makers make their first decision. Subsequent decisions are made at t = 1, 2, ...

FIGURE 4

Strategy Combinations and Payoff Table

DECISION TREE



PAYOFF TABLE

TEAM II

		Skim	Penetrate
TEAM I	Skim	1, 1	2, 3
	Penetrate	3, 2	4, 4

The Payoff Table reflects the profits of the two teams (I on the left, II on the right) resulting from the combinations of strategies as shown in the cells and in the decision tree above.

decision maker	i (i = 1,2)
combined actions	e (e = 1,2,3,4)
time	t (discrete)

A flow chart of the simulation is presented in Figure 5. This shows the nature of the various steps and the sequence in which they occur.

THE EXPERIMENTS

Since experimentation with our model involves introducing changes, the hypotheses which can be tested are simply statements about the effects of the changes as follows:

(1) Differential power vs. equal power within each team.
(2) Profit vs. market share as the objective to be maximized by the teams.
(3) Degree of willingness to take risk by each decision maker in the team.
(4) Level of the "external world" variability as measured by the standard deviation of the probability distributions of the consequences.
(5) Degree of conflict in perceptions of the initial payoff tables.

In interpreting the results of the present study, it should be kept in mind that only one basis of power is modeled here and that the outcomes of the simulation are dependent on the particular values of the parameters which will be used.

The decision to be made jointly by two simulated decision makers (a manufacturer and a distributor competing against a similar dyad) was the choice of a marketing strategy for the introduction of a new product into the distributor's exclusive territory. The first of the two alternatives is a "skimming" strategy with a price that provides a high margin per unit, a high advertising budget, and an adequate distribution budget. The other strategy is a "penetration" strategy with a price representing much lower margins with a somewhat lower advertising budget and a somewhat higher distribution budget. The means for the distributions of profit and market share were generated with a model of marketing strategy in new product introduction developed by Kotler [3]. The resulting payoff tables are shown in Figures 6A and 6B. It can be seen that "penetration" is the dominant strategy when both payoff tables reflect the true means of the probability distributions over consequences.

FIGURE 6A

Payoffs - Profit

	Team I	
Team I	Skim	Penetrate
Skim	-7082,-7082	-6417, 6170
Penetrate	-6170,-6417	-5476,-5476

FIGURE 6B

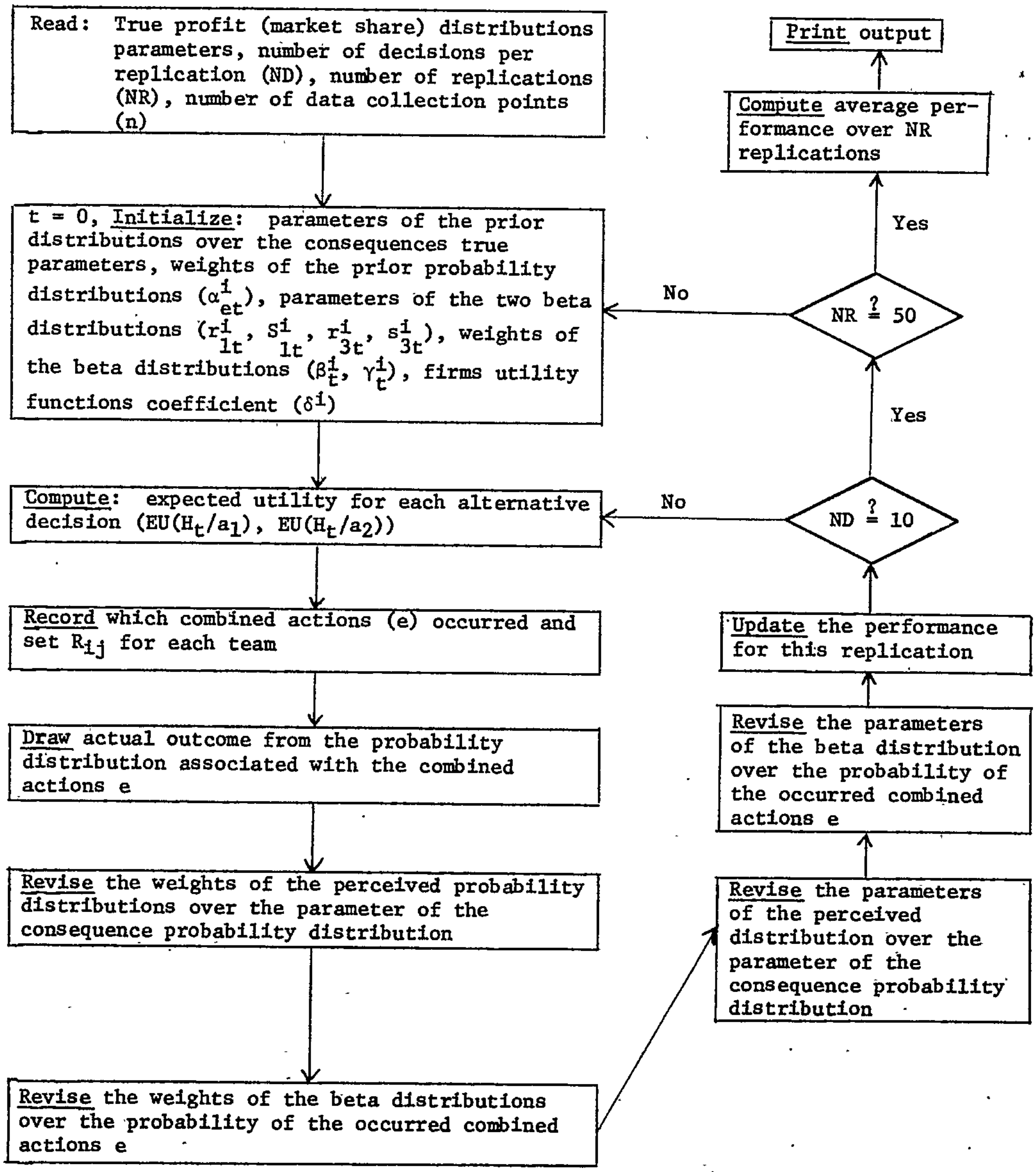
Payoffs - Market Share

	Team II	
Team I	Skim	Penetrate
Skim	50%	41%
Penetrate	59%	50%

The simulation was run in the same manner as in the previously reported study. The beta distributions were initialized as before using data from a convenience sample of 30 decision makers. The number of data collection points between two consecutive decisions was 5, the number of decisions in each run was 10, and the number of replications was 50

FIGURE 5

Flowchart of the Simulation



as before [1]. The "perceived means" (initial estimate of true means) for both decision makers over the two performance criteria and two levels of market variability are given in Figure 7. Under the profit criterion (nonconstant sum game), both decision makers perceive that penetration is the dominant strategy and there is no conflict in perceptions. Under the high variability condition, decision maker 1 perceives "skim" as the dominant strategy for both teams while decision maker 2 perceives that "penetration" is the dominant strategy for both teams, resulting in a conflict in perceptions between the two decision makers. A similar result is observed under the market share (constant sum) criterion with the two decision makers in each team perceiving that penetration is the dominant strategy for both teams under the low variability condition but under the high variability condition, decision maker 1 perceives that "skim" is dominant for Team I and "penetrate" is dominant for Team II while decision maker 2 perceives that "penetrate" is dominant for both teams.

Results will be presented from a simulation experiment involving two levels of risk attitudes and four patterns of expert power. In one risk attitude treatment both decision makers in both teams are risk aversive. In the other treatment, both decision makers in Team I are risk takers and both decision makers in Team II are risk avoiders. The four unique patterns of expert power reflect whether or not the more expert decision maker is given more weight in each of the two teams, as shown in Figure 8.

It can be seen from the results that expert power as operationalized in the simulation model had no effect on the results for any of the runs using the market share criterion. This was also true for the runs using the profit criterion in the low variability condition. Under the high variability condition with the profit criterion, there were some small differences in the t scores over the four power treatments. When all decision makers were risk avoiders (Figure 8A), there seemed to be a slight improvement in Team I's performance (smaller t scores) under the equal power condition. When Team I's decision makers were risk takers and Team II's were risk avoiders in the high variability condition (Figure 8B), Team I's performance declined when power was equal. While these results are quite interesting, they are undoubtedly influenced by the particular starting conditions and the pattern of the simulated decision makers "perceptions" and should not be taken too seriously until additional runs can be made.

Confirming prior findings, competition appeared to be much more intense (larger differences in performance between teams) with the market share criterion than with the profit criterion. This should be expected because of the normative nature of the decision task and the "purely competitive" nature of the constant sum game.

SUMMARY

A previously reported simulation model was modified to include "expert power" as a variable and a pilot experiment was run. Expert power had no effect on the results when the market share criterion (constant sum game) was used but weak differences were found under the high variability condition with the profit criterion (nonconstant sum game). Further runs with different starting conditions and different sequences of random numbers are needed before any conclusion can be reached about the effect of expert power in group decision making against competition.

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FIGURE 7

Perceived Means Obtained by Random Draws

PROFIT CRITERION

Standard Deviation	Decision Maker 1			Decision Maker 2		
		Team II			Team II	
	Team I	Skim	Penetrate	Team I	Skim	Penetrate
σ = 500	Skim	-6361,-6361	-5821,-5719	Skim	-6977,-6977	-6348,-6125
	Penetrate	-5719,-5821	-5774,-5774	Penetrate	-6125,-6348	-5560,-5560
σ = 2000	Skim	-4198,-4198	-4034,-4368	Skim	-6662,-6662	-6140,-5990
	Penetrate	-4368,-4034	-6688,-6688	Penetrate	-5990,-6140	-5184,-5184

MARKET SHARE CRITERION

Standard Deviation	Decision Maker 1			Decision Maker 2		
		Team II			Team II	
	Team I	Skim	Penetrate	Team I	Skim	Penetrate
σ = 5	Skim	57.21	46.98	Skim	51.05	41.69
	Penetrate	63.50	47.02	Penetrate	59.45	49.15
σ = 20	Skim	78.84	64.83	Skim	54.20	43.77
	Penetrate	77.02	38.08	Penetrate	60.80	46.62

FIGURE 8

Results of Simulation Runs

A. Both Decision Makers in Both Teams Risk Aversive

PROFIT CRITERION

Expert Power		Difference in Mean Performance (Team I-Team II; t scores)	
Team I	Team II	σ=500	σ=2000
Differential	Differential	-1.707	-1.250
Differential	Equal	-1.707	-1.250
Equal	Differential	-1.707	-1.156
Equal	Equal	-1.707	-1.156

MARKET SHARE CRITERION

		σ=5	σ=20
Differential	Differential	-2.157	-21.658
Differential	Equal	-2.157	-21.658
Equal	Differential	-2.157	-21.658
Equal	Equal	-2.157	-21.658

B. Both Decision Makers in Team I Risk Takers, Both in Team II Risk Aversive

PROFIT CRITERION

Equal Power		Difference in Mean Performance (Team I-Team II; t scores)	
Team I	Team II	σ=500	σ=2000
Differential	Differential	-1.707	-4.371
Differential	Equal	-1.707	-4.622
Equal	Differential	-1.707	-5.014
Equal	Equal	-1.707	-5.077

MARKET SHARE CRITERION

		σ=5	σ=20
Differential	Differential	-9.958	-10.660
Differential	Equal	-9.958	-10.660
Equal	Differential	-9.958	-10.660
Equal	Equal	-9.958	-10.660