Complexity and Genesis of Strategic Groups: A Genetic Algorithm-Based Model

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Introduction and Literature Review

Since Hunt (1972) first used a term "strategic group" to coin heterogeneous strategic behaviors within an industry, strategic group phenomenon has been of high interest to strategy researchers. Results of empirical investigations on performance difference among strategic groups are inconclusive and conflicting (Cool & Schendel, 1987). Some studies reported performance difference among strategic groups (e.g., Dess & Davis, 1984; Fiegenbaum & Thomas, 1990; Mascarenhas & Aaker, 1989; McGee & Thomas, 1986), while others could not found the difference (e.g., Cool & Schendel, 1987; Howell & Frazier, 1983; Lewis & Thomas, 1990).

This paper offers a new way of thinking about the phenomenon in an attempt to revitalize the research program. In particular, the research strategy of this paper is to investigate and clarify the conditions under which a new strategic group can emerge. Although some studies have explored the emergence of a new strategic group (Caves & Porter, 1977; Cool & Schendel, 1987; Mascarenhas & Aaker, 1989; Porter, 1979), we still do not have a solid theory on the genesis of strategic groups. Since analysis of archival data or perceptual data cannot generate those conditions, we adopt a tool from the literature on genetic algorithm (GA) and tackle the complexity inherent in strategic group phenomena.

Process that generates strategic groups has received some attention but has not been precisely formulated and tested. Caves & Porter (1977) and Porter (1979) used initial random differences among firms in their preferences or the qualities of their assets to explain the genesis of strategic groups. They argued that those differences lead firms to adopt differing strategies and to invest differently in mobility barriers. Once strategic groups are formed, the group structure is maintained by mobility barriers, which explain why firms adopt different strategies even though not all strategies are equally successful (Caves & Porter, 1977). Porter (1979) added exogenous causes: historical development of an industry, which bestows differential advantages / disadvantages on firms, and exogenous causes such as technological changes. Although Porter (1979) added exogenous causes as drivers of strategic group formation, exogenous causes and endogenous initiatives are not formulated to interactively contribute to strategic group formation.

To explain the initial genesis of strategic groups and the changes in the number of strategic groups, we needs a theory regarding why firms adopt differing strategies. Existing studies have used initial differences in preferences and qualities of assets (Caves & Porter, 1977), various enactment of environments (Fombrun & Zajac, 1987; Weick, 1979), and changes in competitive environments to explain why firms adopt differing strategies. However, adopting differing strategies is not a sufficient condition for strategic group formation, since all strategies may not be viable. Only when new strategies adopted by innovating firms are viable, stable new strategic groups are formed even though we can temporarily observe firms without viable strategies. Cool & Schendel (1987) showed that some firms altering their strategic commitments could or did not sustain it and thus changed strategic commitment again. What is really missing in previous studies on strategic group formation is a selection process. Depending on the characteristics of selection mechanism, strategic group can or cannot be formed. Group membership can be merely an observable manifestation of viable niches in the environment and the organization's ability to adapt to them (McGee & Thomas, 1986).

Genetic Algorithms

Genetic algorithms (GA) are a class of robust and efficient search methods based on the concept of biological evolution in nature (Holland, 1975; Goldberg, 1989). GA works as follows: (1) It begins by randomly generating an initial population.

(2) During each iteration, called a *generation*, firms in the population are evaluated by a fitness function. (3) After evaluating the fitness of each firm, a specified number of firms with lowest fitness are removed from the population. (4) Among the survivors, some of the firms are selected to be parents. Parents are selected probabilistically with the selection probability for any firm being proportional to its fitness. Parents are paired and genetic operators – crossover and mutation -- applied to produce new firms, called *offspring*. (5) GA terminates when a prespecified stopping conditions are satisfied, typically some number of generations.

Model

We assume that strategy of a firm can be represented by one dimensional continuous value. We also assume that the payoff function has two peaks, where one is much higher than the other. In ecological viewpoint, this means that there are two differing market niches. In our GA models, we manipulate four parameters: probability of payoffs, stability of payoff function, mobility barriers, and sharing.

Probability of payoffs: In our standard model, we define 3 different success rates for first movers, incumbents, and new entrants respectively. A strategy of a firm, x, is represented as a number between 0 and 1 and encoded as a 10-bit string, where each bit string can have a value of 0 or 1. For example, 1000000001 represents 0.5015. The payoff function is defined as follows (Figure X):

$$
\begin{aligned}
y &= \text{sine}(3\pi x) + 3x && \text{if } 0 \le x < 0.5, \\
&= \text{sine}(3\pi x) + 3x && \text{if } 0.5 \le x \le 1 \text{ and } r < p, \\
&= 0 && \text{otherwise,}
\end{aligned}
$$

where $r \sim \text{Uniform}(0,1)$ and p is the success rate. p is defined as follows:

$$
\begin{aligned}
p &= p_f \quad \text{if } age = 0 \text{ and } n_p \leq n_b \\
&= p_n \quad \text{if } age = 0 \text{ and } n_p > n_b \\
&= p_i \quad \text{if } age > 0
\end{aligned}
$$

where p_f, p_n, and p_i are the success rates for first movers, later entrants and incumbents, respectively; *age* is the number of generations for which a firm has survived, n_p is the number of firms between 0.5 and 1, n_b is the threshold at which mobility barriers are established.

Mobility Barriers: The difference between p_j and p_n represents the mobility barriers. When p_n (the success rate of later entrants) is lower than p_j (the success rate of first movers), there exist mobility barriers. We used n_b as a threshold of mobility barriers being established. For instance, if n_b is 5, the success rate of firms that enter the niche is p_j until there are 5 successful firms in the niche. We use p_j =.10 and p_n=.01, and p_j =.05 and p_n=.005 as cases of mobility barriers.

Stability of Payoff Function: The value of p_i represents the stability of payoff function. p_i of .95 means that once successful in random draw at any generation, the firm's success rate at the next generation is 95%. p_i of 1.00 indicates perfect stability of payoff function. We use 1.00, .98, .95, .90 as a value of p_i.

Sharing: In our standard model, we employ a more sophisticated method called *sharing*. The sharing reflects the concepts of carrying capacity (Hannan & Freeman, 1977) and localized competition (Baum & Mezias, 1993) in population ecology. In sharing, instead of allowing a full measure of payoff for each individual, it is forced to share its payoff with its neighbors (See Goldberg & Richardson, 1987; Deb & Goldberg, 1989 for detail).

Our GA begins by randomly generating an initial population of firms between x =

0 and x = 0.5. This is to show the emergence of a new strategic group from a single homogeneous strategic group. As only a portion of firms, not all firms, are successful in searching for new solutions in higher peak, a new strategic group emerges. We used the population size of 50. During each generation, the firms in the population are evaluated using a fitness function. In this problem, firms can be evaluated in terms of the value of the payoff function. After evaluating the fitness of each firm in the population, parents are selected probabilistically with the selection probability for any firm being proportional to its fitness. Parents are paired and genetic operators applied to produce offspring.

Crossover is the primary genetic operator. Crossover can be thought of either as a change of strategies by considering strategies of previously successful firms or as a founding of a new firm that recombines strategies of previously successful firms (Bruderer & Singh, 1996). It operates on two solutions (parents) at a time and generates offspring by combining segments from both parents. We used uniform crossover in our GA. In uniform crossover, the child inherits a value for each gene position from one or the other parent with probability .5 (i.e., randomly). Mutation independently modifies one or more gene values of a firm that is founded by crossover. It serves to guarantee that the probability of searching a particular subspace of the solution space is never zero. Mutation is analogous to playful experimentation and incorrect transmission of routines (Bruderer & Singh, 1996).

A new generation is formed by removing a specified number of firms with lower fitness value from the population and adding as many offspring to it so as to keep the population size constant. Our GA removes and adds 5 firms -- 10% of the population -- during each generation. Finally, our GA terminates when 2000 generations is reached or when the whole population is populated with one solution.

Results

When model does not have a sharing element, two strategic groups do not emerge. With low inter-temporal stability of payoff function coupled with low success rate of strategic changes, there is only one strategic group of lower peak. With high stability of payoff function, all firms are in a niche of higher peak. One exception is when the payoff function is stable (p_i =1.00) and success rate of strategic changes is very low. However, when we have more iterations, strategic group in a niche of lower peak disappear eventually.

With sharing, two strategic groups emerge in most cases. When two strategic groups emerge, the fitness of firms in differing strategic groups tends to converge with the number of iteration increase. When the stability of payoff function is low (p_i =.90), however, strategic groups do not emerge.

Discussion and Conclusions

This study shows that sharing and the intertemporal stability of payoff function are key elements for the emergence of stable strategic groups. The results questioned the validity of arguments about strategic group formation provided by existing literature, especially Caves & Porter (1977). Although firm's decision to change strategies is important, the characteristics of selection mechanism have a great influence on the formation of strategic groups.

Investigation of the changes of fitness over generations in models incorporating sharing reveals that the fitness difference disappears as generation continues even though there are mobility barriers. This finding can answer why we have conflicting and inconclusive evidence on performance difference among strategic groups in extant literature. The performance difference is only observed in earlier generations.