A RANDOM-STRATEGY CRITERION FOR VALIDITY OF SIMULATION GAME PARTICIPATION

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INTRODUCTION

It has now been over 35 years since the first business simulation game was used in a college class at the University of Washington in 1957 (Watson 1981). Since that time, the number and variety of business games available for classroom use has grown enormously. Interest among academics in the teaching and learning possibilities of business games has clearly grown as well. Presently, over 200 business games are being used by nearly 9,000 teachers at over 1,700 colleges offering business programs (Faria 1989). Empirical research in the area has been extensive. Comprehensive reviews can be found in Greenlaw and Wyman (1973), Keys (1976), Wolfe (1985), Miles, Biggs and Shubert (1986), and Randel, Morris, Wetzel and Whitehill (1992).

Despite the widespread use of business simulations, an important and vexing issue regarding business games is whether or not participation is a meaningful experience. This paper introduces an original criterion for the validity of simulation participation that is akin to the random sampling error basis of statistical hypothesis testing. Specifically, whether the results of participants presumably acting on logical, analytical, thoughtful bases are significantly better than results obtainable on a random decision-making basis. If participants' results are better than those obtained on a random basis, then this would suggest their strategy formulations are purposeful and systematic; that is, they are meaningful in this sense and, too, valid in this same sense.

In this paper the random strategy criterion and its operationalization are first developed. The criterion is then applied to a substantial sample of simulation game participants.

PAST RESEARCH

Meaningfulness, as applied to business simulations, has taken on a number of specific interpretations as reflected in past research including: (1) the learning, or skills training, aspects of simulation gaming, (2) the relative merit of simulation games versus other teaching methods, (3) the external validity of business simulations, and (4) the internal validity of simulation game participation.

Research into the learning or skills training aspects of simulation gaming dates back a number of years. The reported types of learning brought about through simulation participation include goal setting and information processing (Philippatos and Moscato 1 969; Greenlaw and Biggs 1974; Biggs 1975; Biggs and Greenlaw 1976), organizational behavior and personal interaction (Cangelosi and Dill 1965; Chisholm 1979), sales forecasting (Edwards 1987; Hall 1987; Neuhauser 1976; Snow 1 976), financial analysis skills (Faria and Nulsen 1976; Hall 1987), basic economic concepts (Edwards 1987), and selected quantitative skills (Whiteley and Faria 1989).

The relative merit of simulation games versus other teaching approaches has been investigated by a number of researchers (Greenlaw and Wyman 1973; Keys 1976; Snow 1976; Waggener 1979; Wolfe 1985; Miles, Biggs and Shubert 1986; Hall 1987; Specht and Sandlin 1991; Washbush and Gosenpud 1991; Randel, Morris, Wetzel and Whitehill 1 992). Across all of the reported studies, simulation games were found to be more effective than conventional instructional methods in 75 of the comparisons, conventional methods of instruction were found to be superior in 27 of the comparisons, while no differences were reported in 58 of the comparisons. The reported studies included business as well as social science simulations.

The external validity of a simulation model has generally been viewed as a measure of how well the model matches its real-world counterpart (Carvalho 1991; Mehrez, Reichel and Olami 1987; Parasuraman 1986; Stanislaw 1986; Watson 1981; Wolfe and Roberts 1986). In the classroom setting, two approaches have been used to investigate external validity. The first approach has focused on the correlation between a business executive's simulation performance and his/her real-world performance. If the simulation is externally valid, a successful business executive should also be successful when participating in a simulation competition. A number of studies have generally supported the external validity of the simulations being examined (Babb, Leslie and Van Slyke 1966; McKinney and Dill 1 966; Vance and Gray 1967; Wolfe and Roberts 1 986). The second approach to measuring external validity uses a longitudinal research design. In this approach, a student's business game performance is compared to some measure of subsequent business career success. Using this approach, Norris and Snyder (1982) did not find a significant correlation between business game performance and career success although two more recent studies have found such a correlation (Wolfe and Roberts 1986; Wolfe and Roberts 1993).

The internal validity of simulation games has also been examined in two ways. The first approach basically states that if a simulation exercise is to be internally valid, better students should outperform poorer students. Several studies have supported this view of the internal validity of simulations (Gray 1972; Vance and Gray 1972; Wolfe 1987). A second, and more reasonable view of internal validity, examines whether participant decisions in a simulation competition, over time, conform to the environment of the simulation. While the dynamics of the simulation and the actions of competing companies will certainly influence participants' decisions, the simulated environment too must be considered and, ceteris paribus, participants' decisions should reflect or adapt to this environment. If this type of adaptive decision making does occur, the simulation can be said to be internally valid. Several studies of this nature (Faria, Dickinson and Whiteley 1 992; Whiteley, Faria and Dickinson 1991; Dickinson, Faria and Whiteley 1990) have been mildly supportive of the internal validity of the simulations examined.

While each of the four approaches used in the past has merit, a new approach to examining simulation validity and meaningfulness is presented. The authors feel that the random-strategy criterion proposed is conceptually and logically more appealing.

RANDOM-STRATEGY CRITERION

In one major format of simulation gaming, participants are grouped into companies and companies are, in turn, grouped into industries. Companies within a given industry compete against each other with simulation participants managing the companies. The basic premise of the random-strategy criterion is that performance resulting from the presumably systematic strategy planning of participants should better performance resulting from random strategy "planning."

More specifically, if a given industry comprises both "real" companies as managed by participants and "random" companies whose strategies are determined randomly, the performance of the former should be better than the performance of the latter. Participants making planned, informed, systematic strategy decisions should achieve better company performance than achieved by a strategy made up of random decisions.

In many instances of hypothesis testing, the fundamental criterion is the probability that observed data are attributable to chance in the form of random sampling error. It that probability is low, then the alternative general attribution is that the observed data reflect some systematic phenomena.

In parallel fashion, if the performance of companies managed by simulation participants is not significantly superior to the performance of companies managed at random, this would suggest that the participants' strategies do not derive from systematic, i.e., meaningful, decision making and the validity of the participants' experience must be questioned. On the other hand, if real company performance is significantly better than random company performance, this would suggest that participant decision making is purposeful and meaningful.

Logical Basis of the Criterion

The expectation of superior performance of simulation participants' companies is supported by at least four types of factors: internal consistency, targeted strategies, experience, and planning.

First, an effective strategy would have a degree of internal consistency. In a marketing simulation, for instance, a company paying a high salary to salespeople would tend to pay a low commission. High expenditures on advertising or other elements of strategy should allow a higher price to be charged. A company charging a relatively high price should not choose a low price message in its promotion. And so on.

Random decisions might well result in, say, a high salary for the sales force. But since this random decision is independent of the commission decision, the random commission decision could be either high or low, regardless of the salary level. The two random strategy components may or may not be internally consistent, while participants' decisions would be expected to be consistent and, thus, more effective. Random high expenditures on advertising would not impact the random price level, the latter thus not necessarily being consistent with the former. And a low price message might be randomly selected regardless of the level of the random price.

Targeted and otherwise directed strategies may take many forms. For instance, a real company may plan to gain a preemptive foothold or dominant share of a certain market segment. A real company may follow or counter strategies of a specific competing company. A real company may drastically reduce inventory of a specific product. A real company may intentionally devise strategies to mislead competitors. Random strategies would have no such specific targeting or directing capacity.

A third factor in support of the effectiveness of participants' strategies is the experience gained by participants. Participants may be able to discern trends in competitors' strategies and, also, participants accumulate learning as to which strategies are more and less effective. Random strategies do not reflect trends or experience.

And, fourth, participants may plan for the future. One straightforward instance of this factor is where the effectiveness of certain strategy elements is time related. For example, newly hired salespeople may not actually engage in selling activities during the period in which they are hired. They may undergo training in that period and commence selling in the next period. Promotion effects may accumulate and/or decay over time. Generally, a strategy that changes drastically from one period to the next may flat be as effective as a strategy that evolves more gradually. These types of effects are founded in the simulation environment itself and all of the effects are, in fact, part of the simulation used in the study described below. Random strategies do not reflect planning for the future.

The random-strategy criterion is a conceptual development. Its merit is based on the logic underlying it. It simulation participation is not a meaningful experience, strategies formulated should tend to be unsystematic generally. More specifically, in the framework described above, strategies should tend to be unsystematic in the respects of lowered internal consistency, an absence of targeting, lessened reflection of experience, and lessened reflection of planning for the future. Resulting performance, then, should approach that of performance based on random strategies. To the extent that strategy formulation is systematic, i.e., purposeful and meaningful, performance should significantly exceed that of performance based on random strategies.

An application of the criterion is described below, more for purposes of illustration than for the purpose of testing the criterion.

HYPOTHESIS

Based on the reasoning above, the hypothesis tested in applying the random-strategy criterion is that real companies will outperform random companies, both on a period by period basis and on a cumulative basis.

Hai: In Period i the performance of companies managed by participants will be greater than the performance of companies using random strategies.

Hb: The cumulative performance of companies managed by participants will be greater than the cumulative performance of companies using random strategies.

DATA COLLECTION

The random-strategy criterion was applied using <u>LAPTOP: A Marketing Simulation</u> (Faria and Dickinson 1987). Participants in the LAPTOP simulation take on roles of the top marketing managers for a medium size company that manufactures laptop computers. Participants are responsible for their company's entire marketing program. This includes the product, price, place, and promotion decisions for their companies. Companies may sell one or both of two models of laptop computers in one or two geographic territories. Together these comprise four product-market segments. All told, 32 strategy decisions affect demand. In addition, 1 2 separate market research studies maybe requested.

LAPTOP proceeds on a period by period basis. Participants formulate their strategies and receive the results of those strategies in the form of updated financial statements, market share data, and other types of information. With those results and considering the new status of their company, participants again formulate their strategies. Each period companies realize after tax earnings. In LAPTOP these earnings are transformed to earnings per share which is the bottom line measure of performance for a given period. These period earnings per share may also be accumulated as a competition progresses, yielding cumulative earnings per share (CEPS). It is CEPS that is the usual final measure of overall company performance at the end of the competition.

Operationalizing Random Decisions

In the usual fashion, students involved in this study were grouped into companies and companies were grouped into industries. For purposes of this study, an additional researcher-controlled company was added to each industry. This was the random strategy company.

The range or available categories for each of the 32 decisions in LAPTOP is restricted. However, the allowable ranges are extremely wide. For instance, price may range from $0 through $9,999, expenditures on broadcast advertising may range from $0 through $999,000, sales force commission may range from 0.00% through
99.9%, and so on.

Despite their being allowed, decision values over much of the range are clearly unrealistic. For instance, prices above about $3,000 (about four to seven time's unit cost) result in zero unit sales. Due to diminishing marginal response, broadcast advertising expenditures above about $80,000 have almost no impact on unit sales. And commission percentages above about 20% increase expenses more than revenues. For this reason, then, random decision values could not be generated throughout the entire allowable range.

In addition, considerable experience shows that during the competition different industries take on different strategy "mentalities." Specifically, companies in some industries come to spend much more than companies in other industries. (In LAPTOP total market demand expands and contracts partly as a function of overall spending. Thus, profits may be realized whether or not companies in a given industry take on a spending mentality.) For this reason, too, a single set of random decision values could not be generated for researcher-controlled companies in all industries. A random broadcast advertising expenditure of, say, $40,000 might be in the ballpark of real companies' expenditures in a growing, i.e., spending, industry, but much higher than real companies' expenditures in an industry that has not grown appreciably.

In order for random decision values to be within a range relevant to real competing companies within an industry, the following approach was taken to generate random decision values. For each decision, the highest and lowest values for the real competing companies defined a range. A random decision value was generated with a uniform probability across that range. Thus, if the highest and lowest prices were $2,000 and $1,200, respectively, a random decision value was generated between these two values. In this way, random decision values were kept within a range relevant to the real competing companies.

Advertising message types and sales promotion types both comprise categories from which participants may select options. For these decisions, a type of message or promotion was selected at random.

Four types of factors that should lead to real companies' performances bettering those of random companies were described above. One of these was experience, whereby participants might identify trends or discern the sensitivity of the market environment to specific strategy variables. With the operationalization of the random strategies used in this study, the experience factor effect is mitigated somewhat. Random decisions to some degree tend to follow the collective wisdom of the real companies with respect to experience. However, the random decisions are <u>not</u> a function of the <u>mean</u> strategies of the real companies. The high-low range of which the random decisions are a function is not necessarily a good indicator of the collective wisdom of eli the real companies. The high-low range, obviously, reflects the strategies of only two real companies, not all of the companies comprising an industry. And these two real companies, just as obviously, represent opposing strategies, not consensual strategies.

Dependent Variables

As explained earlier, in LAPTOP earnings per share (EPS) is the overall measure of company performance for a given period. Cumulative earnings per share (CEPS) at the end of the competition is the final overall measure of performance.

In this study, each period of the competition provides an opportunity to compare the performances of real and random companies and EPS is used for this purpose. In addition, CEPS at the end of the competition is used to reflect the total performance of companies over the entire competition.

Sample

Data were collected from four sections of an undergraduate introductory marketing course. All sections were taught by the same instructor using a common syllabus and format. The total of 660 students were grouped into 165 companies, each company managed by four students. Students selected their own group members. LAPTOP performance contributed 20% to the final course grade with performance being determined by individual period EPS and final CEPS.

The 1 65 companies were grouped into 55 industries of three companies each. To each industry was added a fourth company, the researcher-controlled company using random strategies. As is a common practice, an initial trial period allowed participants a single opportunity to familiarize themselves with the general effectiveness of their strategies. After the trial period, results were discarded and the simulation started again. The actual competition extended over eight periods.

In sum, the data comprised EPS for 1 65 real companies and 55 random companies for each of eight periods plus CEPS for each of the companies at the end of the competition.

ANALYSIS

For each period, average EPS was calculated across the 1 65 real companies and across the 55 random companies. As well, average CEPS for the real and random companies, respectively, was calculated at the end of the competition. The initial statistical hypothesis tested for Hai is that the vector of eight mean EPSs for the real companies is equal to the vector of eight mean EPSs for the random companies. The single independent variable is whether a company was managed by real participants or used a random strategy.

"Subjects" in this study were the real and random companies. EPSs were measured for the same real companies, i.e., the same simulation participants, for each of the eight simulation periods. While it might appear that the random strategy companies were not the same companies from period to period, this is not the case. Though their strategies were random, each such company did indeed carry over its status, e.g., balance sheet, inventory levels, lagged and cumulative market response effects, sales force morale, etc., from period to period. The appropriate analysis for Hai, then, is a repeated measures or within-subject multivariate analysis of variance (Bray and Maxwell 1985, p. 69).

RESULTS

Mean EPSs for real and random companies are summarized in Table 1. The basic MA NOVA significance level was 0.063. Thus, it may be concluded that over all eight periods, companies managed by participants did indeed realize earnings different from (actually, greater than) earnings realized by random companies. The basic premise that the simulation participation experience is a systematic, i.e. meaningful one is supported. Mean EPS for the real companies exceeds mean EPS for random companies for each of Periods 2 through 8

TABLE 1
RESULTS SUMMARY

Period	Real EPS $	Random EPS $	Real Random Difference	p-value	Real/Random EPS Percent
1	-0.62	-0.52	-0.10	599	…
2	0.57	-0.20	0.77	0.84	…
3	1.16	0.35	0.81	.133	177
4	2.14	0.95	1.19	.053	225
5	3.11	1.58	1.53	.035	197
6	5.06	3.52	1.54	.051	144
7	6.52	4.68	1.84	.009	139
8	7.77	5.96	1.81	.027	130
Cumulative	25.70	16.31	9.39	.011	158

- one-tail t-test

Utilizing directional univariate t-tests, mean EPS for the real companies was significantly ($p<.10$) greater than that for random companies in six of the eight decision periods. One of the exceptions was the first period, when participants likely engage in some exploration, and the other exception was nearly significant ($p = .1\ 3$) in Period 3. Starting with Period 3, real company mean EPS was at least 30 percent greater than random company mean EPS for each period. Thus, Hai is supported.

Discussed earlier were several factors supporting the expectation of superior performance by simulation participants over random companies. Several of these involve learning by participants. As would be expected, then, real company mean EPS increased as the competition progressed and learning took place. Random company mean EPS also increased, no doubt reflecting the operationalization of random decisions based on the range of real companies' decisions. However, as participants' learning increased, their performance differential over that of random companies increased fairly regularly over the eight periods.

The mean CEPS of real companies at the end of the competition was significantly ($p<.02$) greater than the mean CEPS of random companies. Overall, real companies earned an average of 58 percent more than did random companies by the end of the competition. Hb is supported.

Additional Descriptive Results

Within each industry three real companies competed against a single random company (as well as amongst themselves). Within each industry each period, then, there were 3 real versus random company competitions. Across the 55 industries and 8 periods, 1,320 real versus random company competitions took place. By chance alone, a real company's EPS would exceed a random company's EPS on one-half of these occasions. In fact, however, real companies' EPSs exceeded random companies' EPSs on 61 .8 percent of the occasions.

For Periods 3 through 8, i.e., discounting the two initial periods when participants would be in the steepest part of their learning curve (along with the initial trial period), the percent of the 990 occasions when real companies' EPSs exceeded random companies' EPSs increased to 64.4 percent.

DISCUSSION AND CONCLUSION

Based on their superior performances over random strategies, it is clear in this study that participants' strategies were systematic. i.e., purposeful and meaningful. Participant performance was not significantly superior during the first few periods of the competition, likely reflecting the unsystematic or exploratory character of early strategies. However, the trend toward superiority as the competition progressed is unmistakable. For the last five of the eight periods, real companies' mean EPSs were significantly greater than the mean EPSs of random companies. Over the course of the entire competition, real companies on average earned 58 percent more than random companies.

In head to head competition, real companies bested random companies between 62 and 64 percent of the time. In sum, it appears that the simulation participation experience was meaningful.

The primary contribution of this paper is the conceptual development of a random-strategy criterion for the validity of simulation participation; validity in the sense that strategy formulation takes place on a systematic basis. Application of the criterion was illustrated using a popular marketing simulation and based on a substantial number of participants.

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