SIMULATING LIFE CYCLES: LIFE SPAN AS THE MEASURE OF PERFORMANCE IN BUSINESS GAMING SIMULATIONS

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ABSTRACT

Life span is proposed as a comprehensive, simple, and flexible measure of individual performance in business simulations. In a testing context, participants' life spans should increase as other performance targets are met. In a teaching context, they should decrease as other performance targets are met. Data from a business gaming simulation are presented. They suggest that learning took place over the first life cycle of a 4-cycle gaming simulation experience, and that life span is a generally valid measure of performance in the gaming simulation exercise.

INTRODUCTION

Benjamin Franklin obviously overstated the case when he observed that "in this world nothing can be said to be certain, except death and taxes." In the everyday world, clearly, death is certain, but taxes can be avoided and evaded. On the other hand, in the simulated world that delights some business scholars, taxes are certain but deaths usually do not occur.

It is because simulated business executives of business gaming simulations do not die and because the simulated companies of these simulations generally are not permitted to die that developers of many business simulations have difficulty supplying simple measures of performance that motivate participants appropriately. Thus, the profit-based measure is common, and it may even be the "ultimate or substantive criteria when evaluating the effectiveness of student game teams" (Wolfe, 1993, p. 54), but as Teach (1990) has observed, profit is a short-term measure that "encourages the short-term perspective.... It is not one that should be fostered in the minds and habits of young managers" (p. 15).

To be sure, death may be said be simulated when the simulation exercise terminates, an event that some administrators do not announce in advance, to discourage end gaming (Meier, Newell, & Pazer, 1969). From another perspective, however, end gaming is preparing for the inevitability of death, which should therefore be encouraged rather than discouraged. The problem is that if death is catastrophic, so that all simulated companies and their executives pass away at the same time, as would be the case at exercise termination, then no one is in a position to receive the wealth of those who leave, so no one has reason to protect that wealth. Thus, the likely consequence of aggressive end gaming is chaos as all participants gird for the expected catastrophe of simultaneous deaths.

In the more common case when the deaths of some lead to the transfer of wealth to others, those approaching death work towards an orderly transfer to ease the pains and heighten the pleasures of their final moments, while those far from death find it in their interest to maintain stability so as not to lessen the value of the wealth they are about to receive. In this case, therefore, chaos is not likely to accompany the transition.

Accordingly, to simulate death in gaming simulations without inviting chaos, the simulation might distribute the deaths so that as some die others receive the wealth that is left behind. The deaths must be reasonably predictable, so that planning for them would be sensible. And if all participants are to experience both the giving end and the receiving end of the life cycle, every participant must live through two or more life cycles if all participants begin their first life cycles together, as may be necessary to conform to the administrative constraints of college teaching.

Within these constraints, performance could be measured by the length of each life cycle, that is, by the life span. Accomplishments could give rise to a longer life span, as in a survivor-of-the-fittest competition, or accomplishments could give rise to a shorter life span, as in the genteel game of golf. In both cases, the life span measure should avoid the short-term emphasis of the profit measure, should unquestionably be an ultimate and substantive criterion, and should be readily understood because of its meaningfulness in everyday living.

MEASURES OF PERFORMANCE

While profit is the underlying measure of performance in many business simulations, applying the profit measure to a business simulation is not simple. Investments and dividend payments affect profit, so adjustments may be necessary, especially towards the last periods of the gaming simulation exercise. Replacement costs and intangibles may be missed by the profit measure, so adjustments for these also may be made. Subjective judgment, either by the administrator or by competing firms, may be incorporated. Stock prices may be modeled by an algorithm, and thrown into the mix. Goal achievement and forecasting accuracy may be included as well, after which weights may be used to aggregate a variety of measures into a single number.

Thavikulwat (2004) has supplied a recent review of these methods.

Moreover, the profit measure is a company measure, not an individual performance measure. Profit measures how well a company has performed in a business over a length of time. The profit measure becomes an individual performance measure only under the restrictive condition that the company is dominated by an individual whose control over the company is unchallenged over the measured duration. But when the simulation exercise involves fewer companies than participants, so that each company is managed by more than one participant, or when the exercise allows participants to move among the companies, or both, the close association between company performance and individual performance is lost.

Individual performance measures, such as personal net worth and consumption (Thavikulwat, 1990), are useful for these less restrictive cases. If life span is linked to these measures, such that a participant's life span is either lengthened or shortened by personal net worth or consumption or both, then the life span measure incorporates all subordinate considerations in a single simple entity..

THE LIFE CYCLE CONCEPT

Although business gaming simulations heretofore may not have addressed the human life cycle in their design, the related concepts of product and company life cycles have been modeled (Carvalho, 1991, 1992; Chiesl, 1986; Thavikulwat, 1989) and incorporated into many marketing and total enterprise simulations (Breinholt, Chesteen, Cooper, 1992; Cannon, Yaprak, & Mokra, 1999; Chiesl, 1980, 1990; Dickinson & Faria, 1993, 1995; Faria & Nulsen, 1981; Gandhi, 1993; Gentry, Macintosh, Stoltman, & Wilson, 1994; Gold & Pray, 1998; Hsu, 1990 ; Jones, 1980; Keys & Biggs, 1990; Lerviks, 1979; Malik & Howard, 1995; Pasold, 1987; Rashid, Cannon, & Morgan, 1988; Schaffer, 1999; Schwartz, 2001; Shane & Collins, 1984; Teach & Schwartz, 1999). In these simulations, the life cycle is addressed as a series of stages, such as startup, growth, and maturity, through which the products or firms must pass, but not much consideration is given as to how products and firms may affect each other when they are at different stages of their life cycles.

While the human life cycle also may be divided into a series of stages, the particularly salient aspect of the human life cycle is how the life-cycle stage of one person has consequences for the life-cycle stage of another person. Thus, a person at the beginning stage (a child) depends entirely upon others who are at later stages (adults) for sustenance. Midpoint into the life cycle, the successful individual manages a complex network of relationships, benefits from several sources of income, and produces a surplus that may be shared with others. At the ending stage of the life cycle, the more astute liquidate their holdings to enjoy more fully the fruits of their labors and investments. All lose theirs to heirs and others in due course.

Death is the all-encompassing event of the human life cycle. When the business simulation makes room for death, it makes room for intergenerational transfers of wealth, for intergenerational dependency, and therefore for a vibrant economy. Death resolves the otherwise conflicting demands of enriching the simulation experience and simplifying its measure of performance.

THE LIFE SPAN MEASURE

Business gaming simulations can be used either for testing or for teaching. When used in testing, a survivor-of-the-fittest competition wherein the most capable are kept in the competition for the longest time should generally be desirable, because it allows for the clearest distinction among those who perform the best inasmuch as the rewards to the best generally differ substantially depending on where one places in the competition. When used in teaching, however, a survivor-of-the-fittest competition promotes a climate hostile to learning, which is facilitated when participants work towards realistic targets, with those who have more difficulty reaching targets being allowed more time. Accordingly, simulation accomplishments should extend participants' life spans in a testing context and shorten their life spans in a teaching context. In both cases, however, life span should suffice as the singular, all-inclusive measure of performance.

The life span measure will be crude if the simulation runs for only a few periods, 8 to 12 in many cases (Anderson & Lawton, 1992). Thus, if a 12-period simulation run is to include two life cycles, the average length of each life cycle might be 6 periods. The best-performing participant might complete a life cycle in 4 periods whereas the worst-performing one might do so in 8 periods, allowing for only five levels of distinction (4, 5, 6, 7, and 8), which may nevertheless be sufficient. Ideally, the simulation should run for many more periods, but this is practical only if the simulation's time is not administratively driven, but is either participant-, clock-, or activity-driven (Thavikulwat, 1996).

Ideally also, the life span measure should be individualized, as free-riding is a frequent accompaniment of team-based scores (Biggs, 1986. 1990; Hornaday, 2001; Markulis & Strang, 1995; Wolfe, 1990). Individualizing scores, however, are meaningful only if participants are able to work and invest in more than one firm, and are practical only if a computer program that tracks individual activity is included with the simulation package.

Measurement is generally assessed by examining its reliability and validity. To assess the reliability of the life span measure, one might consider correlating participant life spans in a simulation exercise that involves two or more sequential life cycles, expecting that statistically significant positive correlations among life spans will be evidence of reliability. To assess validity, one might correlate life spans with scores from conventional examinations.

The problem in assessing reliability by correlating sequential life spans is that in a time-synchronized simulation (Thavikulwat, 1996), life span is identical to time-on-task, which is among the most important conditions of learning. Consequently, the participant who spends more time in an earlier life cycle may learn more about how to perform well in the second life cycle by observing the performance and avoiding the mistakes of those who have gone ahead, than the participant who spends less time. If so, the consequence will be a negative correlation between the earlier and the later life spans, considering that the earlier life span measures learning whereas the later one measures performance, the result of learning. This contrary result will be especially likely if the rewards for performance are less for the earlier life span and more for the later one, and if faster completion of the later life span requires an adaptive response that can be learned, such as shifting rapidly from liquidating assets towards the end of the earlier life span to accumulating assets at the beginning of the later life span. Thus, an absence of positive correlations among sequential life spans should not be immediately interpreted as evidence of an absence of reliability. On the other hand, a distinctly negative correlation is evidence that time-on-task in the earlier life span translated into learning that enable participants to advance faster through the later life span. Accordingly, the first null hypothesis of this study is as follows:

H1: *In a time-synchronized simulation wherein participants advance through two or more life cycles in sequence, their life spans of an earlier life cycle will not be negatively correlated with those of a later life cycle.*

The assessment of validity is more straightforward. Examination scores should correlate negatively with life spans to the extent the examination questions cover the attributes of the simulation. Accordingly, the second null hypothesis of this study is as follows:

H2: *Life spans will not correlate negatively with scores from an examination that include questions about the attributes of the simulation.*

METHOD

Data for this study came from a business gaming simulation, GEO, involving 65 undergraduates enrolled in three sections of an international-business course at a comprehensive university. The gaming simulation was computer-assisted. Time was clock- and activity-driven, synchronized for all participants, and set to advance at the pace of about 60 periods a week after the initial registration and startup phases. The class met twice a week in a computerized classroom, where each participant had access to a personal computer. Participants were encouraged to work on the simulation for a few minutes before and at the beginning of every class period. They also could access the simulation from other computers on the campus at any time. The exercise took place over the entire semester.

The exercise simulated a global economy. Participants were assigned to one of three nations, depending upon the class section in which they were enrolled. They could found companies, employ each other, and trade stock in the founded companies of any nation. No one was required to join a team, but as the production level of each company increased with the number of different participants employed by the company, the simulation built in a substantial incentive for companies to employ more than one participant, and thus, to form teams. Considering that the members of these teams had well-defined roles and that any member could leave the employment of a company to accept employment in another company at any time, the teams so formed were more akin to those of the everyday world than to student teams put together for many classroom exercises, wherein roles are often poorly defined, work is uncompensated within the exercise, and participants are not allowed to move from one team to another at will.

Participants were told that for the exercise, they would each pass through four sequential simulated life cycles. They would gain 10 course points, out of a grand total of 200 course points, towards grades for completing each of the first two life cycles, and a variable number of course points, not exceeding 15, depending upon their relative performance in completing each of the remaining two life cycles. Those who complete their first two life cycles earlier would simply get their work done sooner; they would earn no more in points towards grades than those who required more time. Accordingly, the emphasis of the first two life cycles was on learning, as relative performance did not affect grades, whereas the emphasis of the last two life cycles was on performance, as relative performance translated into a difference in points towards grades. Even so, participants were told that relative performance in each of the last two life cycles counted towards grades only if it exceeded their performance in the rest of the course.

To complete each of the first two life cycles, each participant was asked to “consume" products sufficient to reach two targets. The first target was the sum of the absolute consumption values associated with each product that the participant bought from producing companies through an anonymous auction market (Thavikulwat, 2003). The second target was the cumulative sum of the relative consumption scores that the participant earned in each period. These scores depended on how much each participant consumed relative to the average consumption level of all participants. Accordingly, performance was based on both absolute and relative consumption, and consumption affected the length of each participant’s life cycle. Those who consumed more and consumed less erratically reached their targets sooner, and so had shorter life spans than others.

Table 1
Descriptive Statistics of Variables

Section		Exam 1	Exam 2	Exam 3	Final	Span 1	Span 2	Point 3	Point 4
1	Mean	20.09	18.91	16.09	33.30	229.91	172.50	7765.96	5659.48
	N	23	23	23	23	22	16	23	23
	Std. Dev.	2.49	3.92	3.95	6.44	94.34	66.89	6789.88	5499.00
	Minimum	13	8	10	23	114	0	1260	0
	Maximum	24	25	23	46	431	297	32842	22205
2	Mean	17.85	17.45	16.35	29.61	232.60	179.10	3897.35	743.30
	N	20	20	20	18	20	10	20	20
	Std. Dev.	2.48	3.00	3.75	6.01	111.25	64.77	1462.16	855.03
	Minimum	15	13	9	23	106	120	1443	0
	Maximum	23	24	23	47	433	304	7190	2616
3	Mean	18.77	18.36	15.18	26.11	166.50	192.00	6409.45	3013.59
	N	22	22	22	22	22	12	22	22
	Std. Dev.	2.78	3.43	3.29	6.41	53.18	29.97	3225.96	2704.34
	Minimum	11	11	5	16	105	158	939	0
	Maximum	23	23	19	38	282	253	13707	8520
Total	Mean	18.95	18.28	15.86	29.74	208.95	180.39	6116.49	3251.28
	N	65	65	65	63	64	38	65	65
	Std. Dev.	2.707	3.49	3.65	6.92	92.75	56.32	4737.44	4132.87
	Minimum	11	8	5	16	105	0	939	0
	Maximum	24	25	23	47	433	304	32842	22205

The first two life cycles were forced to a close after 8 weeks. By then, only 1 participant had not completed the first life cycle, 27 had completed the first but not the second, and 37 had completed both. The missing life span values of those who had not completed both life cycles were excluded from the correlational analyses on a pairwise basis, inasmuch as any adjustment of the life cycle to account for the missing periods would require an arbitrary projection algorithm.

As for the last two life cycles, both began and ended at the same time, so all participants experienced life cycles of the same length. The third life cycle spanned four weeks, and the fourth spanned two weeks. At the conclusion of each life cycle, relative performance was assessed by an exponential formula that gave 90% of the allotted course points to the participant who consumed at the average level; 100%, to the participant who consumed at three times the average level or more; and 0%, to the participant who consumed nothing.

The demand for products to consume was incentive for companies to form to produce those products. Revenues earned by the productive companies paid for resources produced by other companies downstream of the supply chain, for salaries of participants hired as employees, for taxes and fees assessed by national governments, for interest expenses, and for dividends distributed to participants who had purchased company stocks. The complexity of executing the decisions of participants and tracking the consequences of those decisions is managed by a local-area-network program with access to a centralized set of files.

RESULTS

Eight cross sectional measures were collected for this study. Of the eight, two consisted of the life spans of participants who complete each of the first two life cycles of the exercise (Span 1 and Span 2); two, of the consumption points of the participants on their third and fourth life cycles (Point 1 and Point 2); three, of the multiple-choice exam scores of participants on three 25-item examinations administered to all sections of the class throughout the semester (Exam 1, Exam 2, and Exam 3); and one, of a final examination consisting of 35 multiple-choice items and three essay questions (Final). Items about the attributes of the gaming simulation appeared in the first exam only. They amounted to 13 of the 25 items.

Means, standard deviations, minimums, and maximums of these eight measures are given in Table 1. Each measure is broken down by class section; each section met at a different time. The one-way analysis of variance of the four data sets (Table 2) shows that differences across sections do exist on five of the eight measures ($p < .05$). The partial correlations of the measures, controlling for sections, is given in Table 3, and the Pearson correlations of the three measures that did not evidence sectional differences (Exam 2, Exam 3, and Span 2) are given in Table 4.

The data suffice to reject the first null hypothesis unequivocally. As shown in Table 3, the partial correlation between Span 1 and Span 2 is substantial and statistically significant ($r = -.5678$, $p = .000$). Accordingly, participants who took more time to complete the first of two completed life cycles learned more in their first life cycles, as

Table 2
Analysis of Variances

		Sum of Squares	df	Mean Square	F	Sig.
Exam 1	Between Groups	54.622	2	27.311	4.088	.021
	Within Groups	414.240	62	6.681		
	Total	468.862	64			
Exam 2	Between Groups	23.148	2	11.574	.949	.393
	Within Groups	755.867	62	12.191		
	Total	779.015	64			
Exam 3	Between Groups	16.105	2	8.053	.596	.554
	Within Groups	837.649	62	13.510		
	Total	853.754	64			
Final	Between Groups	581.815	2	290.908	7.301	.001
	Within Groups	2390.613	60	39.844		
	Total	2972.429	62			
Span 1	Between Groups	60494.741	2	30247.371	3.833	.027
	Within Groups	481414.118	61	7892.035		
	Total	541908.859	63			
Span 2	Between Groups	2630.179	2	1315.089	.401	.673
	Within Groups	114748.900	35	3278.540		
	Total	117379.079	37			
Point 3	Between Groups	162956883.285	2	81478441.643	3.967	.024
	Within Groups	1273418648.961	62	20539010.467		
	Total	1436375532.246	64			
Point 4	Between Groups	260428821.758	2	130214410.879	9.695	.000
	Within Groups	832731447.257	62	13431152.375		
	Total	1093160269.015	64			

Table 3
Partial Correlations of Variables Controlling for Sections

	Exam 2	Exam 3	Final	Span 1	Span 2	Point 3	Point 4
Exam 1	**.5176****	**.4079****	**.3976****	**-.2449***	-.1983	**.2075***	.1538
	df = 62	*df* = 62	*df* = 60	*df* = 61	*df* = 35	*df* = 62	*df* = 62
	p = .000	*p* = .000	*p* = .001	*p* = .027	*p* = .120	*p* = .050	*p* = .112
Exam 2		**.4754****	**.3805****	-.1564	-.2707	.1607	.0789
		df = 62	*df* = 60	*df* = 61	*df* = 35	*df* = 62	*df* = 62
		p = .000	*p* = .001	*p* = .110	*p* = .053	*p* = .102	*p* = .268
Exam 3			**.4460****	-.1475	-.0810	.0345	.0374
			df = 60	*df* = 61	*df* = 35	*df* = 62	*df* = 62
			p = .000	*p* = .124	*p* = .317	*p* = .393	*p* = .385
Final				-.0960	-.1311	.1166	.0850
				df = 59	*df* = 34	*df* = 60	*df* = 60
				p = .231	*p* = .223	*p* = .183	*p* = .256
Span 1					**-.5678****	-.1080	-.1099
					df = 34	*df* = 61	*df* = 61
					p = .000	*p* = .200	*p* = .196
Span 2						-.0797	-.0293
						df = 35	*df* = 35
						p = .320	*p* = .432
Point 3							**.5782****
							df = 62
							p = .000

** $p < .01$ (1-tailed).
* $p < .05$ (1-tailed).

evidenced by their shorter life spans in their second life cycles.

The data suffice to reject the second null hypothesis generally. The partial correlation between first examination and the two life spans are consistently negative, but statistical significance is reached only for the partial correlation of Exam 1 with Span 1 ($r = -.2449$, $p = .027$).

The correlations among examinations ($.3805 \leq r \leq .5175$, $p \leq .001$) attest to their reliability. Likewise, the correlation between the two consumption measures ($r = .5782$, $p = .000$) also attest to reliability.

The remaining partial correlation, between Exam 1 and Point 3, and the Pearson correlation between Exam 2 and Span 2 suggest some overlap of the different measures. Remarkably, Span 1 and Span 2 do not correlate with Point 3 and Point 4, which suggest that they measure different qualities.

Table 4
Pearson Correlation

	Exam 2	Exam 3	Span 2
Exam 2		**.479****	**-.277***
		df = 65	*df* = 38
		p = .000	*p* = .046
Exam 3			-.095
			df = 38
			p = .286

** $p < .01$ (1-tailed).
* $p < .05$ (1-tailed).

CONCLUSION

The data suffice to conclude that learning took place over the first life cycle of the simulation experience and that life span is a generally valid measure of performance in the exercise. The conclusion that learning took place applies, however, only to the 57% of participants who completed both life cycles. Nothing more can be said about the remaining participants who were unable to complete both life cycles in the allotted time. The conclusion that life span is a generally valid measure of performance in the exercise is remarkable, considering that the instructor vigorously coached the participants in their first life cycles, spending more time with those who were slower in progressing through their life cycles and less with those who were faster. Apparently, life span, as a measurement of performance, is a robust measure that is not much contaminated by vigorous coaching.

The absence of correlation between the life span measures of the first two life cycles and consumption point measure of the last two life cycles also is remarkable, considering the apparent validity of the life span measure and the apparent reliability of the consumption point measure. As constructed, the life span measure depended on a steady level of consumption whereas the consumption point measure depended on cumulative consumption without regard to its distribution over time. These results may be seen as consistent with two different kinds of business skills: managerial skills, required for steady work, and entrepreneurial skills, required for making deals. The data of this study does not suffice to clarify this speculation, so the results call for more research.

This study does establish that life span as the measure of performance in a business simulation can be advantageous. The measure is comprehensive, simple, and flexible. In a testing context, the life span should increase when other performance targets are met; in a teaching context, the life span should decrease when other performance targets are met. The study presented herein is from a teaching context.

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