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A NOTE ON A SIMULATED STOCK MARKET

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by

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1. Introduction

This note describes a stock market game played in a simulated stock market associated with the playing of a business game. The possibility of using a stock market game as an experimental device to study expectations and market behavior is discussed and the data from a run of this game together with some analysis are presented.

2. History

In 1959 the General Electric Marketing Game designed by George Feeney¹ was run at the General Electric Management center at Crotonville. The marketing game provides as a background a simulated oligopolistic market with four firms of equal strength. The optimal size for an active team appears to be no more than three or four (although over ten individuals tried to run one team by majority vote, with a fair amount of chaos resulting). As there were well over sixty

* Research undertaken by the Cowles Commission for Research in Economics under Contract Nonr-3055(01) with the Office of Naval Research.

¹Feeney, G. J., "Simulating Marketing Strategy Problems," Marketing Times (New York: General Electric Corp.) 2:1, January 1959, pp. 8-24.

people available it became apparent that not all could participate actively in the game. It was decided that the surplus of available participants presented an opportunity both to illustrate to all the details of the functioning of a stock market and to investigate the feasibility of experimenting with a stock market game. As there was no previous experience whatsoever many errors were made in the setting up of the controls over this exercise. Furthermore the market was somewhat "thin." This experience and the subsequent one both indicate that the optimum size for a stock market is above 100 participants, possibly around 150.

The market or business game required about 20-25 minutes per period to run. A full day's run can cover between 16-20 periods.

On January 20, 1960 the same game was run at the Stanford Research Institute. There were between 80 to 100 participants. The market game ran all day and the stockmarket opened at 9:13 a.m. and ran until 4:35 p.m. covering 14 out of the 20 periods of play. Both members of the individual firms and the "trading or investing public" held shares. This already introduced a degree of complication which is not necessary unless one has an experiment designed to consider differences between corporate insiders and the general public. A far more important aspect of experimental control was made clear by both plays of the game. If the institutional problems in running the stock market game do not make it imperative to actually run a business game simultaneously to generate the inputs to the stockmarket,

then a much more satisfactory procedure is to use a "canned game," i.e., the outputs from a previously played game or a set of constructed outputs from a fictional game chosen by the experimenters. Among the very important advantages associated with such a procedure is that the experimenter becomes immune to machine failures and to delays in the market game play. New information may be posted every 10 minutes and the stockmarket game may proceed at the speed of 5-6 periods per hour. Furthermore the experimenter will be able to control the non-zero sum aspects of the market in which the firms operate and hence be more careful about the briefing given to the investors or traders.

In the game which was run at the Stanford Institute the participants were sold shares at \$1.25 per share which were at a premium of 59 cents over asset liquidation value at that time. They were briefed that the profits of the industry as a whole would grow sufficiently that the issue price (on the average) would be equalled or exceeded. Furthermore they were briefed that at the end of the exercise all shares would be redeemed in direct proportion to the asset values of the firms (the non-zero sum aspect of the game meant that the "house" stood to pay for any growth that had occurred). The details of the specific stockmarket structure and the briefing are given in the Appendix. Four members of the San Francisco stock exchange were invited and came to give advice on the versimilitude of the exchange and to operate the four trading posts.

Short sales were permitted, however another and apparently unnecessary source of distortion was introduced when the players were instructed that those who were caught short at the end of trading would have to pay a penalty of twice the final liquidation price of the shares. Although this might realistically reflect the effect of a corner, experimentally it appears as an unnecessary complication. In the actual play there were very few short sales relative to long purchases. In any future run it seems to be reasonable to permit short sales and to require a cover at final market price.

In toto 428 shares were issued (some in units of less than 8 in spite of the initial briefing) and in the course of play 449 shares were traded in a total of 174 trades, which were broken down as follows:

Table 1

	Bid	Offer	Trade	Volume
Company 1	67	64	40	124
Company 2	50	61	39	130
Company 3	49	57	44	94
Company 4	64	68	51	101
			<u>174</u>	<u>449</u>

The stock market opened at the third period of play of the game. The first two periods were preprogrammed and designed to give both the members of the firms and the participants some feeling for

the nature of the market. It had been intended to run the stock market up to the last period in the functioning of the business game however owing to machine failures and other administrative difficulties the stock market closed at the 16th period although the liquidation values were nevertheless based upon the 20th period. This introduced another source of "noise" in the game. Owing to time constraints people knew that the stock market had to close somewhat before 5 p.m.

3. Players and Goals

The players were upper middle and upper echelon managers from firms associated with and using Stanford Research Institute as well as some staff members of S.R.I. and faculty members of Stanford. They used their own money to buy the initial issue of the shares and appeared to understand the money-making possibilities available to them.

4. Uses for the Game, Hypotheses and Analysis of Data

A simulated stock market appears to provide an environment for the experimental study of trading and expectations. Dividends, stock splits, information time lags, brokers fees and the other myriads of institutional details are not present. The value of the stock at the close of the exercise can be calculated in a manner that is a stock market analyst's dream. The financial reports are the same for all companies and cannot be used to conceal or confuse. All trading is done directly to the individual's own account.

The stock market in this simplified form serves as a stage for the study of expectations or anticipations. If the individual were able to judge the abilities of the different firms he would be in a position to adjust his portfolio accordingly.

Two hypotheses were made. The first concerns the relationship between stock market price and asset value.

Hypothesis 1 The market average will be always above the average asset value of the firms.

This is a relatively weak hypothesis for the start as the subscription price for the shares was 59 cents more than the then asset value. The hypothesis becomes more interesting when the average asset value of the firms is greater than \$1.25.

The second hypothesis concerns the spread between stock price and asset value as related to the growth of the firms.

Hypothesis 2 (a) The ratio of initial to final average (first 4 and last 4 periods) "spread" between asset value and market price will be greatest for the most profitable firm and (b) least for the least profitable firm.

This hypothesis is in keeping with the "growth stock" psychology that has caused 60 and 80 times price earnings ratios to be not uncommon for "glamor issues."

There are many other hypotheses primarily involving dynamics

and the time series aspects of expectations; however the two hypotheses noted were the only ones formulated prior to examining the data. A more careful running of a similar but better controlled stock market is called for before much faith could be attached to the results of a time series analysis.

The stock market price and asset information are presented in Table 2 below. The prices quoted are for the last trade of the period. When two prices are given such as 1.10-1.25 this indicates the bid offer spread in a period during which no trade took place. In one instance (Company 4, period 3) there was an offer but no bid. This is indicated by -1.25.

The final asset values (rounded to the nearest five cents) which were used to determine the liquidation worth of the shares were:

155	175	100	135 ,
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these may be compared with the final trades and the asset values at the end of the 16th period which were respectively:

160	170	100	150
127	144	97.9	138

The following five graphs display the information in Table 2. Whenever there was a bid-offer spread the midpoint was plotted. A simple inspection of Figure 5 shows immediately that Hypothesis 1 is confirmed. Furthermore the average price at period 16 was higher than the final liquidation value 4 periods later! If we wish to con-

Table 2

Quarter	Company 1		Company 2		Company 3		Company 4		Average	
	Assets	Price	Assets	Price	Assets	Price	Assets	Price	Assets	Price
3	69.02	80-85	69.99	80	69.78	1.25- 1.40	69.42	-1.25	69.5	
4	69.85	95	71.40	1.00	70.85	1.15	70.66	.95	70.8	101.3
5	71.57	1.05- 1.20	71.76	1.05	71.17	1.10- 1.25	71.23	1.00	71.6	106
6	73.26	1.20	73.01	1.00	72.31	1.10	72.53	1.10	72.8	110
7	75.37	1.25	75.66	1.20	74.35	1.10	74.68	1.05	75.0	115
8	77.73	1.25	78.15	1.45	77.46	1.10	78.28	1.20	77.9	125
9	82.42	1.25	82.77	1.50	78.69	1.10	82.21	1.25	81.5	127.5
10	89.15	1.40	89.87	1.50	80.64	1.05	86.61	1.20	86.6	128.7
11	96.22	1.75	97.41	1.65	83.40	1.00	88.93	1.10	91.5	137.5
12	103.21	1.75- 1.90	106.00	2.15	86.29	1.05	97.08	.90 -1.30	98.1	153
13	100.65	1.20	118.42	2.00 -2.25	88.87	1.15	110.59	1.25	104.6	143
14	108.00	1.30	129.85	1.75	82.72	1.00	123.39	1.50 -1.75	111.0	142
15	119.32	1.40- 1.50	137.52	2.10	93.16	1.00	130.78	1.50	120.2	151
16	127.71	1.60	144.48	1.70	97.94	1.00	137.95	1.50	127.0	145
issue price	1.25		1.25		1.25		1.25			
asset value at issue	68		68		68		68			
final asset value	1.55		1.75		1.00		1.35			
stock last trade price	1.60		1.70		1.00		1.50			
assets value at period 16	1.27		1.44		.979		1.38			

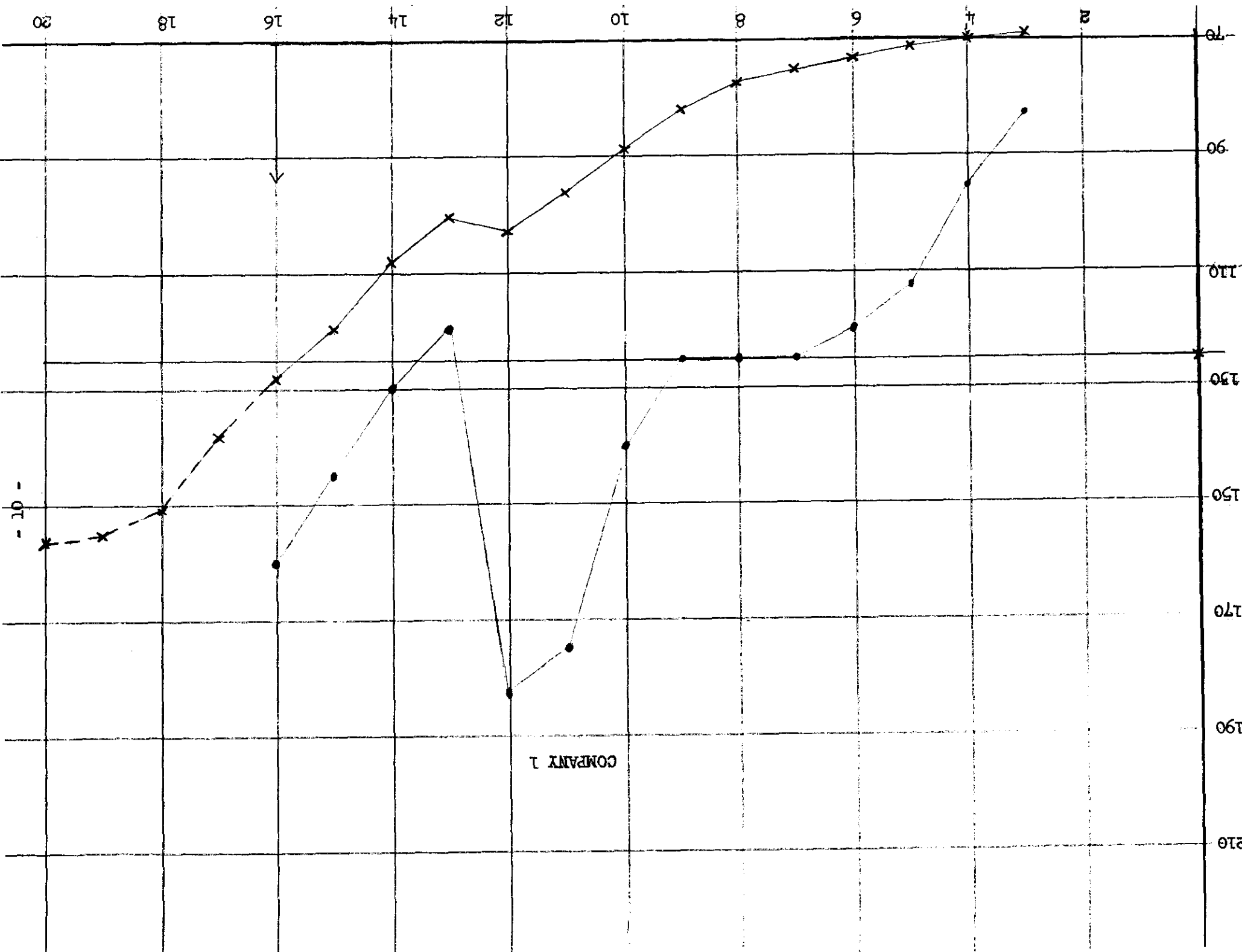
sider that the market discounts the future it apparently did so by between 6 to 8 periods as can be seen by inspecting Figure 5.

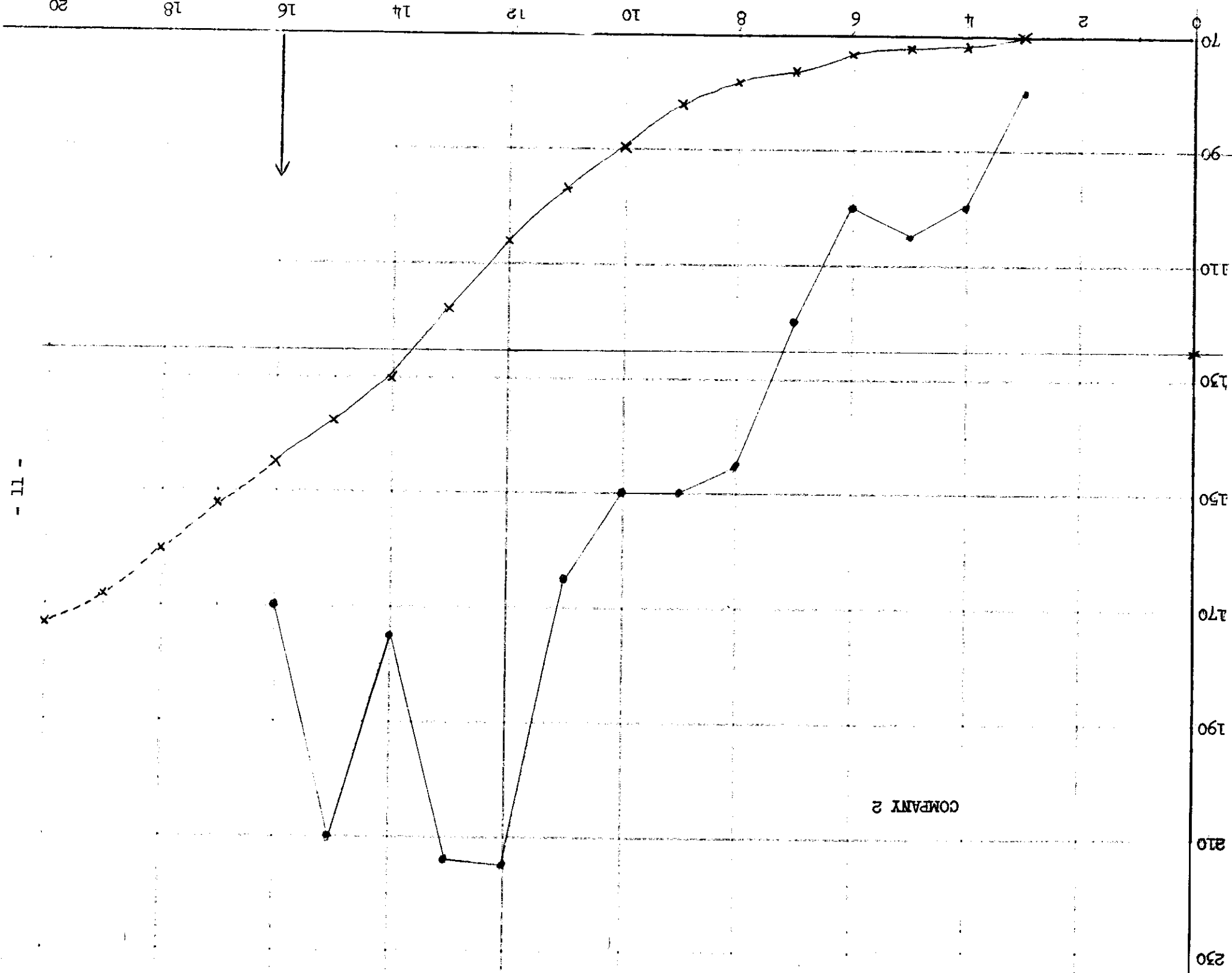
It is of interest to note that from period 4 to 20 the assets of the firms approximately doubled or were growing at approximately 17% per annum.

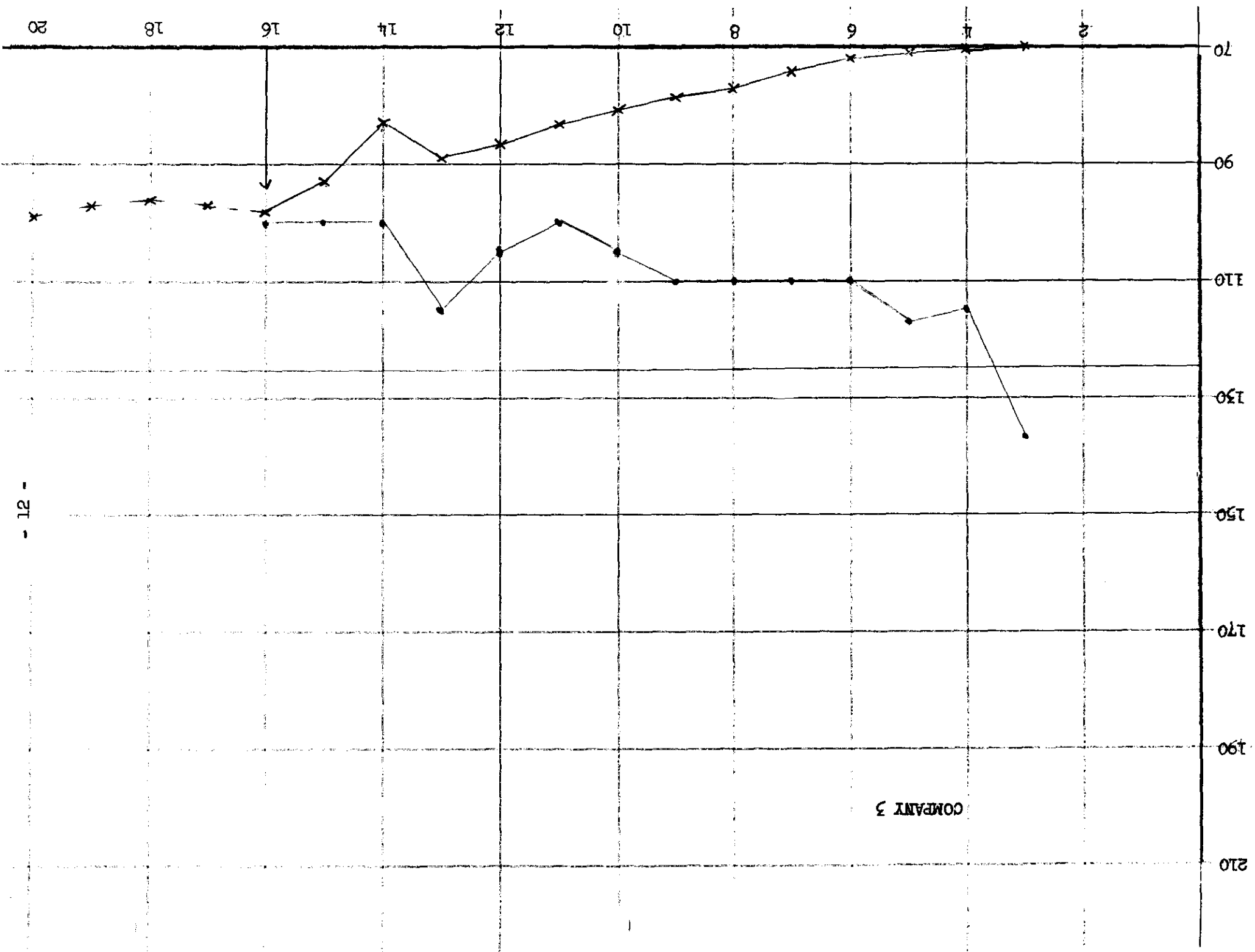
In Table 3 the per period growth and the spread between the stock prices and asset values for the four firms is presented. The first column gives $Assets(t) - Assets(t-1)$ and the second the spread.

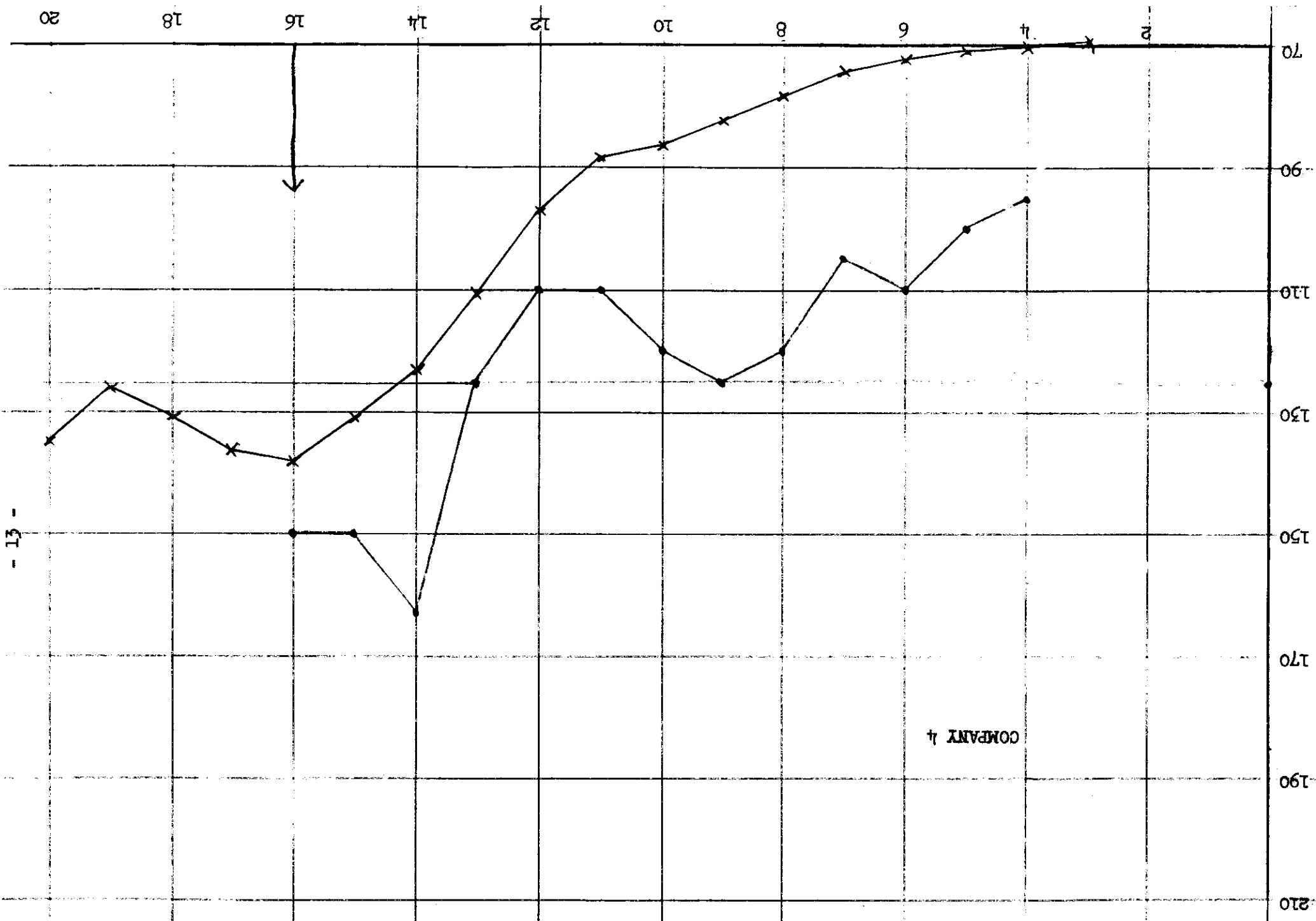
Inspection of Table 3 shows that the first part of Hypothesis 2 is confirmed here. The average spread actually widened for the major growth stock. The second part of the hypothesis was also confirmed the least profitable firm by Period 16 showed the narrowing of average spread. There are obviously considerable serial effects and on any repeated run an appropriately sophisticated statistical analysis is called for.

It should be noted that in Period 13 a panic developed in the trading of the stock of Company 1. It fell around 60 cents or by about 1/3 immediately after losses were announced following five periods of good growth. People actually charged from the bulletin and information boards and mobbed and fought to get to the trading post of Company 1 during this period. Ex post facto this was precisely the time to have bought the stock of Company 1.









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COMPANY 4

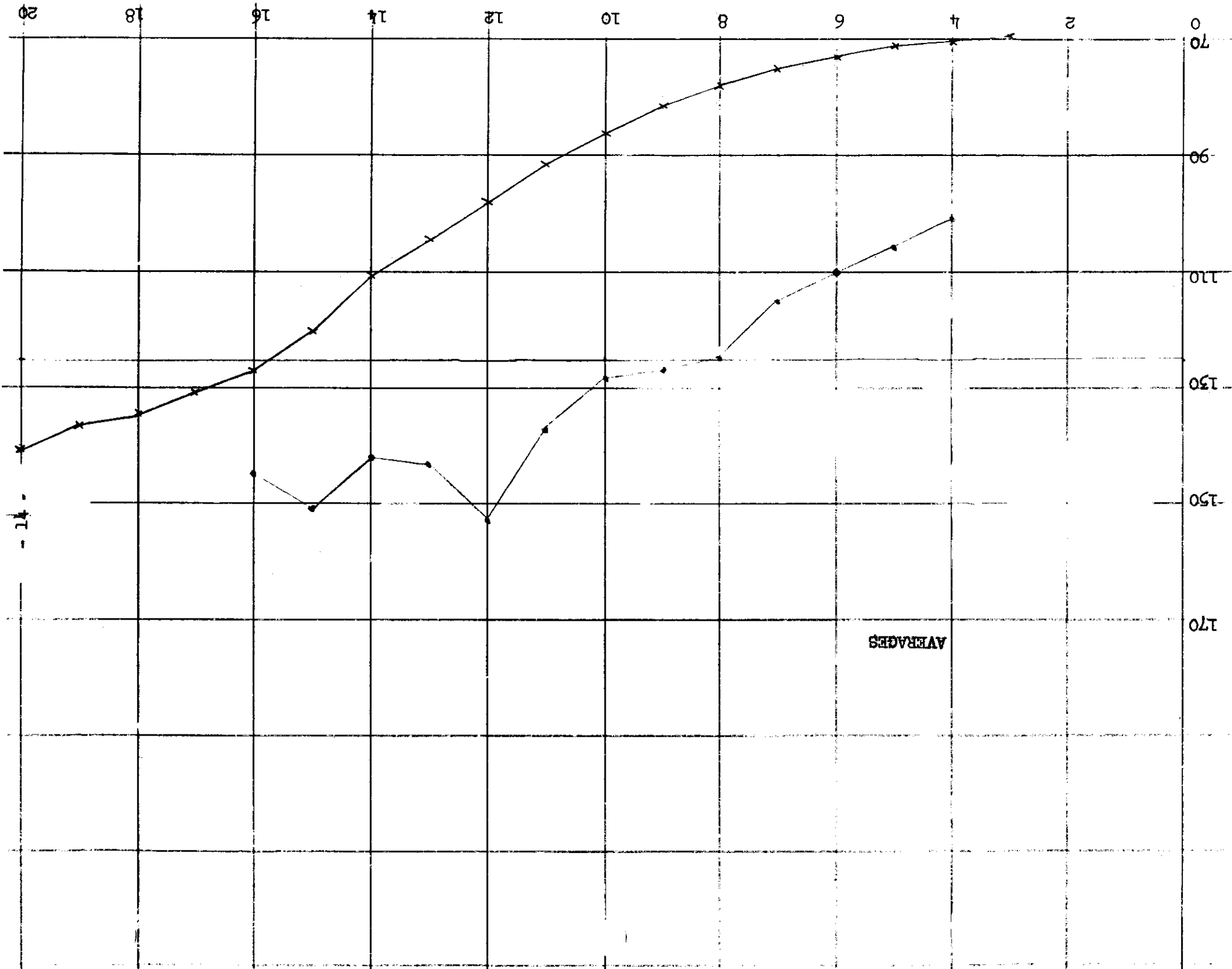


Table 3
Growth* and Spread for

Quarter	Company 1		Company 2		Company 3		Company 4	
	3	1	13	2	10	2	62	1
4	1	25	1	29	1	44	2	24
5	2	40	1	33	0	46	0	29
6	1	47	1	27	1	38	2	37
7	2	50	3	46	2	36	2	30
8	3	47	2	67	3	33	3	42
9	4	43	5	67	2	31	4	43
10	7	51	7	60	2	24	5	33
11	7	79	7	68	2	17	2	21
12	7	79	9	109	3	19	8	13
13	-2	19	9	94	3	26	14	14
14	7	22	12	45	-6	17	12	39
15	11	25	8	72	10	7	8	19
16	9	32	6	26	5	2	7	12
final spread initial	$\frac{108}{125} = .86$		$\frac{237}{99} = 2.39$		$\frac{52}{190} = .27$		$\frac{84}{120} = .70^+$	
Assets at Period 16	128		144		98		138	

* Both sets of figures are rounded off to the nearest cent per share. As there were no dividends the first column gives: $\text{Earnings}(t-1) = \text{Assets}(t) - \text{Assets}(t-1)$.

⁺The missing first period spread was taken as the average of the other three at the very worst it could have been 56 cents (difference between asset value and offer).

5. Conclusions

The results from the analysis of the data are slim, but somewhat suggestive. The major purpose of this exercise was to explore the possibility of using a simulated stock market for gaming to study individual mass behavior (the trading floor was more a mass of individuals than a large group, except during the panic when it came close to being a mob).

It appears that the game is feasible and although not easy, neither very hard nor costly to run. The main problem is to be able to find more than 100 participants for a period of 4-6 hours. Around 8-10 people are needed to operate the game (4 traders, 1 or 2 for a clearing house, a floor president and 2 or 3 to post information and spell others).

The game not only has research value but after the debriefing on both occasions it was run there were comments concerning the added insights obtained into the role and functioning of a stock market.

It appears that not only should a prepared market be used as the input to the stock market (so that around 30 periods could be covered within 6 hours); but that it might be of interest to use the appropriately edited information together with verbal releases on four or five actual firms. Furthermore it might be of considerable interest to play this game with a group of participants such as the New York Society of Market Analysts.

APPENDIX

DESCRIPTION OF AND INSTRUCTIONS FOR A SIMULATED STOCK MARKET GAME

I. RELATION TO THE PLANNING SIMULATION EXERCISE

The business game utilized in the planning simulation exercise serves as a data generation source for the stock market game.

The stock market game provides a model of an "ideal" stock market where all traders are completely informed about all firms whose stock are being traded; and in which all "frictions" such as brokerage fees, taxes, transfers costs, etc., are zero.

The addition of the stock market to the planning simulation exercise permits a much larger active participation than would otherwise be possible. It furthermore serves as both an exercise and experiment in market evaluation and expectations.

II. DESCRIPTION OF SIMULATED STOCK MARKET GAME

1. The Exchange

The Exchange is a large room with four trading posts each equipped with a large pad and easel upon which bids, offers and trades can be prominently displayed. In the room there is a series of graphs indicating the states of the four companies. These are up-dated every quarter. The yearly plan of each company is also displayed and up-dated every year.

2. Specialists

Four specialists act as the major focal points for trading. Each maintains a market in one stock. They are permitted to trade to their own accounts if they wish to do so. They may also subscribe as investors to the initial issue.

3. Shares and the Initial Issue of Shares

The shares issued by each company are in the form of bearers' certificates of seventy cents per value. The actual form of these certificates is shown below. The subscription price for the initial issue is \$1.25 per share.

The initial offering is in lots of eight (8) shares of their own companies to officers in the four companies. To all other investors, the offering is in lots of eight (8) shares consisting of two (2) shares in each of the four companies.

4. Trading Including Short Sales

Trading is carried out only at the four specialists' posts. Short sales are permitted and when they take place a signed note is issued indicating the number of shares and who was short to whom. The type of the note is shown below:

<p><i>H. Jones</i> SHORT 5 SHARES OF COMPANY 2 TO <i>S. Smith</i></p>

7

Registered John Jacob Astor
Fiduciary Trust

N

C O M P A N Y I

BEARER CERTIFICATE

✓ O N E ✓

fully paid and non-assessable share

\$1.00 Par Value

Common

L. Rasputin
Treasurer

P. T. Barnum
President

N

Countersigned P. Stanford
Company I

7

5. Value of Shares at End of Exercise

At the end of the game the shares are evaluated in direct proportion to the final asset standing of each company. For example, if the initial assets of a company were \$2,000,000 and the par value of the shares were 70 cents, then at the end, if the terminal assets were \$4,000,000, the final redemption value of the stock would be \$1.40.

Any short position outstanding at the end of the play will be required to cover at twice the redemption value of the shares involved. New shares will be issued to shorts at the end of play.