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A Preliminary Paper on

The Construction of a Business Game for Teaching and Research Purposes

(Part 1)

Martin Shubik

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1. Introduction

During the past few years, at many business schools, corporations, and department of economics, business games have been constructed, primarily for the purpose of teaching and training. These games vary in size and complexity from detailed functional representations of a job-shop all the way up to highly complex models of an over-all market. Useful experimentation can be carried out with games of this type provided that a great deal of care is exercised in their construction.

A game consisting of a market with one to six firms programmed in such a manner that the number of variables under the control of each firm would vary from one to six or seven, would permit each firm to be manipulated by anywhere from one to five people. This particular type of game could be useful for investigations in experimental work on oligopoly, organization, and learning.

The game being constructed for operation with the 650 computer is somewhat simpler than the one which is envisioned; eventually, however, even this program includes analytical and simple statistical procedures as part of the design.

With the exception of some very simple games used strictly for experimental economics such as those of Flood, Fouraker, Hoggatt, Rapoport, Shubik,

Siegel, Stern, and Stone; it is all but impossible to employ analytical procedures to merely find out what behavior patterns would be predicted by various theories of oligopoly when applied to business games. By careful selection of functional forms and parameters, and by careful design of the over-all market structure it is possible to construct a game which may range from being fairly simple to extremely complex; and, yet will be amenable to analysis in any of its forms.

The optimal group for the construction of a business or oligopoly game amenable to analysis calls for cooperation between individuals with a knowledge of economic theory, psychology, social psychology, statistics, organization theory, data processing, and programming.

The mere attempt at construction of such a game serves as a useful learning device in and of itself. The effort expended in well-defining a problem for computer operation serves as an excellent device for obtaining additional insights and understanding of the problem. The game constructed here serves as a pilot study for larger combined teaching and research uses to come.

This first paper gives a general description of the game and its format. The second paper discusses the theoretical aspects of the game. The third gives flow diagrams and a discussion of details and the fourth the program and comments on use for teaching and as a research tool.

This initial game designed for IBM 650 operation is not very flexible. Eventually it would be desirable to construct a modular game which would permit experimentation with and additions to sections.

A listing and brief discussion of the properties of the game is given below:

2. The Industry

2.1.	Number of teams	less than or equal to 6
2.2.	Number of players per team	not in program
2.3.	Number of products per team	1
2.4.	New products	no
2.5.	Intermediate markets	no
2.6.	Number of markets	1
2.7.	Price: an independent variable?	yes
2.8.	Production: an independent variable?	yes
	if costs are linear, there is a production limit	
2.9.	Distribution: an independent variable?	no
2.10.	Development: an independent variable?	no
2.11.	Advertising: an independent variable?	yes
2.12.	Cycle in overall economy (optional)	yes
2.13.	Trend (mature or growing market etc., optional)	yes
2.14.	Inventory costs	yes
	a linear cost	
2.15.	Production costs	yes
	first form linear but adjustable	
2.16.	Demand function	adjustable
2.17.	Random variables	optional: one per player in advertising
		optional: one on overall demand

2.18. Capital conditions — liquid assets and inventories reported

2.19. Ruin (or exit) conditions — optional

2.20. Dividends — optional

2.21. Overheads — yes

2.22. New capacity — no

2.23. Liquidation values — optional

2.24. Initial conditions: — set outside of program with consideration given to near joint max, equilibrium or "efficient" solution as well as non-symmetric initial conditions

2.25. Symmetry: — in the "Mark 1" Model symmetry is kept in costs and demand structure, only because of ease of computation for analysis. This part of the program is arranged for ease of modification.

2.26. Information conditions — for the most part the briefing on these lie outside of the program. The exception concerns the amount of knowledge concerning the specific actions and balance sheets of competitors.

2.27. Time lags — effect of advertising lagged up to 3 periods, timing of production lagged up to 3 periods, these lags are optional

2.28. Financing — no external financing or other ways of generating liquid assets than by sales in "Mark 1"

2.29. Discount rate — optional

2.30. Objective function for the most part the briefing on this is outside of the program. The exception concerns when teams are explicitly instructed to maximize discounted stream of dividends paid out plus end value. It is furthermore experimentally desirable to be able to play for money on occasions.

2.31. End of play and termination rule set external to the program. The briefing of players on this can be done in several ways reflecting various game theoretic considerations.

3. Stock Market

The Mark 1 Model does not have a stock market. Eventually capital structure should be introduced via several subroutines.

4. Player Input Formats

DECISION RECORD

Company _____

Quarter	Price	Advertising (000)	Production (000)	Dividends (000)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Two sheets each with 15 periods on them are adequate. If time lags are present, then the players commence to make their decisions at period T+1 where T is the largest lag. The initial conditions will be entered in the briefing.

5. Player Output Formats

The formats below have been based heavily upon the formats designed by G. Feeney for the General Electric marketing game.

In the part on industry and individual statistics a company may know nothing but its own affairs. It may know its own status and the market average or it may know everything in detail.

Taxes can be introduced and appear here as a flat percentage. Administrative costs are regarded as fixed. Depreciation is also given as fixed at such a level that plant maintains a constant value throughout the game.

The player reports appear as two sheets of paper. The first contains the P and L and financial information while the second has the industry statistics.

QUARTERLY REPORT

Company _____ Quarter _____

PROFIT AND LOSS STATEMENT (000)

Net Sales Billed	$14,762
Direct Cost of Sales	9,608
Depreciation	1,000
Gross Margin	$ 4,154

COMMERCIAL AND ADMINISTRATIVE

Advertising	1,000
Inventory charges	142
Administrative overheads (fixed)	300
Net Profit (- Loss)	$ 2,712
Tax Reserve	1,356
Net Profit (- Loss) After Taxes	$ 1,356

FINANCIAL CONDITION (000)

Short Term Assets	
Cash	$16,000
Inventories (at cost)	7,234
	$25,234
Long Term Assets	
Plant	20,000
	$20,000
Total	$45,234

INDUSTRY AND INDIVIDUAL STATISTICS

PRICES	co 1	co 2	co 3	co 4	co 5	co 6	Average
$	173	165	165	168	172	177	170.0

SALES	co 1	co 2	co 3	co 4	co 5	co 6	Total
units							
$	643,210	724,639	684,211	529,864	483,281	529,078	3,594,283
$(000)							

ADVERTISING	co 1	co 2	co 3	co 4	co 5	co 6	Average
$(000)							

PRODUCTION	co 1	co 2	co 3	co 4	co 5	co 6	Average
units							

INVENTORIES	co 1	co 2	co 3	co 4	co 5	co 6	Average
units							

NET PROFITS	co 1	co 2	co 3	co 4	co 5	co 6	Average
$(000)							

DIVIDENDS	co 1	co 2	co 3	co 4	co 5	co 6	Average
$(000)							

Rate of interest	6%
Present value of dividends paid to date	$2,729,641

It may be desirable to issue "newsletters" and other qualitative reports to the players on occasion; this can be done outside of the program.

There is no provision for introducing a "computorized dummy player." However simple experiments may be performed by merely entering in the actions of a dummy player based upon computations external to the program.

6. Analysis and Final Output

6.1. Theoretical Solutions

Three theoretical solutions are used to provide a grid against which to measure performance. They are:

(1) Joint maximization

(2) The non-cooperative equilibrium point (modifications and detailed specifications are made)

(3) A "threat" or strictly competitive solution

These are discussed in detail in the second paper and the specification of the program.

There are obviously learning and organization theories as well as many other economic solutions such as price leadership, various threat behaviors, the Shapley value and so forth which could be examined. However the three chosen provide us with useful reference points from which to view behavior. Among the first modifications to be made later should be the inclusion of routines to test simple learning theories.

6.2. Graphical and Statistical Outputs

PRICE

QUARTER	co 1	co 2	co 3	co 4	co 5	co 6	Average	S1	S2	S3
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

The S1 , S2 and S3 stand for the three predictions of the different theories of solution.

ADVERTISING (000)

QUARTER	co 1	co 2	co 3	co 4	co 5	co 6	Average	S1	S2	S3
1										
2										
3										
4										
5										
. . .										
25										

SALES

PRODUCTION

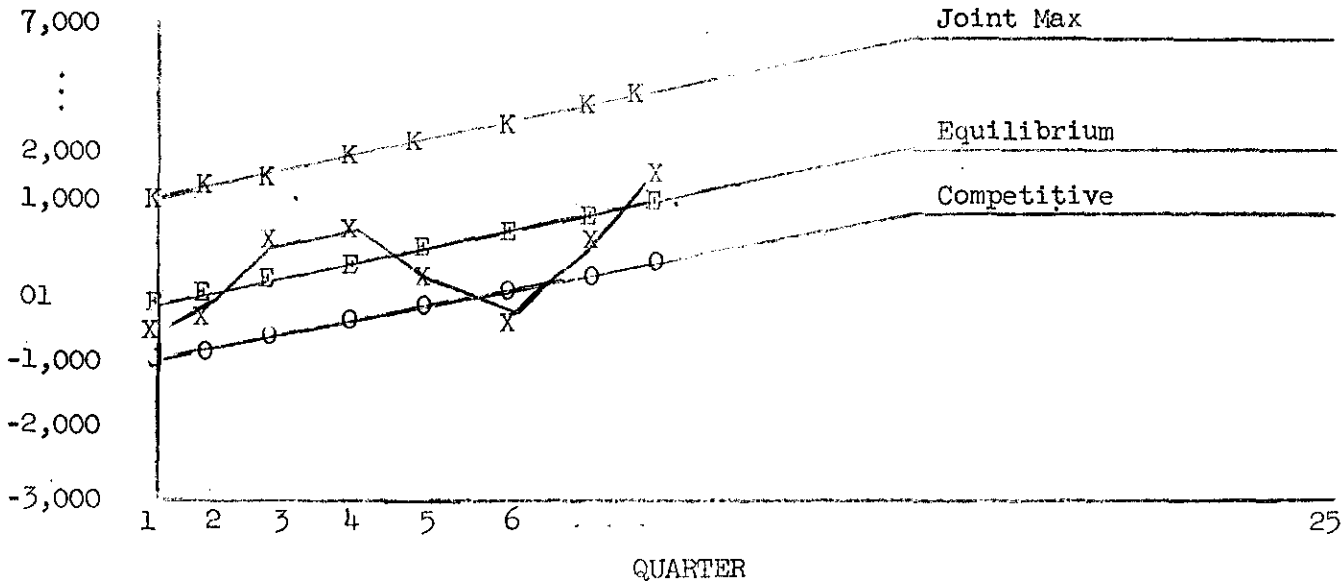
INVENTORIES

DIVIDENDS

The same format is used for each of these items.

The above 6 tables are also to be put out on X-Y plots for Average, S1 , S2 , S3 .

An example of the type of graph is given in the next diagram.



The statistical analysis is based on the readings k-1 to k-ℓ . In effect around the 5 or 6 penultimate readings.

Let the average be x and the three theoretical readings be a , b , c . We calculate

$$\bar{d}_a \ , \ \bar{d}_b \ , \ \bar{d}_c \qquad = \Sigma(x_t - a_t)/N \qquad \ldots$$

$$\sigma_{d_a} \ , \ \sigma_{d_b} \ , \ \sigma_{d_c} \qquad = \sqrt{\Sigma \frac{(d_{a_i} - \bar{d}_a)^2}{N-1}} \qquad \ldots$$

$$\sigma_{\bar{d}_a} \ , \ \sigma_{\bar{d}_b} \ , \ \sigma_{\bar{d}_c} \qquad = \sqrt{\frac{\Sigma(d_{a_i} - \bar{d}_a)^2}{N(N-1)}} \qquad \ldots$$

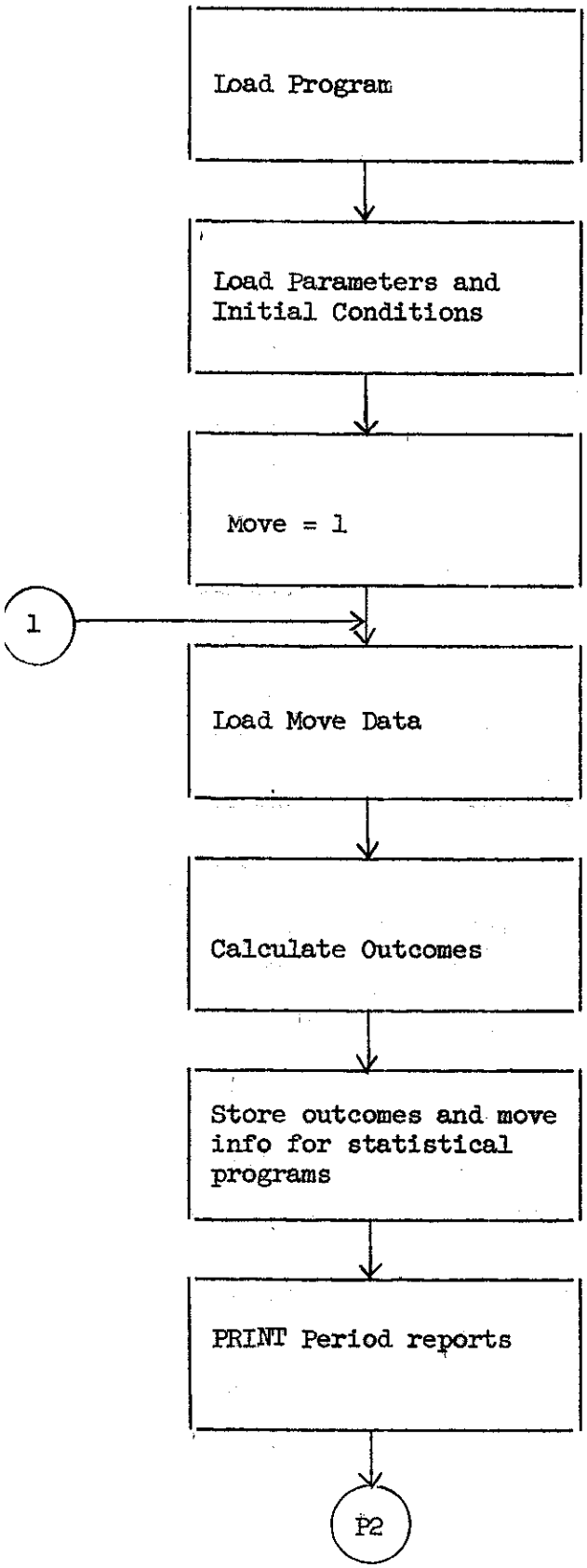
$$t_a \ , \ t_b \ , \ t_c \qquad = \bar{d}_a/\sigma_{\bar{d}_a} \qquad \ldots$$

This is merely a crude statistical check for the "closeness" of the actual performance to the three predictions. At this level of complexity it is evident that given the tables and graphs from the final output program statistical processing can be done for the most part outside of the program. Nevertheless eventually given the amount of experimentation necessary and the amount of data generated from games it is desirable to design games with the structure, the analysis and as much data processing as possible all internal to the machine.

The choice here of readings k-1 , to k-ℓ where ℓ is between 5 to 8 is based upon the desire to cut out much of the learning aspects of the early plays. The last play is rejected owing to terminal effects. The theoretical structure of Games of Economic Survival[1] is designed to avoid terminal pathologies, nevertheless there are many reasons why the experimenter should still reject the last readings especially if the players are aware that they are terminating the game on that play.

7. An Overall Flow Diagram

There is in general a fair amount of leeway in the final form of a program depending upon the economics of the specific machine, programming time and so forth. The flow diagram below is presented merely to give a quick overall guidance to the program together with comments on major alternatives.

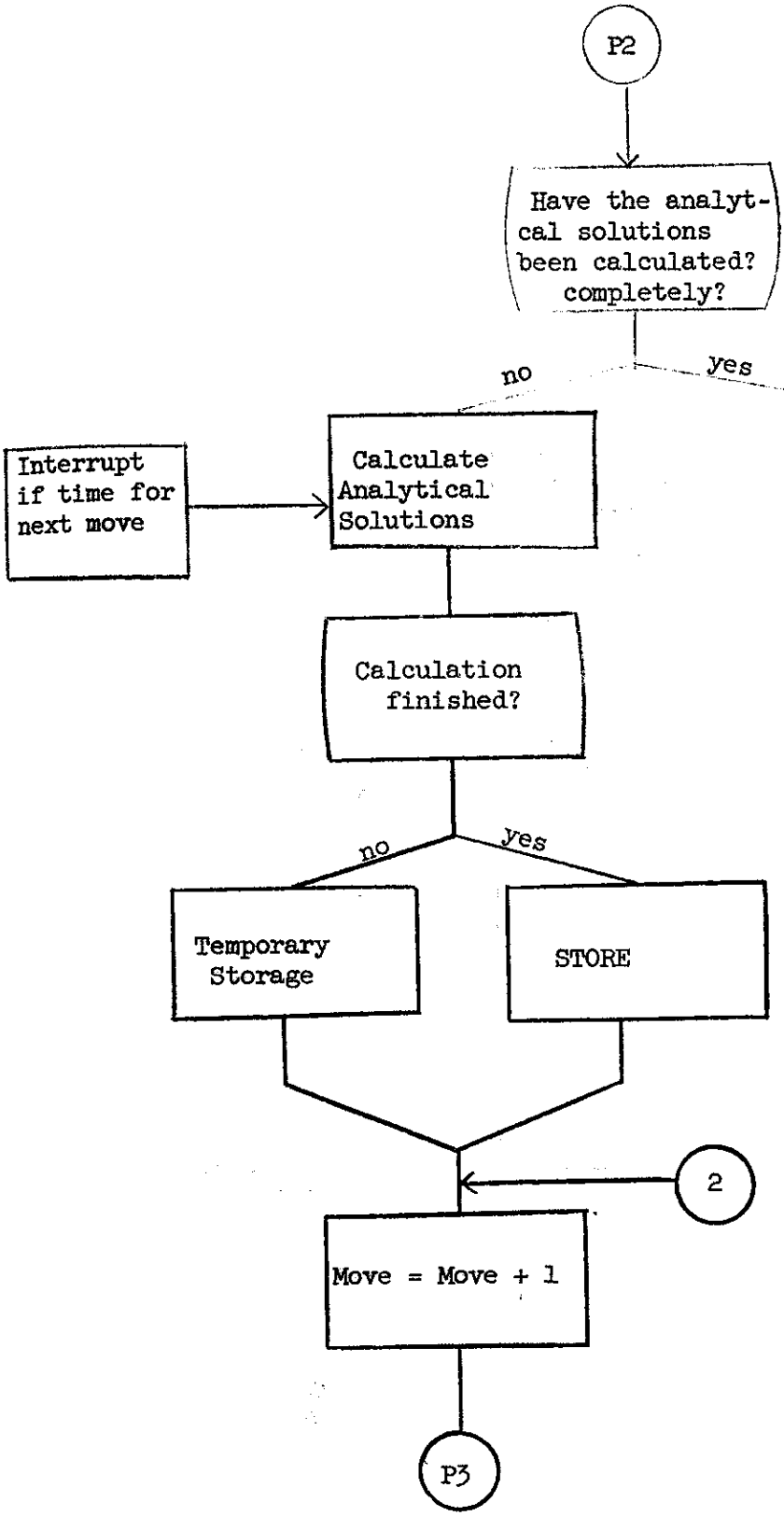


Comments

It is desirable to be able to change the functional form of demand hence it should be made a subroutine. Production costs should also be adjustable.

A move approximately every 5 - 20 minutes.

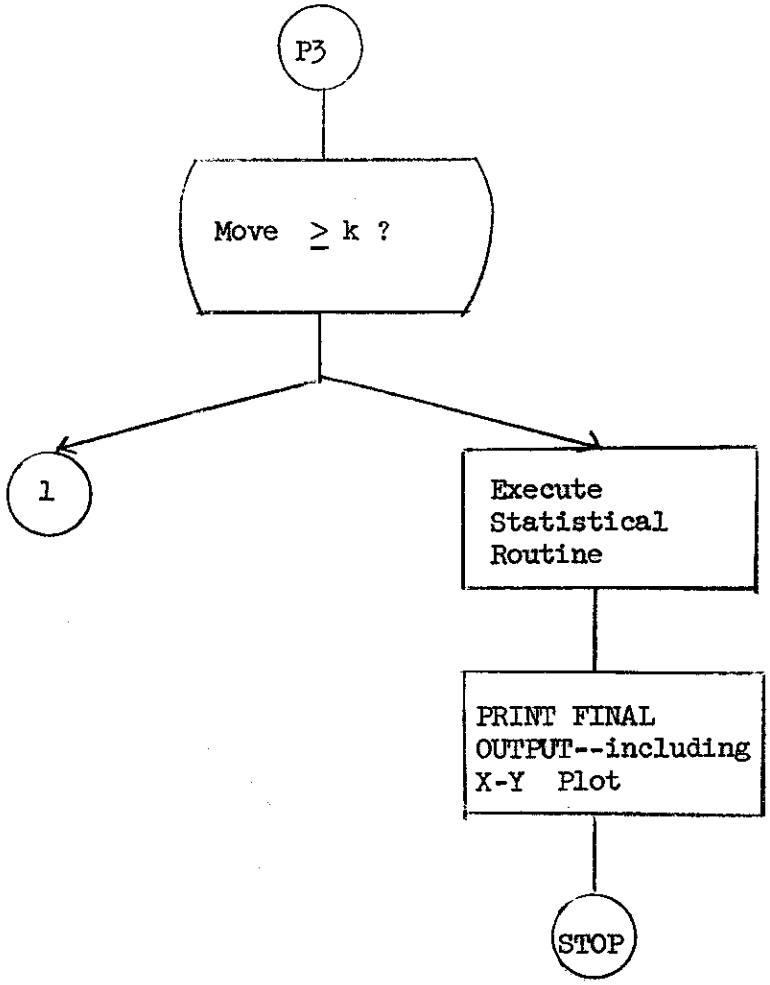
This is not needed until the final output hence it could go out on cards as most of it is needed for the period reports. The information could be fed in again at the end.



Comments

The analytical solutions can be computed separately as they are only needed in the computations in the final output routines.

It might be cheaper to perform plays as is suggested here--it is, however, not necessary to do so.



FOOTNOTES

[1] M. Shubik, Strategy and Market Structure (New York: John Wiley and Sons, 1959), Chs. 9 and 10.