COWLES FOUNDATION FOR RESEARCH IN ECONOMICS

AT YALE UNIVERSITY

Box 2125, Yale Station
New Haven, Connecticut

COWLES FOUNDATION DISCUSSION PAPER No. 115, Part 1, Revised



# A Business Game for Teaching and Research Purposes

Martin Shubik

September 11, 1961

# A Business Game for Teaching and Research Purposes

(Part 1, Revised)

## General Description

Martin Shubik



---

*Research undertaken by the Cowles Commission for Research in Economics under Task NR 047-006 with the Office of Naval Research.

---

## 1. Introduction

During the past few years, at many business schools, corporations, and departments 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 constructed here for operation with the 650 computer is somewhat simpler than the one which is envisioned eventually; however, even this program includes analytical procedures as part of the design.

With the exception of some very simple games used strictly for experimental economics and psychology, such as those of Flood, Fouraker, Hoggatt, Rapoport, Shubik, Siegel, Stern, Stone and others, 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. However, by judicious selection of functional forms

and parameters, and 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 provides 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 a larger game for combined teaching and research uses.

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 program; and the fourth gives directions to those wishing to utilize the game 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 will be desirable to construct a modular game which would permit additions and substitution of modules.

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? (if costs are linear, there is a production limit) | yes |
| 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 (a linear cost) | yes |
| 2.15 | Production costs (first form, linear but adjustable) | yes |
| 2.16 | Demand function | adjustable |

| | | |
|---|---|---|
| 2.17 | Random variables | optional: one per player in advertising<br>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 the program |

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 takes place 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 can be lagged up to 4 periods, timing of production can be lagged up to 4 periods, these lags are optional

2.28 Financing: external financing or other ways of generating liquid assets than by sales in "Mark 1" can be obtained by setting conditions on the availability of funds.

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 occasion.

2.31 End of play and termination rule are set external to the program. The briefing of players on this can be done in several ways reflecting various game theoretic considerations. (For example, randomizing for the end of the game to avoid "truncation" effects.)

## 3. Stock Market

The Mark 1 Model does not have a stock market. Eventually capital structure should be introduced via several subroutines. This game can, however, be played in conjunction with the stock market game designed previously.[1/]

---

[1]Shubik, M., "Description of a Stock Market Game," G.E. Internal Paper OR&SCS: New York, Mimeographed, 1959.

DECISION RECORD

Company _____

| Quarter | Price | Advertising (000) | Production (000) | Amount Offered For Sale (000) | Dividends (000) |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |

4. Player Input Formats

The decision formats for the players is given below. The current program requires the players to make decisions on at least price and production. Advertising and dividend decisions are optional. Modification is required for limiting the amount offered for sale (this allows for an active inventory policy). With little modification it is possible to limit the players' decision to any subset of the five decisions on the format. (For example, to rule out price, a predetermined price may be entered in the decision sheets.) 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 give a very simple balance sheet and profit and loss statement.*

In the formats 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 contains the industry statistics.

---

*They have been based upon formats designed by Dr. George Feeney of General Electric Co. for a marketing game.

Profit and Loss Statement

| | |
|---|---|
| Net Sales Billed | 14,762,000 |
| Direct Cost of Sales | 9,608,000 |
| Depreciation | 1,000,000 |
| GROSS MARGIN | 4,154,000 |

Commercial and Administrative

| | |
|---|---|
| Advertising | 1,000,000 |
| Inventory Charges | 142,000 |
| Administrative Overheads (Fixed) | 300,000 |
| NET PROFIT (-LOSS) | 2,712,000 |
| Tax Reserve | 1,356,000 |
| NET PROFIT (-LOSS) AFTER TAXES | 1,356,000 |

Short Term Assets

| | |
|---|---|
| Cash | 16,000,000 |
| Inventories (At Cost) | 7,234,000 |
| TOTAL | 25,234,000 |

Long Term Assets

| | |
|---|---|
| Plant | 20,000,000 |
| GRAND TOTAL | 45,234,000 |

## INDUSTRY AND INDIVIDUAL STATISTICS

| | co 1 | co 2 | co 3 | co 4 | co 5 | co 6 | Average |
|---|---|---|---|---|---|---|---|
| PRICES ($) | 173 | 165 | 165 | 168 | 172 | 177 | 170.0 |
| SALES (Units) | 643,210 | 724,639 | 684,211 | 529,864 | 483,281 | 529,078 | 3,594,283 |
| ADVERTISING ($) | xxx | xxx | xxx | xxx | xxx | xxx | xxx |
| PRODUCTION (Units) | xxx | xxx | xxx | xxx | xxx | xxx | xxx |
| INVENTORIES (Units) | xxx | xxx | xxx | xxx | xxx | xxx | xxx |
| NET PROFITS ($) | xxx | xxx | xxx | xxx | xxx | xxx | xxx |
| DIVIDENDS ($) | xxx | xxx | xxx | xxx | xxx | xxx | xxx |

Rate of interest 6%

| | | | | | | |
|---|---|---|---|---|---|---|
| PRESENT VALUE OF DIVIDENDS PAID TO DATE ($) | xxx | xxx | xxx | xxx | xxx | xxx |

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

A major problem in the interpretation of the play of a business game is the development of measures. Three solution concepts are used to provide a grid against which to measure some of the competitive aspects of 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 in 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 for extended use of the program should be the inclusion of routines to test simple learning theories.

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.

6.2. Graphical and Statistical Outputs

The following is merely a suggested first rough procedure for the data processing of output. It is easy to prepare from the quarterly output cards as is noted in the fourth paper.

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

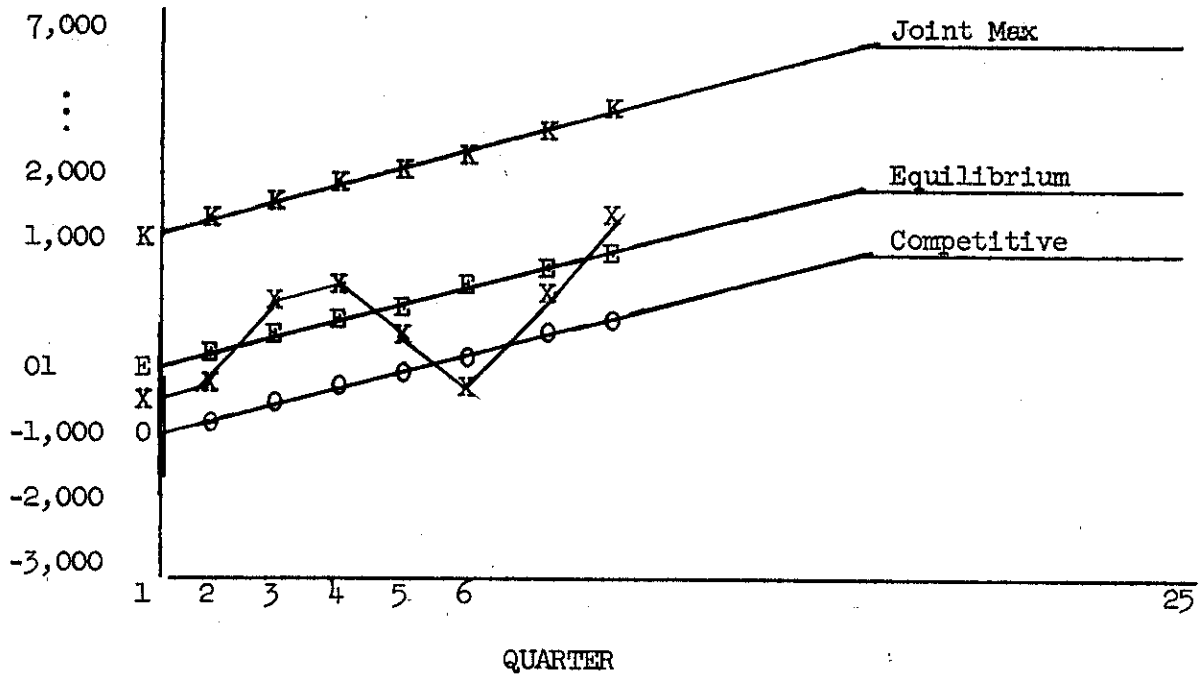
PRODUCTION

INVENTORIES

DIVIDENDS

} The same format to be used for each of these items.

It is convenient to output these tables graphically. On the 650 this can be done by X-Y plots for Average, S1 , S2 , S3 . An example of the type of graph is given in the next diagram. Although there is no difficulty in doing the above by hand, it is desirable to mechanize as much routine data handling as possible.



A simple suggested statistical test for simple economic aspects of oligopolistic competition is based on the readings k-1 to k-$\ell$ (in effect around the 5 or 6 penultimate readings).

Let the average be $x$ and the three theoretical readings be $a$, $b$, $c$. Calculate

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

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

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

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

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-$\ell$ where $\ell$ 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[2/] 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.

The few comments on data processing have been directed primarily towards examining the output of this business game in terms of various conjectures concerning oligopolistic behavior (usually referred to in economics as "theories of oligopoly"). However, it is to be stressed that a guiding consideration in the design of this game has been to make it possible to perform not only experiments in economics but also in certain aspects of psychology and sociology within the same format. Thus, for example, the one person version should be of use for some simple learning experiments.

---

[2] Shubik, M., Strategy and Market Structure (New York: Wiley, 1959), Ch. X.