

# Developments in Business Simulation & Experiential Exercises, Volume 12, 1985

## The Development of a Microcomputer Distributed Processing Business Game

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Several microcomputer versions of sophisticated business simulations are being redesigned for classroom use~ [1] Most of these are rewritten copies of the mainframe programs. These conversions seem to combine the worst attributes of both types of hardware. They require substantial floppy disk handling, produce large amounts of paper output, and they tend to reproduce the mainframe product without enhancing the learning process. Micros are not fast processors, especially for programs written in interpretative BASIC and their printers are painfully 810w. When one uses a microcomputer to develop a business simulation, care should be taken to enhance the learning process by using those features for which micro's can be used to the best advantage. Unlike a computer terminal to a mainframe, micros can provide a lot of calculations as a stand alone computer for analysis of decisions and results. If any ancillary analysis is to be done most games require data to be taken from paper output and reentered via the keyboard. When using mainframe simulations students some- times punch the entire set of decisions and the resulting output into an SPSS data base for analysis. When Micro's became available, students first began by using VisaCalc and later Lotus 1-2- 3 for analysis. Here again, the students were required to reenter the data from paper output.

The development of distributed processing simulations allows part of the processing to be done on the instructor's machine while the remaining calculations are finished and displayed using the student's machines. This speeds up the turn around time and reduces the time requirement on the part of the instructor. [2] If care in design is taken all the output statements can be formatted to fit a screen of 24 or 25 lines and 80 characters or less in length. Individual screens can be created for the Income Statement, for the Balance Sheet, for cash flow statements, production and inventory reports, sales force reports, and as many as needed for the marketing research. Thus, paper output can be eliminated altogether if the student teams desire or screen prints can be produced for those wishing to obtain a hard copy. In addition, extensive analysis of the decisions, their results and their interactions can be made without the need to rekey all the data. Keying in data to a machine is a skill that one hopes is not needed to be taught and hopefully can be done without. Graphics can be incorporated as well as the standard statistical analysis. Micro's are particularly well suited for elementary graphics, the kind most students would or could apply to the analysis required in a simulation. The primary advantage that distributed processing allows, is the almost unlimited number of "what if" situations that can be evaluated under ceteris paribus conditions.

While this type of analysis is not necessarily real world it can greatly enhance the learning process while reducing the number of times that the simulation must be played. It has been the author's experience that most sophisticated mainframe simulations require as many as twenty to thirty or even more plays in order to maximize the learning experience.

A distributed processing simulation may utilize one or more microcomputers and require two floppy disk drives or one floppy and a shared hard disk on a LAN. The simulation this paper is based, SIAM-I, [3] requires an IBM or compatible PC and uses the DOS 2.0 operating system and dual floppy disks. It is written in BASIC which will be compiled prior to release in order to speed up the processing.

The microcomputer simulation is made up an entire set of programs. First the students' programs will be described. Each team is given a set of files containing: 1) A conversational program for the decision input, with error trapping and a full screen editor built in. 2) A historical data base in which all previous decisions and outcomes are stored. This data base updates itself after each play. It also contains all the marketing research information that has been purchased. 3) A program to display on the screen the results of any period and any purchased marketing research. 4) A graphics program which will allow any two variables in the data base to be plotted against one another. This program also allows data transformations and calculations on these data. Thus, variables such as deseasonalized sales can be plotted against time, against actual or relative prices. Additional statistical analysis could be included here using linear combinations of transformed independent variables or multiple linear regressions. 5) A program to simulate the simulation. In this program all the competitors decisions are to be considered fixed and an entirely new set of decisions can be made and rerun. These new trial decisions can be as different or as similar as the players wish. The results of these trial decisions are reported but not stored in the team's data base. Note what this accomplishes. The students may interrogate the system using as many simulated plays as they wish. In these trials they can learn about price sensitivity, the interaction among price, advertising, and the direct sales effort, and even try strategies and tactics without showing their ideas to their competitors. This in no way affects the competitive interactions, for in the next real iteration each competitor is likely to do something different. This technique rewards those teams who do the most analysis by giving them the means to make better decisions. Except for the data entry routines these types of programs provide a radical departure from current gaming. It is the ability to explore the "what ifs" that make distributed processing games or simulations interesting.

The instructor's or the administrative set of programs Contain 1) an interactive program to establish or change the operating parameters of the game. This contain a full screen editor and error trapping. 2) A program whose principle purpose is to allocate demand to each of the firms playing in the simulation. 3) An ongoing data base that includes each play's decisions and the results. 4) An analysis program that tracks the teams and provides standard progress reports and assists in reporting strategic and tactical errors

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of the teams. 5) A graphics program to plot whatever variables the instructor wishes to view. The main program allocates the demand among the firms and puts the marketing information each firm purchased and the competitive information in aggregated form. The aggregated data is necessary to run the "what if" conditions on each team's disk or portion of a shared disk. Actually the administrative program does all of the calculations, both the demand allocations and the results in the administrators database. It is important to notice that this procedure does not allow for the instantaneous reallocation of unfilled demand due to stockouts to other firms in the industry. However such reallocation may still occur but not until the next iteration. It is not prevented only delayed until the next time period. WAP's, wild \*?! plays, must be constrained in a more artificial way.

If one were to use the demand equations of a single product game as described by Gold and Pray [4] the allocations would be simple. The Gold and Pray model represents market demand as;

$$Q + g_1 * P^{-g_2 + g_3 P} * M^{g_4 - g_5 M} * R^{g_6 - g_7 R}$$

- where: Q = the total demand in the market place  
 P = the harmonic mean of the prices of all the firms.  
 M = exponentially smoothed total marketing expenditures.  
 R = exponentially smoothed total R & D expenditures.  
 g parameters set by the game administrator.

Sales force effect on demand could be easily added to this function or it could be assumed that the sales force has only an order taking function. If the latter were the case the sales force information would only affect the ability of the firm to fulfill its demand. The allocation of demand among firms was defined by a set of equations by Gold and Pray. For a distributed processing simulation using "what if" conditions only can be used. The first is the weighting function.

$$w_i = [p_i + k_1]^{-k_2 + k_3 p_i} [m_i + k_4]^{k_5 - k_6 m_i} [r_i + k_7]^{k_8 - k_9 r_i}$$

- where  $w_i$  = the weight of firm i.  
 $p_i$  = the price of firm i's product.  
 $m_i$  the marketing expenditures of firm i.  
 $r_i$  = the R & D expenditures for firm i.  
 $k_i$  = parameters or constants.

The second equation uses the weights to establish the market share for each firm.

$$s_i = w_i / \sum_{j=1}^n w_j$$

where  $s_i$  = the market share allocated to firm i.  
 $w_i$  = the weight of firm i calculated above.  
 $\sum_{j=1}^n w_j$  = the sum of the weights across all firms.

The last equation simply multiplies the market share of each firm times the market demand to establish the demand level in units for each firm.

$$q_i = s_i Q$$

where  $q_i$  = the allocated demand to firm i.  
 $s_i$  = market share as defined above.  
 Q = the total industry demand.

All of these values can be calculated and stored on the each team's disk excluding that team's data. When the students run their data to the aggregations and the demand allocation equations are complete. The program finishes the calculations and determines if the firm has enough supply to meet the demand, displays the results to the screen and stores the result permanently on the team's disk. Then, when and if the students try their "what if" types of analysis the results will be the same as if they had originally made these new decisions. The results of the "what if" conditions are not stored on the disk.

Below are some screen prints of SZAM-1, a distributed processing game. First the instructor's initial screen:

```

*****
                                TEACHER'S MAIN MENU
*****
1-EDIT UNIT COSTS, PRICES, GAME RATIOS & MKT COSTS
2-EDIT MATERIALS INVENTORY FOR GAME START
3-EDIT MACHINE AGES FOR GAME START
4-EDIT BALANCE SHEET FOR GAME START
5-EDIT PARAMETERS FOR MARKET SHARE AND MACHINE FAILURES
6-EDIT COPY START DATA TO THE STUDENT'S DISKETTES
7-EDIT TRANSFER DECISIONS FROM STUDENT DISK TO INSTRUCTORS DISK
  AND RUN THE SIMULATION
8-EDIT HISTORY COMPARISONS OVER ALL COMPANIES
9-EDIT ENTER LIBRARY OF COMPANIES
10-EDIT CHANGE PERIOD
11-EXIT
*****
                                ENTER YOUR SELECTION
    
```

An instructor first utilizes Selection 1 to set the game's parameters. It is expected that these values would be fixed for the duration of the game but could be altered to reflect sudden changes the instructor wanted to interject into the game such as higher labor costs due to a new union contract. This menu allows quick and easy changes to be made between terms insuring that the same strategies do not work time after time. The screen print from Selection 1 contains two pages and is as follows:

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```

*****
UNIT COSTS, CAPACITY, AND GAME RATIOS
PAGE 1
STEP I
1-LABOR COSTS          $/UNIT      1.50  4  6.0
2-COST PER SALES PERSON      5000.00  4  5.5
3-ADMINISTRATION COSTS      44000.00  2  2.0
4-COST OF RAW MATERIAL      1.40  1  1.1
5-RAW MATERIAL CARRYING COSTS $/UNIT      .06  0
6-FIN GOODS CARRYING COSTS  $/UNIT      .08  0
7-COST PER MACHINE          EACH      3000.00  1  2.2
8-MACHINE MAINTENANCE      PER UNIT   .03  0
9-MACHINE CAPACITY          UNITS/PERIOD 3800  0
10-TAX RATE                I          44.00  0
11-INT. RATE EMERGENCY LOANS I/YR      21.00  0
12-BANK CHARGE FOR ENERGY LOAN      700.00  0
*****
DO YOU WISH TO CHANGE ONE OF THESE (Y/N)

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*****
UNIT COSTS, CAPACITY, AND GAME RATIOS
PAGE 2
STEP I
13-INT. RATE TERM LOANS     I/YR      15.00  0  IMC
14-INT. RATE INVESTMENTS    I/YR      12.00  0
15-COST PER SALES MANAGER    10000.00  4  8.0
16-# OF SALESPERSONS/MANAGER #          5  0
17-HIRING COST PER SALESPERSON $8000.00  4  7.0
18-FIRING COST PER SALESPERSON $3000.00  0
19-DIVIDENDS PER PERIOD      $100000.00  0
20-ACC'TS RECEIVABLE         I OF SALES 33.00  0
21-BAD DEBTS                 I OF RECVEV. 5.00  0
22-ACC'TS PAYABLE            I OF PURCH. 25.00  0
23-PLANT DEPRECIATION        I OF COST   3.75  0
24-COST PER GRAPHICAL DISPLAY      50.00  0
*****
DO YOU WISH TO CHANGE ONE OF THESE (Y/N)

```

The above two screens provide the controls for the cost structure. Notice that each cost component is allowed to have different inflation rates. The cost of labor goes up once a year at a given percentage increase while the cost of materials goes up every period. With minor changes, any of these cost structures could be a random variable whose mean and variance are controllable.

The next screen to view from the MAIN MENU prior to starting the simulation would be Screen 5 -EDIT PARAMETERS

```

*****
YOUR PRESENT SET OF PARAMETERS          PAGE 1
1-PARAMETER FOR SMOOTHING ADV. EXPENDITURES      .400
2-PARAMETER FOR SMOOTHING PRICE DECISIONS        .222
3-PARAMETER FOR SMOOTHING SALES FORCE CHANGES    .150
4-PRICE ELASTICITY AT $7.00 PER UNIT             .500
5-PRICE ELASTICITY AT $15.00 PER UNIT             2.000
6-FIRM PRICE ELASTICITY AT $7.00 PER UNIT         .300
7-FIRM PRICE ELASTICITY AT $15.00                1.800
8-ADVERT. ELASTICITY $50000 PER PERIOD           3.000
9-ADVERT. ELASTICITY $150000 PER PERIOD          .500
10-FIRM ADV. ELASTICITY $50000 PER PERIOD        3.500
11-FIRM ADV. ELASTICITY $150000 PER PERIOD       1.000
12-SALES FORCE ELASTICITY 4 SALESMEN              3.000
13-SALES FORCE ELASTICITY 16 SALESMEN            1.000
14-FIRM SALES FORCE ELAST. 4 SALESMEN             3.100
15-FIRM SALES FORCE ELAST. 16 SALESMEN           1.250
16-FIRM DEMAND PRICE INFLUENCE (1-10)            5.000
17-FIRM DEMAND ADVERTISING INFLUENCE (1-10)      3.000
18-FIRM DEMAND SALES FORCE INFLUENCE (1-10)       2.500
*****
DO YOU WISH TO CHANGE ONE PARAMETER (Y/N)

```

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*****
YOUR PRESENT SET OF PARAMETERS          PAGE 2
19-SEASONAL FACTOR FIRST SEASON                 1.050
20-SEASONAL FACTOR SECOND SEASON                1.200
21-SEASONAL FACTOR THIRD SEASON                1.000
22-SEASONAL FACTOR FOURTH SEASON              .750
23-STOCKOUT CARRY BACK TO INDUSTRY             .500
24-STOCKOUT CARRYOVER TO NEXT PERIOD (FIRM)     .400
25-DEMAND REDUCTION FOR STOCKOUTS PER IK       .050
26-PROBABILITY OF A DEFECTIVE MACHINE           .075
27-PARAMETER TO INCREASE MAINTENANCE COST
DUE TO DEFECTIVE MACHINE (1.0=NO CHANGE)       2.00
*****

```

Each firm may be identified by a name. By using Screen 9 from the MAIN MENU names can be substituted for company numbers. These names may be changed any time in the simulation. The main program that copies the decisions from and to the student disks, checks each disk for the appropriate name and if the wrong one is inserted it stops and prompts the instructor for the correct company name. Identifying the companies by name tends to enhance its realism to the students.

Next the instructor would edit the inventory levels, the individual machine ages and the balance sheet. Then, by selecting Screen 6-COPY START DATA TO STUDENT DISKETTE, the students are ready to start.

The students main menu appears as follows:

```

COMPANY: Uncle Joe's Manufacturing and Sales, Inc. PERIOD: 1
*****
MAIN MENU
1-PREPARE START-UP REPORTS
2-RUN THE GAME PERIOD -1-
3-RUN RESULTS REPORTS
4-INPUT OR EDIT NEXT PERIOD INPUT DATA
5-DATA INPUT FOR TEST RUN
6-RUN TEST FOR PERIOD -1-
7-REQUEST HISTORICAL TABULAR OUTPUTS
8-REQUEST HISTORICAL GRAPHIC OUTPUTS
9-CHANGE PERIODS
10-EXIT
*****
ENTER YOUR SELECTION

```

The start up reports provides the teams with the starting positions of the firms. Under options 2 and 6 the period number to the right updates itself. Option 4 calls up the decision input screen:

```

COMPANY: Uncle Joe's Manufacturing and Sales, Inc. PERIOD: 1
*****
YOUR PRESENT DECISIONS
1-PRODUCT PRICE          $8.95
2-ADVERTISING BUDGET     $200000.00
3-SALESFORCE             9          PERSONS
4-PRODUCTION SCHEDULE   230000     UNITS
5-UPPER LIMIT ON EXPRESS PROD. 10000     UNITS
6-RAW MATERIAL PURCHASES 260000     UNITS
7-PURCHASE NEW MACHINES 1          MACH.
8-MARKETING RESEARCH BUDGET $ 25000.00
8-PAY BACK EMERGENCY LOAN $ 0.00
9-NEW TERM LOANS        $ 100000.00
10-PAY BACK TERM LOANS 0.00
11-INVEST IN SECURITIES 0.00
12-SELL OFF SECURITIES 0.00
*****
DO YOU WISH TO CHANGE AN ITEM (N/Y)

```

If the marketing research budget is greater than zero "0" then a sub-menu pops up requesting how the budget is to be allocated. It stops the student whenever the budget is reached. At that time the student may go back to the above menu and increase the marketing research budget.

When the report option is selected from the student's MAIN MENU another sub-menu appears:

```

*****
REPORT OPTIONS
1-BALANCE SHEET
2-INCOME STATEMENT
3-CASH FLOW STATEMENT
4-SALES REPORT
5-FACTORY REPORT
6-PRODUCTION REPORT
7-MARKETING RESEARCH INFORMATION
8-COST INFORMATION
*****
WHICH REPORT DO YOU WISH (0 TO EXIT)

```

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these report options can be obtained for any operating period at any time, the student's MAIN MENU option -9- allows for the changing of the periods when requesting reports.

The uniqueness of distributed processing simulations follows. After the students have received and run their results for any decision period they may investigate the efficacy of other decisions. Since the main program records the aggregations of all other competitors on each team's diskette, each team can find out just what would have happened if all other teams had made the same decisions and their team had made another set of decisions. A crystal ball of sorts. This ability to Look at decisions on the margin provides insight on both the economic interactions and the competitive forces at work in an oligopoly. The students using this type of simulation are able to Learn more about the traditional games where each play or iteration provides only what occurred under a single set of decisions. The students are able to play on under a fixed set of assumptions making decision after decision, not having to guess at what the outcomes may have been. This is no way denigrates any other sets of plays as for each period the teams enter new decisions with changing seasons and altered coats providing new parameters from which to learn new insights.

In a similar way, the Teach model [5] using a gravity flow approach to demand allocation can be adapted to the distributed processing technique. In this model the market place may consist of multiple market segments, multiple products where these products have attributes which are manipulated by the teams in their decision making. The market segments and products are represented as points in N dimensional space. The demand is allocated from each market segment to each product based on a function of the inverse of the distance between the market segments and each of the products. The Teach model restricted its product space to product attributes, however this concept could be expanded to include the other marketing decisions affecting the product space and the mass of the market segments. In this case demand would be allocated in a similar fashion, except that, the allocations would be based on the attraction between market segments and the product positions where the mass of both (the effect of the marketing decisions) would be considered in addition to the distances.

### FOOTNOTES AND REFERENCES

- [1] Two mainframe simulations that have been converted to microcomputers without substantial changes are Ness and Day's, *Marketing In Action* (Ed 5) and Rod Jensen's. The Business Management Laboratory. Others are in the process of being converted.
- [2] This topic or concept was first presented at the University System of Georgia Microcomputer Users Group meeting September 6 and 7, 1984 by Dr. Richard Teach and Mr. Lenard Bernold. This paper was entitled "SZAM-1, A Microcomputer Business Simulation." The further development of this concept resulted in this Paper.
- [3] SZAM-1 is a business simulation developed and written by Dr. Richard Teach and Lenard Bernold.
- [4] Steven C. Gold and Thomas F. Pray, "Simulating Market and Firm Level Demand-A Robust Demand System." in *Development In Business Simulation and Experiential Exercises*, Vol 10 Lee Graf & David M. Currie Editors pages 101-106.
- [5] Richard Teach, "Using Spatial Relationships To Estimate Demand In Business Simulations." in *developments In Business Simulation & Experiential Exercises*, Vol 11 David M. Currie and James W. Gentry Editors pages 244—246.