SIMULATING A "MANAGEMENT GAME" WITH PROGRAMMED DECISIONS

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Abstract: This game differs from many other management games in that respect that the participants do not make their decisions "manually" during the game. Instead the model consists of a control module, a market model and an arbitrary number of information compatible and functionally similar firm models, each with an independent and individual decision structure. Each participating group is responsible for the design of its own control algorithms which during the simulation have to allocate the firm s resources and decide its price for the following period. The decisions can be based on global market information and on an arbitrary amount of local information that each firm is free to gather, analyze and use for its forecasting etc. The primary purposes of the above system of models is to provide an experimental tool for studies of automatic control problems concerning complex business-like systems.

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1. THE PROJECT

The idea to perform this experiment emerged during a 20-hour course in "Simulation Techniques" given to 3rd semester students in Business Data Processing at the University of Stockholm. A parallel course (*) given to the students was "Information Systems for Management Control" with special emphasis on management goal formulation and goal structures. It therefore seemed natural to work out an exercise that would give them training in writing a part of a simulation program and at the same time offer them a possibility to apply some concepts from the latter course.

The market/industry model used in this game is a simplified version of a management game such as the one described by IBM (1963). Our game differs from that and many other games in the respect that decisions are not made "manually" during the game. Instead, each participating group is asked to design and program a decision algorithm which is incorporated into the simulation program and then automatically activated each time when decisions are to be made.

The simulation language used in this experiment is SIMULA I (Nygaard and Dahl, 1965). The program was run on a Univac 1107 computer.

SIMULA I is based on Algol-60 and contains that language as a subset. The fundamental concept in SIMULA is the process. A process is characterized by a local data structure and a "behavioral" (or "operation") rule. The language also contains features for queueing, scheduling and connection of processes. A process can schedule its own behavior or the behavior of other processes. Connection means that a process can interact with other processes and, under certain conditions, access their local data structures. SIMULA is designed to describe discrete event systems. An event is defined as an active phase of a process. A process is, depending on its behavioral rule, active in some stages and passive in others. During an active phase, all actions (i.e. the execution of a part of the behavioral rule) are regarded as instantaneous.

The present version of our model uses only a few of all the concepts introduced by SIMULA. All firms are acting as parallel processes under the control and inspection of the control and market process. Queueing and information delay problems are not considdred in this model.

The firm processes are defined in separate "activity declarations". The data structure of each firm process must contain specified decision and status (= accounting) variables. In addition to

(*) See reference Langefors (1967)

that each firm process may individually declare variables which are to be used for their own better forecasting and control. The behavioral rule of each process is the decision algorithm that, when activated, has to allocate resources for various operations of the firm.

Because of the limited time available and the problems expected in debugging algorithms, which have to control several decision variables,this first version of the model was made as simple as possible. The degree of realism of this model (if this can be measured in number of program statements, variables, restrictions etc.) is therefore considerably less than that of many other well-known games such as described in Cohen et al (1962) and Buchin (1964).

2. AN OUTLINE OF THE SYSTEM

The main parts of the program, the information sets used and the flow of control, are illustrated in figure 1.

The control-level of the system consists essentially of the following parts

- the input/output section
- the control-section, which controls the simulation, initiates decision algorithms, collects and checks decisions for feasibility, excludes firms with bad financial status etc.
- the market section, which generates and distributes orders among existing firms for each simulated time period. One single homogenous product and one single marketing area is assumed.

The actual number of new orders generated each period depends on a potential market level and on aggregated effects on marketing, product research and development (R and D) and price. The three latter effects are dependent on decisions made by the firms (see also figure 2). The number of orders allocated to a specific firm each period depends on a number of factors, as can be seen in figure 3. Some of the factors that influence a firm´s market share are (1) price for its product, (2) marketing expenditure, (3) R and D expenditure, (4) pricing policy and (5) its ability to fill orders. For example, large variations in price and large quantities of unfilled orders decrease that specific firm´s "reputation" and its market share. However, if a firm starts a "better behavior" (in this sense), its reputation gradually improves.

- the accounting section. Accounting for all firms is made centrally by a part of the control programs. In this simple version no firm is allowed to spend more money than available cash from the preceeding period. If a firm´s available cash is below a certain limit, then this firm is excluded from the simulation.

The firm-level of the system consists of a number of decision algorithms, programmed by the participants of the game. The number of different algorithms that can be incorporated in the "market" depends on their size and the computer´s memory capacity.

Each period the firm algorithms have to make decisions concerning price and the allocation of available cash to marketing, research and development, rationalization and automation, plant improvment and production. The algorithms can base their decisions on a global information set, containing prices and no. of orders received for all existing firms for the preceeding period, as well as on local information sets which contain their own last-period decisions and accounting-data. In addition to that, each firm may maintain its own local information set of statistics etc. to be used for various calculations, such as forecasting. The individual firms cannot access each others local data sets.

At the beginning of the simulation, each firm´s initial financial status and first-period decisions are input. The system permits any number of "copies" to be made of a specific decision algorithm. Oligopolistic markets, where some firms have identical decision algorithms (but initially different financial status), can be simulated. Also, firms can be initialized at different points in time. After each simulated period a status report is output (figure 4). After simulation of a prescribed number of periods certain statistics can be obtained for each firm (figure 5).

3. SOME RESULTS

Ten groups of students participated in the first experiment. No guidelines concerning the decision logic of the algorithm (except those needed for compatibility) were imposed upon the participants. As a consequence, the resulting algorithms varied considerably with respect to length, level of aspiration and complexity. Due to the competetive nature of the experiment, the groups kept their approaches to design strictly confidential. During the debugging phase of one month test runs were made bi-weekly. A group could test its algorithm against those of other groups and make necessary corrections of the logic. Seven groups succeeded in getting their algorithms more or less operational.

After the test phase simulation runs were made with various market parameter settings and mixes of algorithms.

In figure 6 - 9 some results are shown from runs A, B, C, D and E. In all runs, firms started with equal initial financial conditions but different initial first-period decisions.

The characteristics of the different runs are

run A <u>potential market</u>: linearily increasing with periodic variations (an imposed sine-curve)
<u>firm mix</u>:nine different algorithms

run B <u>potential market</u>: constant
<u>firm mix</u>: as in run A

run C <u>potential market</u>: as in run A
<u>firm mix</u>: as in run A
The "global information", used by some firms in their decision-making, was "disturbed" by the control program (by imposing random variations on global data)

run D <u>potential market</u>: as in run A
<u>firm mix</u>: all nine firms with identical algorithms, copied from firm no. 16

run E <u>potential market</u>: as in run A
<u>firm mix</u>: all nine firms with identical algorithms, copied from firm no. 19

In runs A, B and C firm 16 succeeded best with respect to total assets and growth rate of net profit during 50 simulated periods. However, when firm 16 was simulated in an environment of identical decision algorithms (run D), the market ceased to exist after about 35 periods (figure 6).

4. CONCLUSIONS

A careful examination and analysis of the algorithms is needed in order to attempt a classification of their decision logic (if this is at all possible) and to draw meaningful conclusions of the market behavior. Statistical treatment of results obtained so far seems to be of no value.

It can be assumed that the ultimate intention for all firms was "long range economic survival". Each firm then tried to transform this intention into subintentions, subgoals and developed operational procedures to attain them. A short examination, however, indicated that firm 16 succeeded in designing operational procedures which clearly pointed to some of their main intentions - a probable reason for their success in runs A, B and C.

This type of experiment seems to be valuable in the education of students in Information Processing, especially in the design of control algorithms with learning capabilities. A more careful design of the decision algorithms and the participation of economists is needed in order to make the model realistic enough for serious research in goal formulation, decision theory and oligopolistic market behavior.

Advantages of this type of models seem to be that

- Decisions made by the firms are formalized and programmed which means that they are fully documented and can be analyzed. Additional experiments can be made without extra work of the participants.
- Many more periods and factor combinations can be simulated and "long range" effects investigated.

But also problems and additional intentions have appeared such as the need for a simple decision and control language. By this the game would be open to non-Algol-programmers and it would be easier to attract experienced decision makers to participate and to formalize their decision strategies.

Another intention is to make the system more interactive to the participants, e.g. by making the game on-line and display-oriented, permitting the firms periodically to review, correct and possibly to expand their decision parameters and algorithms during a simulation run.

5. ACKNOWLEDGEMENT

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Fig. 1

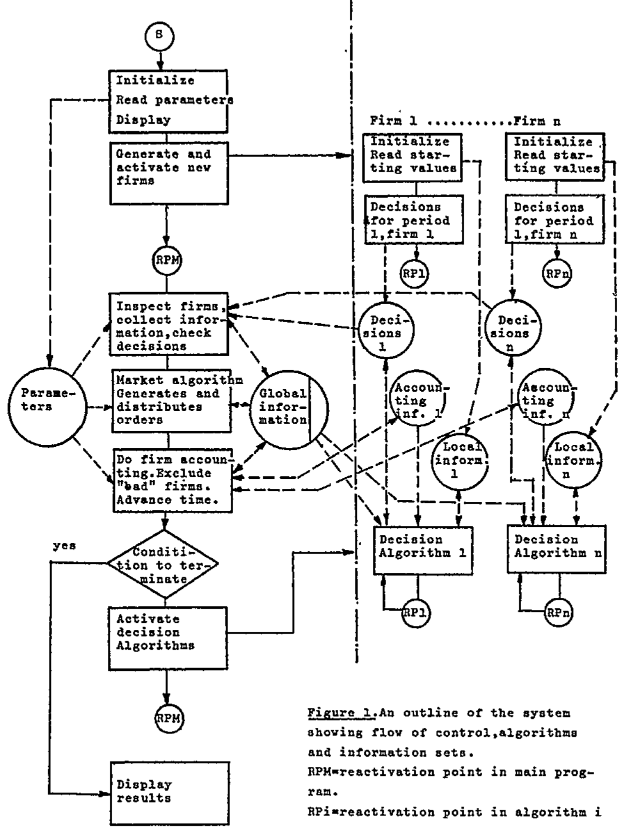

Figure 1. An outline of the system showing flow of control, algorithms and information sets.
RPM=reactivation point in main program.
RPi=reactivation point in algorithm i

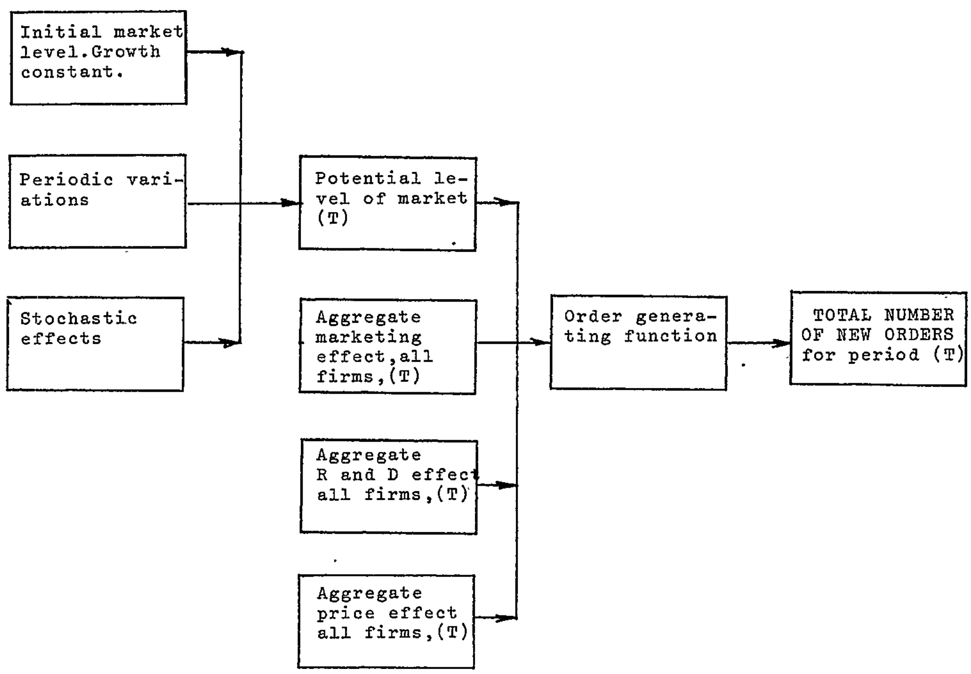

Figure 2.Precedence relations for computing the number of new orders for period (T)

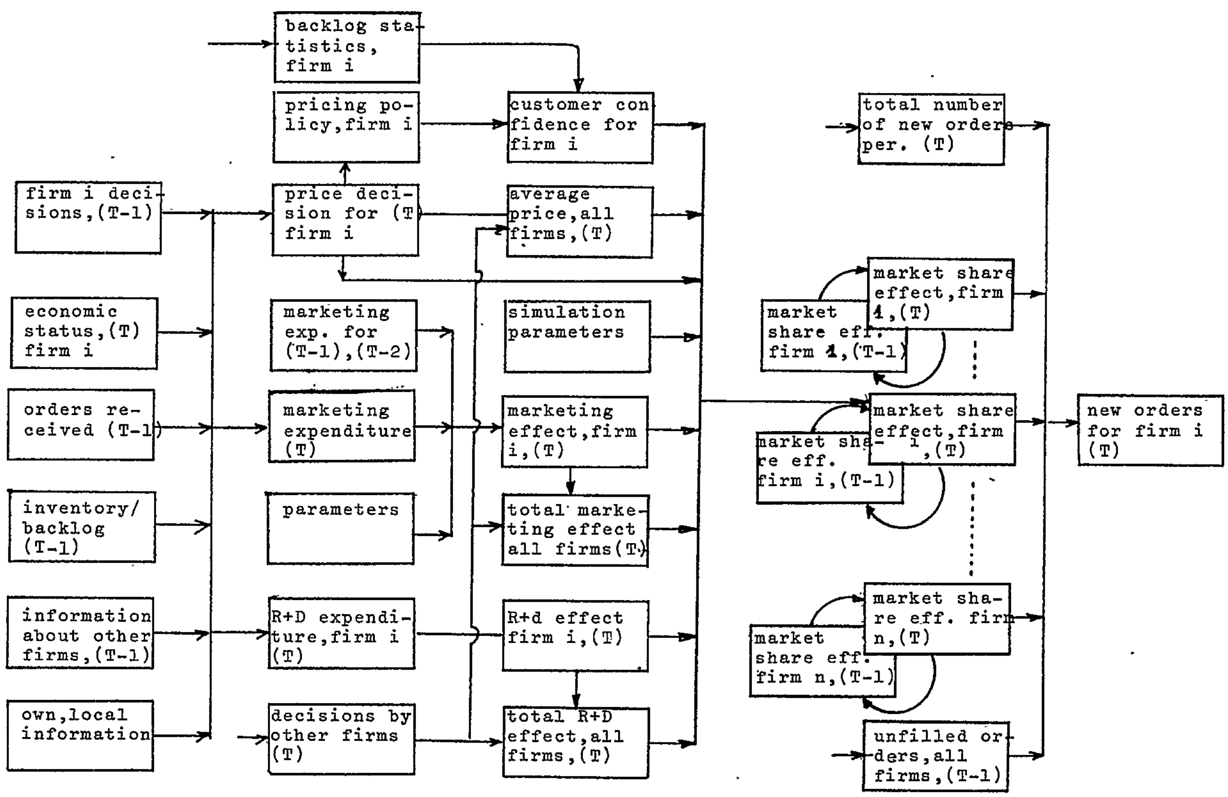

Figure 3. Precedence relations to determine the number of orders allocated to firm i for period (T).

SIMULATION OF A MANAGEMENT PROGRAMMED DECISION MAKING GAME

TIME PERIOD: 80

	* D E C I S I O N S					****************** R E S U L T S ************************													
FIRM	M	RD	RA	PI	PC	P	SHA	PQ	UPC	SALES	IQ	BACKL	IC	UIC	NP	CASH	PV	TA
21	52	34	155	86	1377	867	20	2163	637	2163	0	2156	0	551	50	1770	11474	13244
33	122	32	32	0	386	1623	2	296	1305	430	0	15	0	1299	-100	769	6671	7440
15	92	119	0	0	2	5012	0	1	1743	31	0	14	0	1739	-157	260	6258	6518
16	309	1491	0	363	1969	726	46	6206	317	6206	0	4563	0	386	273	4340	32952	37292
12	250	125	125	125	626	1610	6	1350	464	1035	5464	0	2523	462	351	1432	13768	17723
19	334	39	0	234	1451	753	26	3677	395	3677	0	1930	0	335	462	2473	23302	25775
11	4	4	6	10	61	2111	1	41	1494	41	0	118	0	874	-41	158	6779	6937

TOTAL ORDERS : 18220 TOTAL SALES : 13583 TOTAL M : 1163948 TOTAL RD : 1844638

AVG.PRICE : 1815

Figure 4. Sample of status report generated after each period of time. M=marketing exp.1),RD=research & development exp.1),RA=rationalization&automation exp.1),PI=plant improvement exp.1), PC=production exp.1),P=price,SHA=market share(%),PQ=produced quantity(units), UPC=unit prod.cost,SALES=units sold,IQ=inventory quantity(units), BACKL=backlog(units),IC=inventory value1),UIC=unit inventory value 1), NP=net profit 1),CASH=cash ,available for allocation 1),PV=plant value 1),TA=total assets 1).
1) these figures are in 1000 of dollars.

PLOTTING OF RESULTS FOR FIRM 3

MARKET SHARE = S/100 NET PROFIT = (N-50)* 40000 PRICE = P* 40 SALES REVENUE = O* 100000
TOTAL ASSETS = T*1000000
MARKETING EXP. = M*100000 PLANT VALUE = V*1000000 CASH = C* 100000

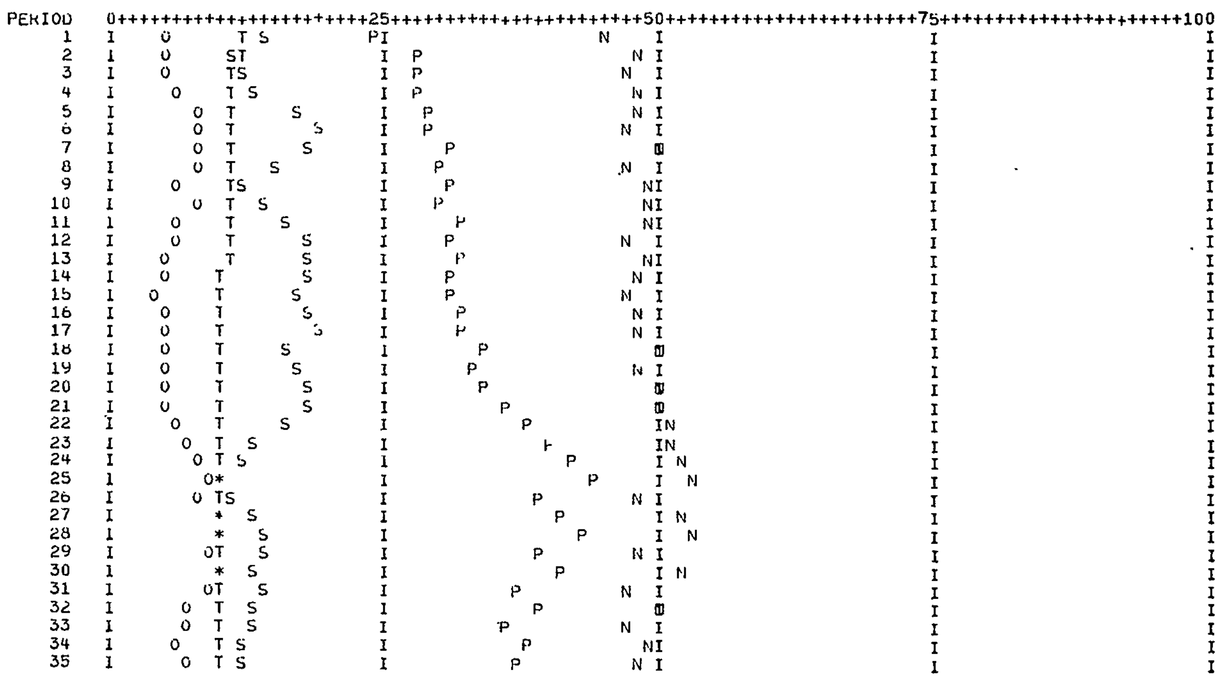

Figure 5. Sample of results plotted after a simulation run.

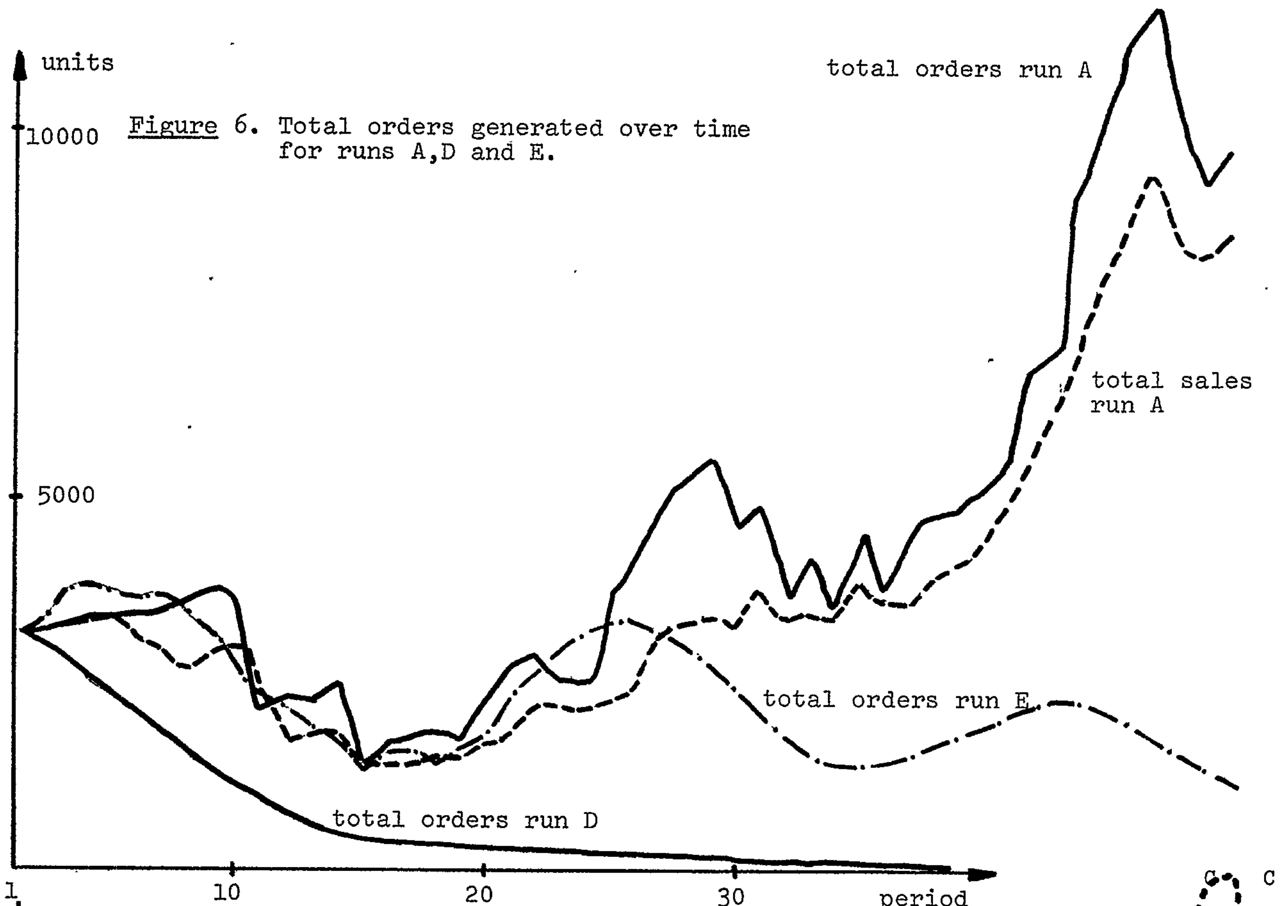

Figure 6. Total orders generated over time for runs A,D and E.

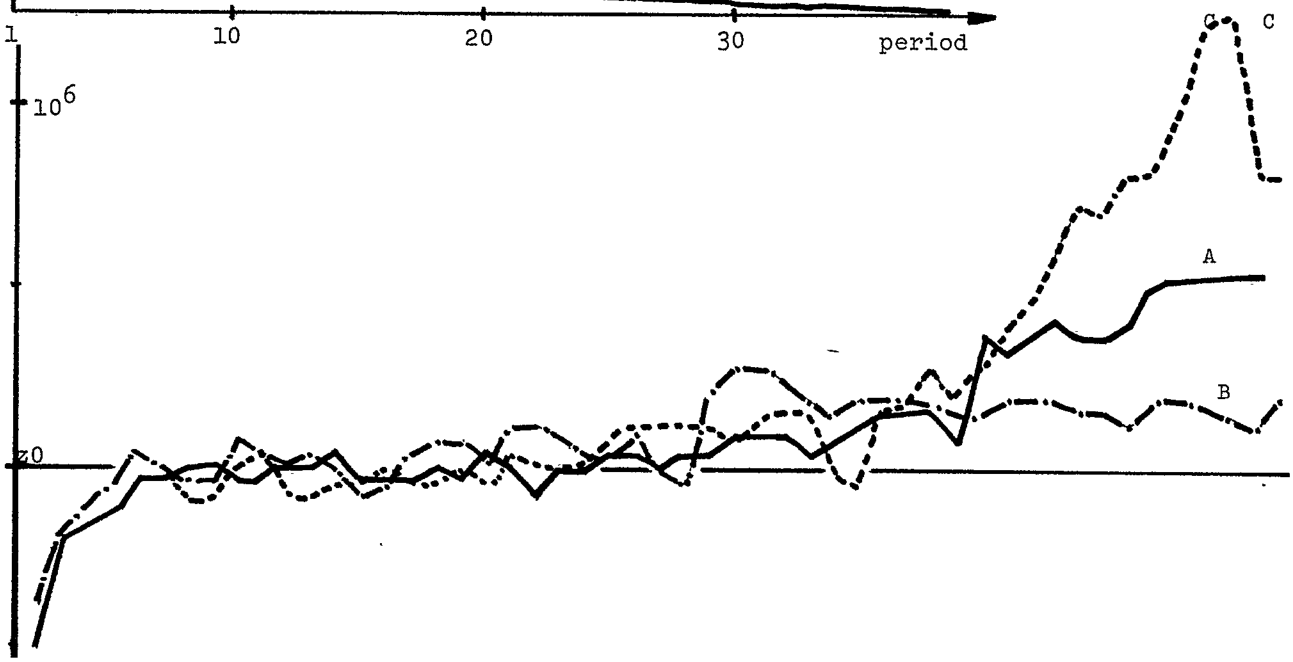

Figure 7. Net profit for firm 16,runs A,B and C.

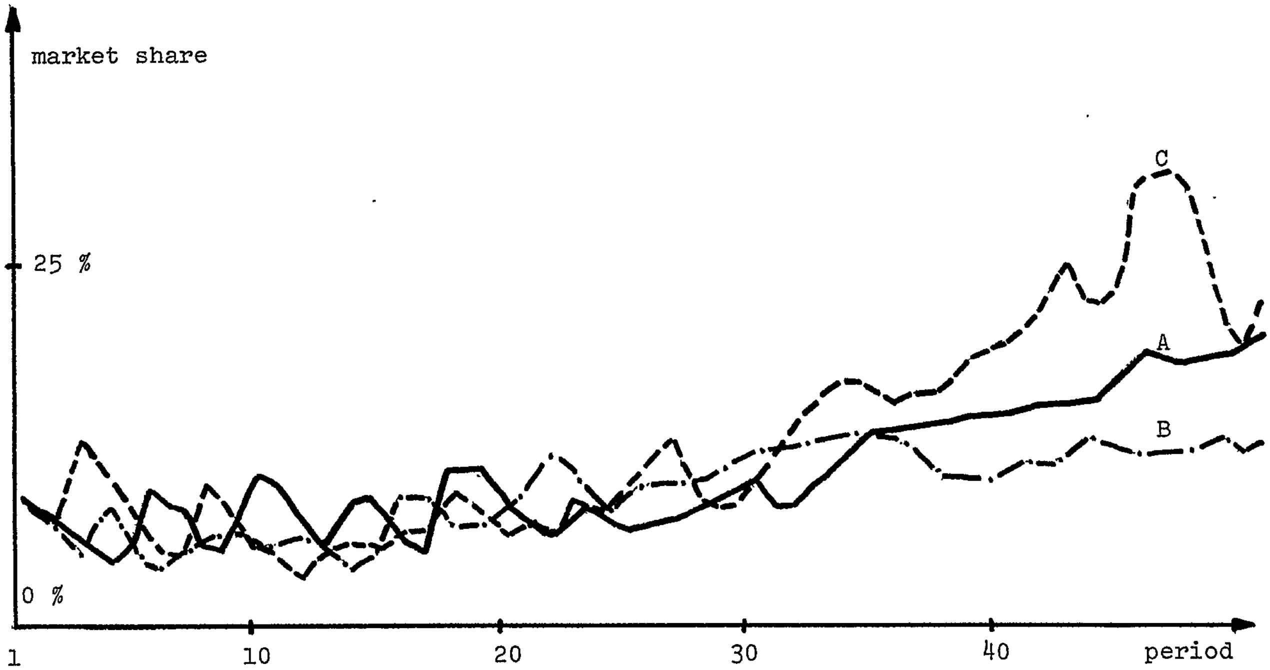

Figure 8. Market share for firm 16,runs A,B and C.

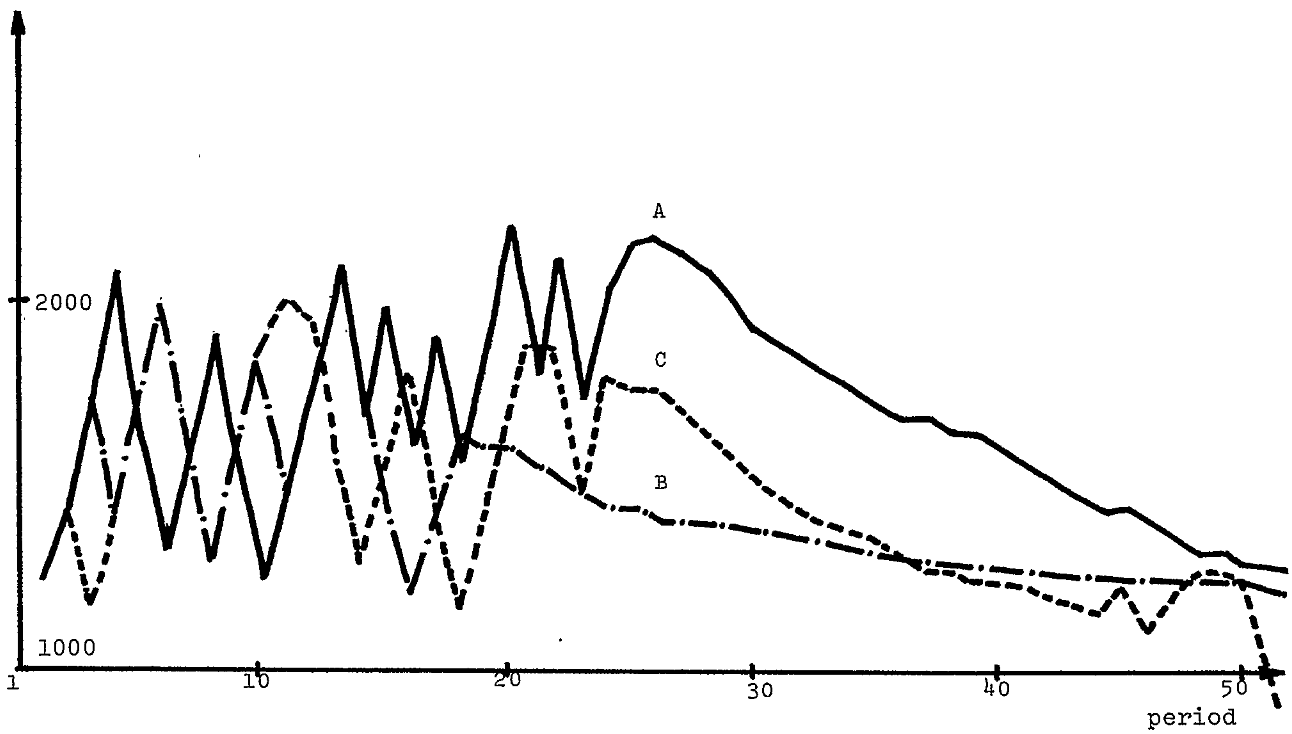

Figure 9. Price decisions for firm 16,runs A,B and C.