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POLICY FORMULATION FOR A CIGARETTE MANUFACTURING COMPANY: A DYNAMIC SYSTEM SIMULATION

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by

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FOREWORD

I would first like to thank my major professor, Dr L. E. Grosh, for his constant support and very helpful comments throughout the preparation of this thesis. I am also thankful to the other members of my committee, Dr Lynn E. Bussey and Dr N. Dean Eckhoff, for their participation in this study.

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George M. Macropulos

Manhattan, Kansas
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CHAPTER I

INTRODUCTION

Policy formulation for profitable growth is a major concern of most businesses. The size and intricacy of management systems, the multiple conflicting goals within the organization, and the interface between the firm and its market all contribute to make successful policy design difficult. The company's own strategies for controlling resources, marketing, and trading off immediate expense for long-term results can have more impact on its growth than potential market demand. The purpose of this study is to investigate how present strategies in a cigarette manufacturing company are affecting growth, and to suggest policy changes that will yield a rapid profitable growth.

The management of the cigarette company is interested in uncovering strategies to improve growth. Recently, large capital outlays for marketing and capacity expansion have been made in an attempt to enhance sales, profits and market penetration. The results of these expenses, however, have not entirely met the company's expectations. Although the company has captured a substantial share of the industry's sales growth has by no means been profitable. Through the use of a computer simulation model, system behavior is observed, and alternative policies in the areas of promotional expenditures and capacity expansion are investigated.

1.1 Corporate Simulation Models

Corporate simulation models are a logical extension of what economists call 'the economic theory of the firm'. This is a collection of theories about the behavior of firms operating under a very special set of environmental conditions. The four basic elements of this economic theory are:

- goals; profit maximization,
- a production transformation process; which converts some finite number of inputs (production factors) into a finite number of different outputs (products),
- information; product demand information, factor-supply information, and production-technology information, and,
- decisions; which can be subdivided into input decisions and output decisions.

In spite of its widespread acceptance among economists, the classical theory of the firm has sustained attacks from critics who doubt the cognitive and motivational assumptions underlying the model. Others assert that the type of firm implied by the traditional model has few characteristics that have come to be identified with business firms in the real world.

> 'The classical economic theory views the firm as an impersonal "black box" which responds automatically to changes in the external world. This theory.....works quite well in predicting long-run trends in prices and costs in industries that are reasonably competitive. There are many important

questions, however, which economic theory of the firm has left largely unanswered.' (5 , p.4)

This called for models of the firm which incorporate a much greater degree of realism and complexity than the traditional model. These theories would answer questions such as:

- What are the effects of organizational structure on managerial behavior?
- How are resources allocated within firms?
- What effect does uncertainty have on decision making?
- What factors influence the firm's growth rate?
- How does the firm interact with its external environment?

The advent of computer simulation techniques has enabled some major innovations in the theory of the firm resulting in several steps forward being taken in attempting to answer the above questions for particular firms. Recently, several large corporations in the United States have embarked on building corporate simulation models (26). Instead of treating production, marketing , accounting and finance as though they were separate, independent functions, corporate simulation models treat the business firm as a 'total system'. The firm's distribution, finance, production, information and control subsystems are treated as though they were completely interdependent.

1.2 The Company as a Control System

Every company is a control system. Each has direction and objectives, whether explicit or implied. Each has policies and

procedures whereby it reaches decisions and takes actions to attain its goals more closely. The company as a whole or any of its subsystems can be represented by the feedback process shown in Figure 1.1.

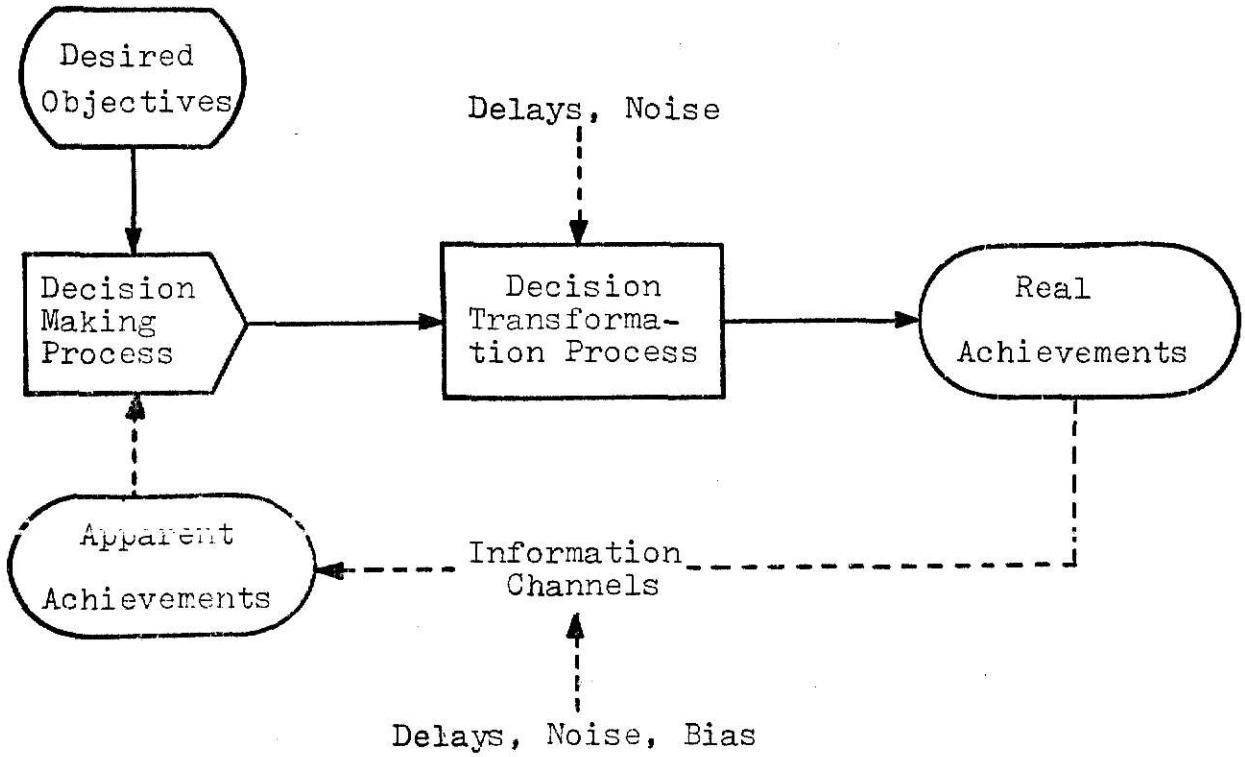


FIGURE 1.1: Control System Structure of Organizations (, p.101)

Four characteristics of this diagram are noteworthy. First, decisions go through an implementation process that transforms them into actual achievements. The implementation process is complicated by complex structural relationships in the organization. The process may be further complicated by time delays between a decision and its implementation, and numerous sources of noise or random behavior in the organization.

The second aspect to be noted is the distinction between achievements that are apparent in the company and those which are real. Apparent achievements will be more or less representative of actual achievements, depending on the quality of information received through the feedback process. This information is affected by delays, noise, and bias in the communication channels.

The third feature of the diagram is that the decision process itself is characterized as goal-seeking behavior which responds to any difference between the company's objectives and its apparent achievements. Although objectives and achievements may be difficult to define precisely and measure accurately, such a goal-seeking behavior is nonetheless present in all organizations. The real problem is to recognize these multiple decision loops and their relationships, and to develop policies and a company structure that will tie these activities into progress toward total organizational objectives.

The fourth characteristic of Figure 1.1 is the continuous feedback path of decision-results-measurement-evaluation and back to decision. It is vital to effective system design that each element of this feedback path be properly treated and that its continuous nature be recognized.

1.3 Approach and Methodology

Industrial Dynamics is a philosophy which asserts that organizations are most effectively viewed, and managed, from

this control system perspective. It is also a methodology for designing and analyzing organizational policy and behavior. This two-pronged approach is the result of a research program that was initiated and directed at the M.I.T. School of Industrial Management by Professor Jay S. Forrester. The results of the first five years of this program are described in Professor Forrester's book, Industrial Dynamics (9).

Although other approaches might have been adopted, industrial dynamics was considered appropriate for this study for several reasons:

(a) A substantial body of theory of corporate growth had been developed. Some of the research suggested a way of addressing this company's problem. It was believed that the processes which encouraged or constrained growth were part of a non-linear, closed loop feedback system.

(b) The relatively low mathematical sophistication required by the industrial dynamics approach enhances the chances of management understanding the system analysis effort. In the area of policy formulation it is likely that such enhanced understanding will be the principal direct and immediate result of a system study.

(c) Emprical data were not available sufficiently to permit use of statistical techniques. The industrial dynamics methodology is less insistent upon data availability, although added confidence in the model formulation does result when derived of relationships can be enhanced by statistical analysis methods. Given these data unknowns, however,

industrial dynamics does offer the advantage of providing an easy vehicle for testing the sensitivity of company performance to deviations form the initial estimates made of the relationships.

1.4 The Company Studied

The company studied is a cigarette manufacturing firm in Mozambique, a Portuguese colony on the east coast of Africa. The company has its principal factory in Lourenco Marques, the capital of Mozambique, and a satellite plant in Nampula. The cigarette manufacturing industry in Mozambique consists of three companies, which is the maximum allowed by government. Until recently the Mozambique manufacturers were allowed to trade freely with other Portuguese colonies, such as, Angola. Due to the increasing deficits in the country's Balance of Payments, however, the government has curbed sales to overseas colonies and now allows limited exports on a quota basis.

The company procures the major portion of its tobacco leaf from local suppliers, although limited quantities are imported from foreign countries. The tobacco is stored in the factory inventories for a substantial time period in order to allow for proper aging. Thereafter, it enters the manufacturing process where it is blended, cut and transfered into the cigarette making and packing departments.

Cigarette manufacturers in Mozambique sell directly to retail outlets and to large ultimate users such as government bodies. General selling pressure for individual brands is exerted by the manufacturers themselves through the medium of advertizing. In addition to outlays for space in magazines and newspapers, and time on radio, salesmen make systematic rounds of the retail trade. They check inventories, accept orders, and generally attempt to overcome the competitive neutrality of retail outlets by arranging for counter displays or other point-of-sale advertizing. Through these, and other special arrangements, salesmen try to get favorable treatment for their brands, or at least prevent favorable treatment to competitors.

Although the company markets several brands, promotional effort is concentrated on the largest selling brand, since equal effort on all brands would tend to neutralize the effect of advertizing. The company has also competed for consumer favor by introducing new brands and varieties of cigarettes. This product innovation, together with advertizing, is the chief avenue of competition in the industry.

The company as it is today was established in 1968 with the merger between the existing firm and an international cigarette manufacturing concern. The advent of new capital and managerial know-how has increased the company's share of the market from 8.5 % in 1968 to 29.7 % in 1973.

1.5 Purpose of Study

The purpose of this study is to build a computer simulation model to be used as a tool in investigating alternative policies in the two problem areas of the company:

- advertizing expenditures; large amounts of money are being spent in advertizing, and although market share has improved considerably, profit has not met with similar success. A basic advertizing policy needs to be formulated.
- capacity expansion; the effects on growth of present capacity acquisition policies need to be studied.

CHAPTER II

GENERAL CONCEPTS OF INDUSTRIAL DYNAMICS

The industrial dynamics philosophy proposes that effective management of an organization should recognize the character of the organization as a series of interconnected feedback networks with dynamic interaction among the components of the organization. As Forrester (9, p. 13) defined it:

> "Industrial dynamics is the study of the information-feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decisions and actions) interact to influence the success of the enterprise. It treats the interactions between the flows of information, money, orders, materials, personnel and capital equipment in a company, an industry, or a national economy.
>
> Industrial dynamics provides a single framework for integrating the functional areas of management-marketing, production, accounting, research and developement, and capital investment. It is a quantitive and experimental approach for relation organizational structure and corporate policy to industrial growth and stability."

Because of the close relationship between the type of simulation model developed and the framework within which the industrial dynamics concept is structured, it is necessary to delve into this

framework in some detail in order to understand the nature and implications of the model. Forrester has not proposed a single model to represent industrial activity; rather, he has proposed the development of particular models to represent specific systems (companies, industries, or economies). In other words, he has suggested an approach to the construction of models.

2.1 Industrial Dynamics Perpective

There are two basic components of the structure of a system viewed from the industrial dynamics perspective. These are the varying rates of flow and the resultant changes in levels of variables in the system. Levels represent accumulations of resources in the system being modeled. They may be inventories of goods, amounts of information of ideas, cash balances, number of orders on hand, number of people in the work force, or the amount of equipment on hand. Levels may exist in the information flows as well as the physical flows in the organization. They may take the form of information about past events or past behavior of rates of flow, as, for example, the average production rate for last week or last month. Levels may also represent ideas or feelings, such as a level of satisfaction or a degree of confidence. Rates of flow represent the activities and decision functions in the system, and may be the movement of goods, payments of money, expenditure of effort, arrival or departure of people, or acqusition of equipment. Decision functions regulate these flow rates.

In an industrial dynamics model, the rates of flow, the flow paths of the components of the system, and the states of the system represented by accumulated levels of the components, are meant to involve all the resources of the organization. These would include materials, orders, money, manpower, capital equipment, the interconnecting information networks, and the decision processes governing the rates of flow.

Typically, individual events are considered in an aggregate sense in order that they may be treated as continuous flows. This permits concentrating on the continuity of the system. This aggregation allows us to examine the over-all behavior of systems and their components, and is similar to a top manager's view of the company. Individual sales are made, individual items are produced, and individual orders are shipped, but the manager is primarily concerned with the rates of flow of orders, production, and shipments. As Forrester pointed out, this perspective is not close enough to consider individual thought processes, nor is it far enough to be concerned only with results and not to consider the nature of the decision processes. The manager is concerned with how goals are set by subordinates, what information sources are utilized in making decisions, and what will be the nature of various subordinates' responses to economic and social pressures. Discrete events are not ruled out of the model, however. Where appropriate, particularly significant events may be singled out for consideration, or discontinuities and noise may be treated as random disturbances generated from a probability distribution.

2.2 The Decision Process as Viewed and Modeled by Industrial Dynamics

The Industrial Dynamics Research Group at the Massachusetts Institute of Technology Sloan School of Management has developed a flow diagramming technique that has been found useful in developing the system of mathematical equations in a model. Figure 2.1 shows the symbols that are used.

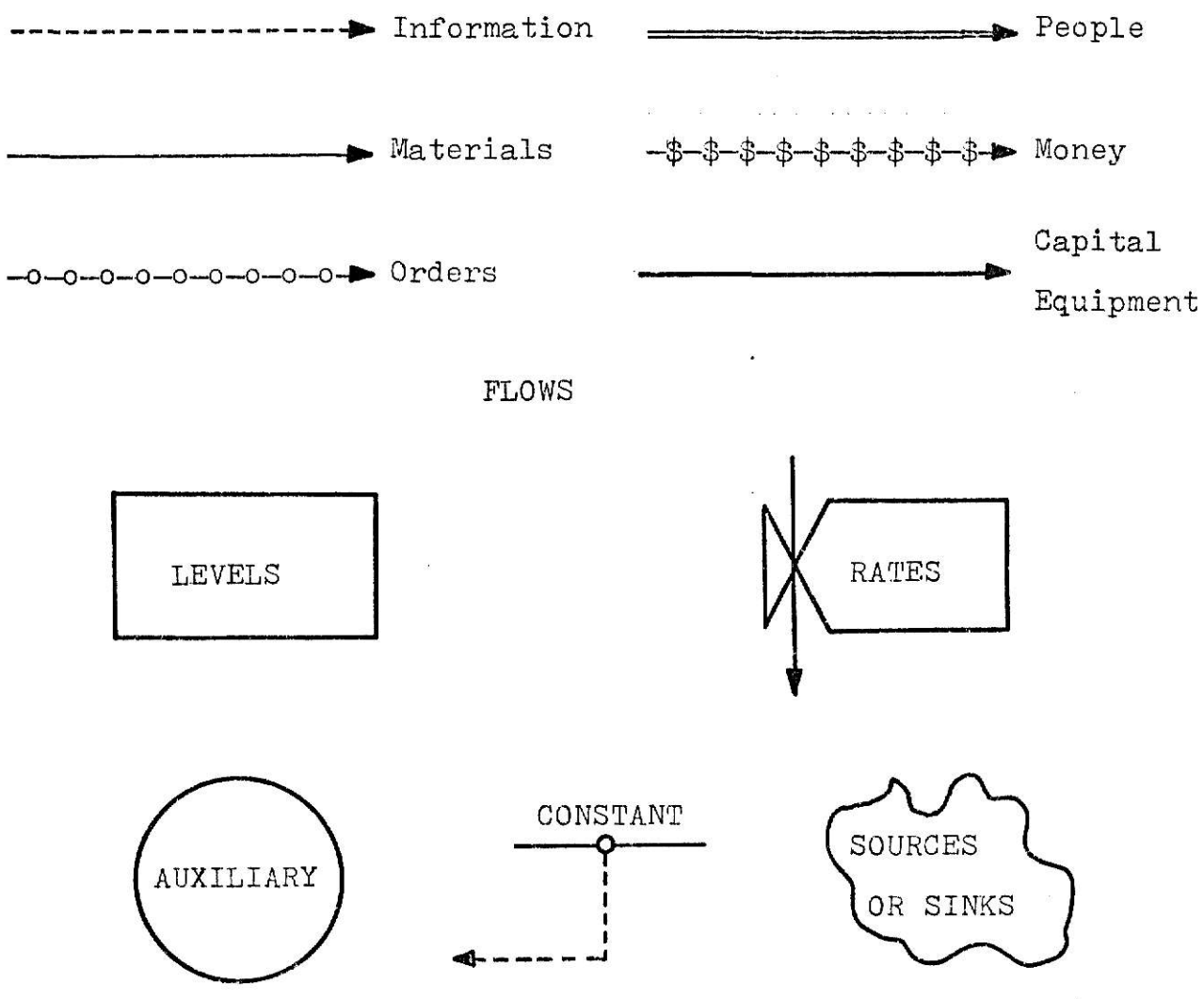


Figure 2.1: Symbols Used in Flow Diagramming Industrial Dynamics Model

The six types of flow are identified by different types of lines used to connect portions of the system. Levels are shown as a block with the contents indicated inside the block. Decision functions are shown as valves that control the rates of flow. Since a decision function may be quite complex, it is often subdivided into a group of auxiliary variables that are represented by circles. Constants, values that do not change with time, are shown as a line above or below the name of the constant and an information takeoff. Sources or destinations (sinks) for flows that are of no further concern in the model are represented by an irregular closed shape.

The decision process is based upon information about levels in the system, and results in the control of rates of flow between levels. These rates determine subsequent changes in levels or system states. The process is illustrated in Figure 2.2. Decisions, as used in this context, may be overt decisions of people in the system, or they may be implicit decisions that result from the condition of the system. As an example, the factory shipping rate shown in Figure 2.2 may result from the number of unfilled orders and the amount of product in inventory.

One test that may be applied to distinguish between rates and levels is whether the value in question would exist independently of the passage of time. Rates represent activity; there would be no activity (and consequently no rate of flow) if time in the system were brought to a halt. On the other hand, accumulated

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quantities in levels would continue to exist. As an example, instantaneous rates of sales in a model would cease, but average rates of sales for the day or week would remain. Thus, an average is a form of level.

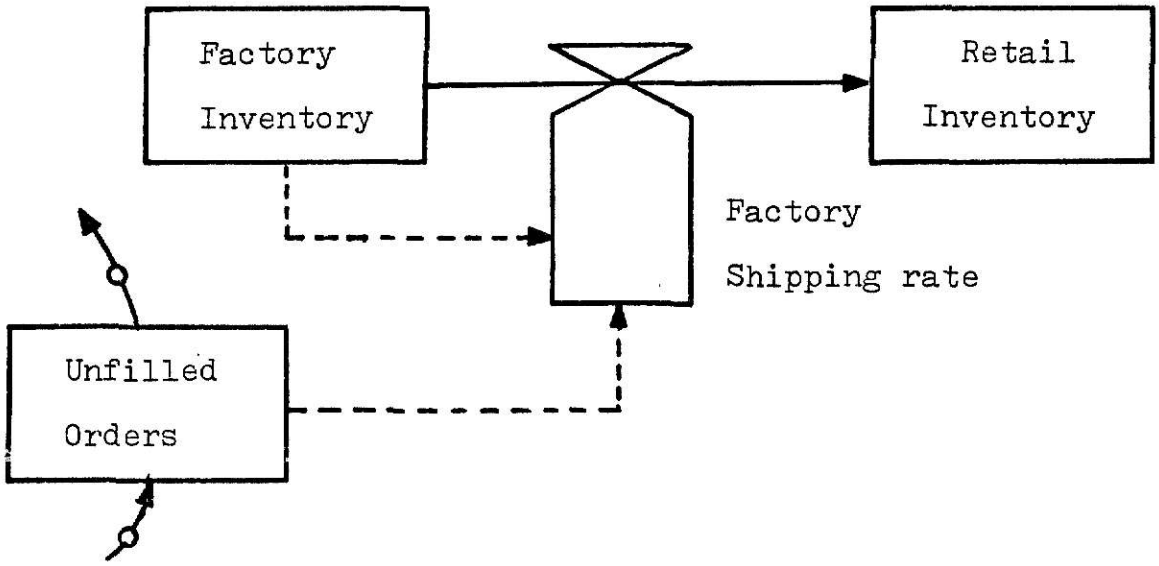


Figure 2.2: Flow Diagram of a Decision Process

An industrial dynamics model is made up of two primary types of equations which represent levels and rates. The mathematics is not complex, consisting mostly of simple algebraic and first order difference equations. The equations have been designed to facilitate the construction of models of the types of organizations and decision processes discussed above. These equation types are readily handled by the DYNAMO computer language. Most of the equations formulated in this study use four alphabetic and numeric characters, chosen for their mnemonic significance, for the variable names. In addition to the identifying characters, each variable name carries

a notation that signifies the time period involved. These time notations are used in the same manner as the subscripts used in difference equation notation. The following level equation (L) illustrates the nomenclature used in DYNAMO:

INVF.K = INVF.J + (DT)(PRFI.JK - SSFI.JK) L

INVF INVentory at Factory (cigarettes)

DT Delta Time, the time interval between solutions of the equations (months)

PRFI Products Received at Factory Inventory (cigs/month)

SSFI Shipments Sent from Factory Inventory (cigs/month)

The equation states that the present amount of cigarettes in inventory at time K equals the amount in inventory at the previous time J plus the change in inventory over the time interval J to K. In difference equation notation, the times represented by J, K, and L would correspond to t - 1, t, t + 1. Change in inventory over the JK time interval is the summation over that time interval of the difference between the rate of receipts, represented by PRFI, and the rate of shipments, represented by SSFI. Multiplying the difference in rates by DT effects this summation. If DT, the solution interval, were one month, then the change in inventory during that month would be the difference between the amounts received and shipped in that month. If DT is some fraction of a month, say 0.05 month, the equation would express the change over one working day as represented by the difference between one day's receipts and shipments. In calculus terminology, an expression analogous to

the above level equation can be derived from the following:

$$d(INVF) = \frac{d}{dt}(INVF).dt = (SSFI - PRFI)dt$$

integrating, $\int_{INVF_{t-1}}^{INVF_t} d(INVF) = INVF_t - INVF_{t-1} = \int_{t-1}^{t} (SSFI - PRFI)dt$

or rewritten, $INVF_t = INVF_{t-1} + \int_{t-1}^{t} (SSFI - PRFI)dt$

Industrial dynamics models use difference equations, since they are easily solved on a digital computer.

The following expression is an example of a rate equation (R):

$$SSFI.KL = \frac{UNOF.K}{DFOF} \qquad R$$

SSFI Shipments Sent from Factory Inventory (cigarettes/month)

UNOF UNfilled Orders at Factory (cigarettes)

DFOF Delay in Filling Orders at Factory (months)

The equation states that the factory shipping rate over the next time interval KL is equal to the amount of unfilled orders at the present time K divided by the delay in filling orders at the factory. In other words, the rate is equal to the value of a level divided by a delay. In this instance, the delay is the average length of delay and may be expressed as a constant.

Conceptually, a model may be constructed entirely from equations for levels, rates, and constants. Rate equations, or decision functions, may be formulated entirely from levels and constants. However, if this were done, many rate equations would become so complex as to obscure their meaning. In order to more

conveniently represent and understand these decision functions, auxiliary equations are introduced which break down decision functions into their component parts. As an example, the function of auxiliary equations (A) may be illustrated by the following series of equations:

$$SSFI.KL = \begin{cases} NSRF.K & UNOF.K \leq INVF.K \\ RSRF.K & UNOF.K > INVF.K \end{cases} \qquad R$$

$$NSRF.K = \frac{UNOF.K}{DFOF} \qquad A$$

$$RSRF.K = \frac{INVF.K}{DFOF} \qquad A$$

SSFI Shipments Sent from Factory Inventory (cigs/month)

NSRF Normal Shipping Rate at Factory (cigs/month)

RSRF Restricted Shipping Rate at Factory (cigs/month)

UNOF UNfilled Orders at Factory (cigs)

INVF INVentory at Factory (cigs)

DFOF Delay in Filling Orders at Factory (months)

The relationships expressed by the above equations could be expressed in a single rate equation:

$$SSFI.KL = \begin{cases} \frac{UNOF.K}{DFOF} & UNOF.K \leq INVF.K \\ \frac{INVF.K}{DFOF} & UNOF.K > INVF.K \end{cases} \qquad R$$

in which all terms are either levels or constants, but in which the meaning is not so clear as in the three separate equations. The above equations will be discussed in more detail in chapter IV.

An auxiliary variable, in principle, depends only on levels that are already known and on other auxiliary variables that can be computed before being needed.

A system of equations is written in the context of certain conventions that state how the equations are to be evaluated. An industrial dynamics model contains a system of equations that controls the changing interactions of a set of variables as time advances. This system evolution implies that the equations will be computed periodically to yield the successive new states of the system. At each point in time, there is a particular sequence of computation implied by the equation system. The sequence used is shown in Figure 2.3.

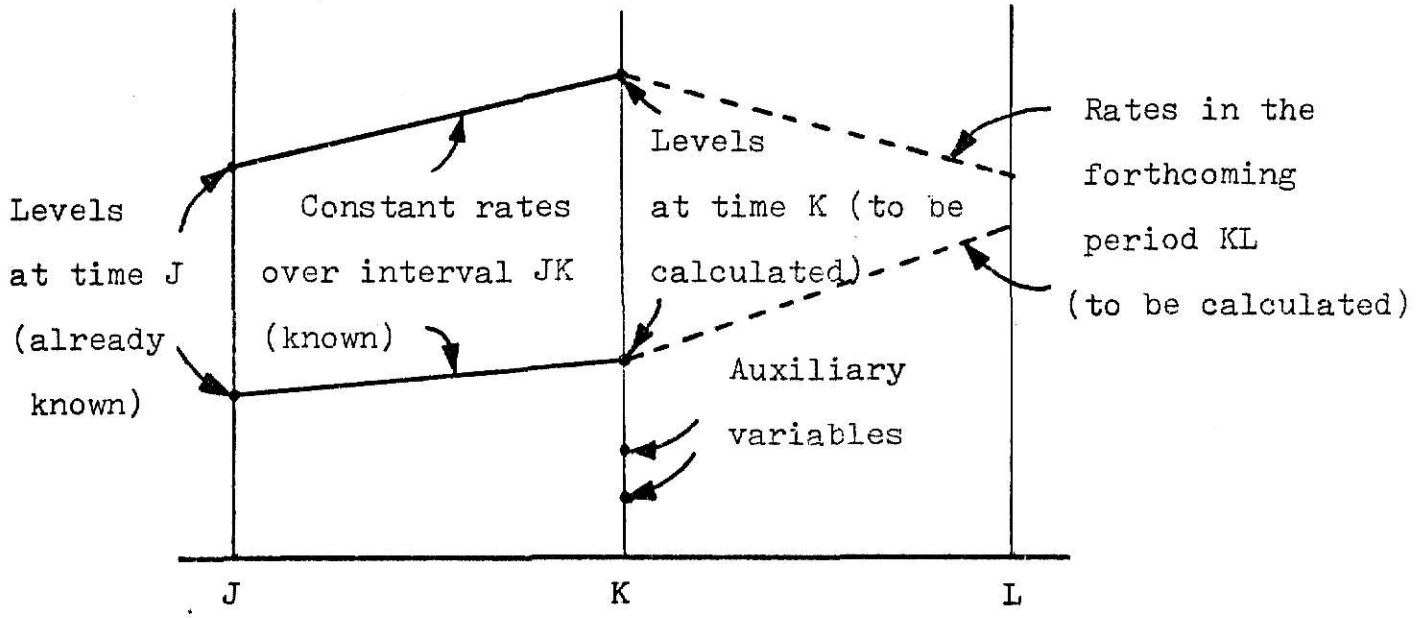


Figure 2.3: Calculations at time K

The continuous advance of time is broken into small intervals of equal length DT, the time increment. By definition this interval must be short enough so that constant rates of flow over the interval are a satisfactory approximation to continuous varying rates in the actual system. In Figure 2.3, successive points in time are given the designations J, K and L. The computing sequence for an equation system is first to evaluate the level equations at period K, then the auxiliary equations at period K, and finally the rate equations for the forthcoming period KL.

Before the first cycle of model equation computation can begin, initial-value equations are used to define initial values of all levels (and some rates) that must be given. For most explorations using this type of model, it is easier and less confusing if the system starts from a steady-state, unperturbed condition, whether or not it turns out that the system is stable. If the equilibrium point is unstable, any disturbance will initiate a growing departure from the initial conditions. As an example of an initial-value equation (N), factory inventory should be initialized with a value equal to the desired inventory level:

```
INVF = INDF                                                    N
```

As can be seen, the time-period notation is not used with the variables in initial-value equations.

Another type of equation that is used in industrial dynamic models are supplementary equations. These are used to define

variables which are not actually part of the model structure but which arise in printing and plotting values of interest about the model behavior. As an example, historical data of an important parameter in the system may be of interest for comparative purposes, although this is not used in any of the decision processes of the model.

2.3 Delays and Smoothing

The importance of the effect of time lags on the behavior of dynamic systems is stressed in industrial dynamics, because time lags determine many aspects of system behavior. Delays may be found in the flows of both physical quantities and information. In the former case, lags would represent delays in movements of goods, people, money, etc... In the latter instance, they would represent such things as information. Smoothing of information flows is closely related to the concept of delaying the flow of physical quantities in a system. Smoothing delays the impact of transient fluctuations on the system and filters out higher frequency fluctuations, thereby altering the sensitivity of the system to them. Thus, in information smoothing there is a tradeoff to be evaluated between reducing impact of noise and other short-term fluctuations and reducing time lags in recognizing significant changes in the data being received.

Two commonly used techniques for smoothing time series are the moving average and exponential smoothing. These two methods have different operating characteristics in terms of the weight

given to data in a time series. In the expression for the n-period moving average $\bar{x}_t$ in the folowing equation, an equal weight is given to each of the previous n periods of data.

$$\bar{x}_t = \frac{1}{n}(x_t + x_{t-1} + x_{t-2} + \cdots\cdots + x_{t-n+1})$$

n = number of periods of data in the average

x_t = data for the most recent period

x_{t-1} = data for the next earlier period

$\vdots$

x_{t-n+1} = data for n periods ago

As the moving average is recalculated each period, the value for the most recent period becomes x_t, the old x_t becomes x_{t-1}, and so forth, to x_{t-n+1}, which is dropped from the average. Until data for a period are finally dropped from the average their weight in the average is the same as when the data entered the average.

There are many times when older data should be given less weight than more recent data, and an exponential moving average does this. When exponential smoothing is used, data for the latest period are weighted by α initially, and in each succeeding period the data are in effect, further weighted by $(1 - \alpha)$. As a result, each period of data is carried along indefinitely, but with a lower and lower weight. The following experssion gives the exponential moving average $\bar{x}_t$:

$$\bar{x}_t = \alpha x_t - (1 - \alpha)\bar{x}_{t-1}$$

x_t = data for the most recent period

$\bar{x}_{t-1}$ = exponential moving average for the previous period

The equation can be rewritten in the following form:

$$\bar{x}_t = \bar{x}_{t-1} + \alpha(x_t - \bar{x}_{t-1})$$

In this form the new smoothed moving average is the old average plus some fraction of the difference between the new data and the old average. In industrial dynamic models, the smoothing constant α is thought of in terms of a smoothing time constant of T time periods. Then α would be replaced by $\frac{1}{T}$:

$$\bar{x}_t = \bar{x}_{t-1} + \frac{1}{T}(x_t - \bar{x}_{t-1})$$

Putting this in DYNAMO notation and generalizing to any solution interval DT gives the following expression for first order exponential smoothing:

$$\text{AVG.K} = \text{AVG.J} + \frac{DT}{T}(\text{DATA.JK} - \text{AVG.J})$$

The average at time K equals the old average at time J, plus a fraction of the difference between the values of the rate of flow over the time period J to K and the old average.

There are other advantages to using an exponential moving average. Since decision processes are being modeled, an exponential moving average may more appropriately reflect intuitive behavior than an arithmetic moving average, because it gives less and less

weight to older information. The choice of smoothing time constant T determines the response of the average to changes in the flow of the series. Larger values of T give less weight to recent data and consequently more weight to the old average. Thus the average would respond more slowly to transients. In this sense exponential smoothing acts also to delay the effect of variations in information flow.

The treatment of exponential delays in the flow of physical quantities requires a slightly different set of equations than for smoothing information. This is so, because often a variable delay is encountered in material flows and it is essential that no units be lost or created by variations in the delay period. Thus the following pair of equations is used to delay the flow of physical units:

$$LEVEL.K = LEVEL.J + (DT)(INFLO.JK - OUTFL.JK)$$

$$OUTFL.KL = \frac{LEVEL.K}{DELAY}$$

LEVEL	LEVEL (amount) or units in the delay
INFLO	INFLOw rate
OUTFL	OUTFLow rate
DELAY	average time of the DELAY

The rate equation indicates that the outflow rate over the coming time period is equal to the amount in the delay divided by the length of the average delay period, the amount in the delay

having been determined by the difference between the inflow and outflow rate over the preceeding time period.

The above equations are for a first order exponential delay in which the delay is a constant. If the rate equation is written in its form for one time period earlier, we have:

$$\text{OUTFL.JK} = \frac{\text{LEVEL.J}}{\text{DELAY}}$$

Substituting this, and the level equation into the outflow rate equation, we obtain:

$$\text{OUTFL.KL} = \text{OUTFL.JK} + \left(\frac{\text{DT}}{\text{DELAY}}\right)(\text{INFLO.JK} - \text{OUTFL.JK})$$

This last equation is of the same form as the smoothing equation, except that it bases the new outflow rate on the old outflow rate.

When the dynamic behavior of systems is being evaluated, not only is the average delay important, but also the reaction of the delay to transients. One can shape the transient response of the model by cascading first order exponential delays into higher order delays or by selecting other delay functions, such as a discrete delay. Because the character and behavior of delays are fundamental to industrial dynamics analysis, the transient response of several delay functions will be examined.

In Figures 2.4 and 2.5 are shown output rates from first, second, and third order exponential delays in response to a unit step increase and a pulse input rate at time zero. Note that for the

first order exponential delay there is a small increase in the output rate at once rising to approximately sixty per cent of the input rate at the time of the average delay. For the second order delay the output rate is zero at first, but it begins to rise immediately afterwards. In the case of the third order delay the output rate is also zero at first, but there is a delay before any output appears. The output rate increases slowly, rises to a maximum, and then declines.

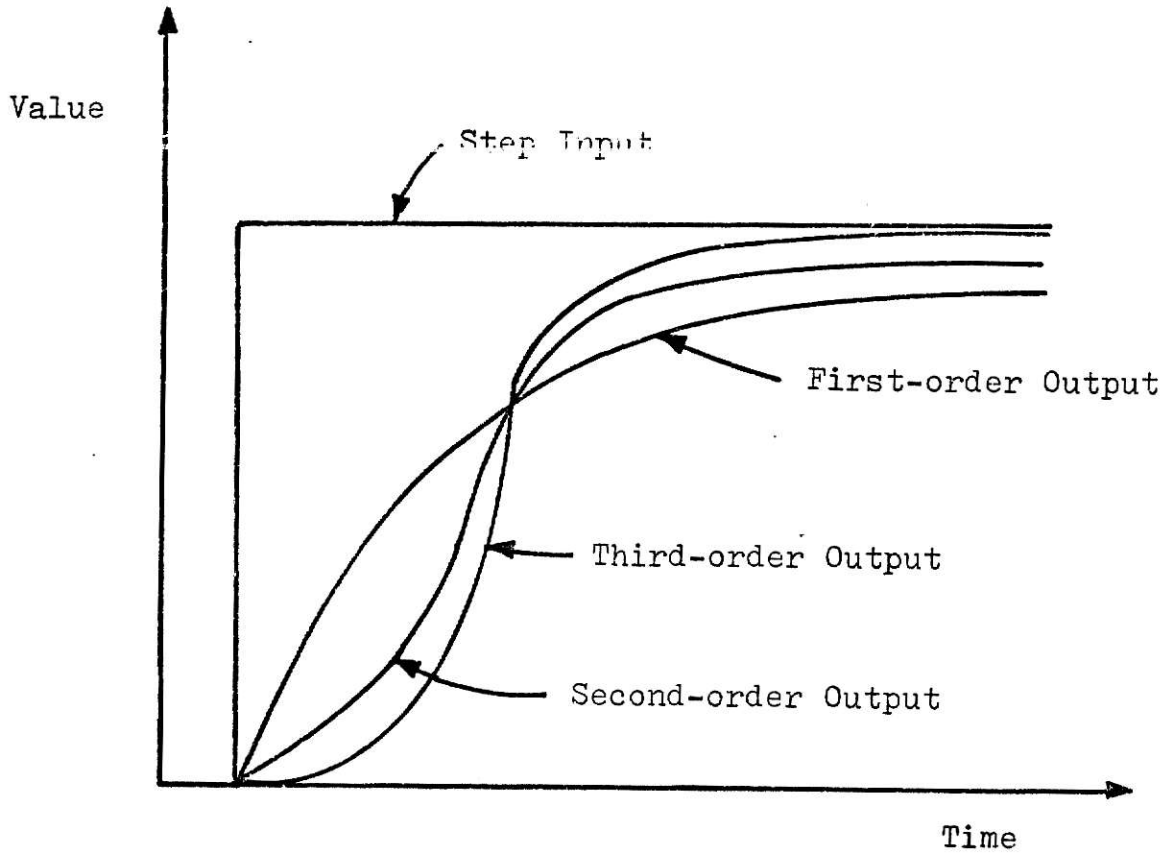


Figure 2.4: Delay Output - Step

A third-order exponential delay can be written as a cascade of three first-order exponential delays:

$$\text{VARI1.KL} = \text{VARI1.JK} + \frac{\text{DT}}{(\text{DELAY})/3}(\text{INFLO.KL} - \text{VARI1.JK})$$

$$\text{VARI2.KL} = \text{VARI2.JK} + \frac{\text{DT}}{(\text{DELAY})/3}(\text{VARI1.JK} - \text{VARI2.JK})$$

$$\text{OUTFL.KL} = \text{OUTFL.JK} + \frac{\text{DT}}{(\text{DELAY})/3}(\text{VARI2.JK} - \text{OUTFL.JK})$$

The outflow of the first is defined as the variable flowing into the second, and the outflow of the second becomes the inflow to the third. The outflow from the third is the outflow from the delay. Each section contains one-third of the total delay.

Because of the frequency with which third order delays are used, the DYNAMO compiler provides a function for them in which the user need only specify the inflow and outflow rates, and the average delay period.

OUTFL.KL = DELAY3(INFLO.JK,DELAY)

Higher order exponential delays would prolong the rise in output rates still more. At the extreme is the discrete delay, in which there is no response to the input rate until the end of delay period, when the output rate reflects the input rate.

It is important to select delay functions that adequately represent the system being modeled. As an example, a first order delay might represent response to an advertisement to which there is a small initial response, rising to a peak shortly thereafter. A third order delay might represent the response to a transpor-

tation system in which goods are being delivered to different destinations. In this case there is a delay before any goods arrive at their destination.

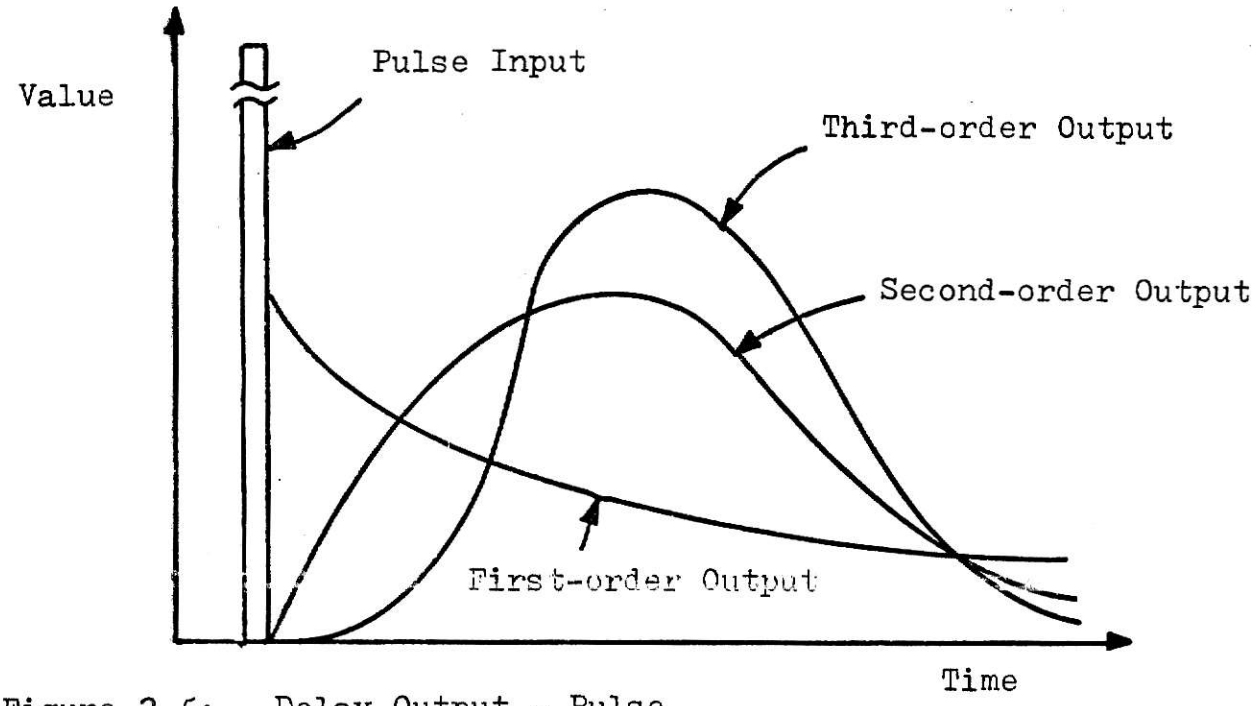


Figure 2.5: Delay Output - Pulse

A discrete delay might represent the flow between two points, where all goods put into the system traverse it in the same time interval.

2.4 Industrial Dynamics Models

Most of the work done to date in industrial dynamics can be classified into three major areas:

- the dynamics of steady-state systems,
- the dynamics of growth systems, and
- the inclusion of intangable factors and organization policy.

2.4.1 Dynamics of Steady-State Systems

The purpose of this class of model is generally to stabilize fluctuations in activities at steady-state levels. An important example of this type of analysis is the study by Forrester of the Sprague Electric Company (9 , ch. 17 & 18). This project, the first to explore the application of industrial dynamics to an actual situation, was undertaken to evaluate the interaction of production, inventory, and employment policies for the purpose of reducing costly fluctuations. One product line was selected for detailed examination, and a simulation model was developed to test hypotheses about causes of aggregate system behavior patterns.

Extensions of this work to include similar applications to other companies have been reported in the literature. Schlager (27) reported on the application to three companies in the Milwaukee area who were found to have systems and problems not unlike those of the Sprague Electric Company. One company was a manufacturer of instruments for liquid flow measurement which was experiencing significant fluctuations in production and employment. Another company was encountered which produced high unit value industrial machinery. In that study it was found that neither product nor direct labor hours could be used as the basis for the aggregated physical flows in the model because of the unique characterictics of the system. As a result the study team turned to the concept of using a flow of projects as the basis for the model instead of a flow of goods through the system. A third study dealt with analyzing product life cycles.

An industrial dynamics simulation of a tufted carpet mill has been conducted by the National Bureau of Standards (33). It is of interest because it illustrates many of the problems encountered in aggregating into a continuous model varieties of product lines and manufacturing processes.

Interesting applications of industrial dynamic models to economic-biologocal systems may be found in the extensive analyses that have been made of the management of commercial salmon fisheries along the western rim of North America by the College of Fisheries at the University of Washington (22). Research has been directed at designing management systems for establishing policies that will maximize long-run production of food and protect this resource from depletion. This model has proved most useful in acquiring some understanding of behavioral causes in complex biological systems.

2.4.2 Dynamics of Growth Systems

In contrast to steady-state systems, growth systems exhibit long-term trends over time. Characteristic of this type of system are the growth of product markets, enterprises, industries, and economies, as well as systems dealing with projects having discernible life cycles, such as research and development projects.

The first case example to appear in book form of industrial dynamics applied to growth situations was a study by Nord (20), in which the interaction of capital investment policy of a firm with the market's response to availability of a product were shown.

The way in which this interaction occurs creates some of the important growth patterns seen in new products.

Certain aspects of growth patterns of small firms were investigated in a study by Packer (21), in which the impact of two sets of basic policies on growth of the firm were examined. These policies governed the acquisition of professional manpower, both technical and managerial and acquisition of productive capacity.

The dynamics of the life cycles of research and development projects undertaken by research and development firms were analyzed in a study by Edward B. Roberts (25). As a result of analyzing the behavior of the simulation model, Roberts concluded that two policies critical to the success of such projects are willingness of the firm to undertake risks, and its integrity in bidding on cost reimbursement contracts.

Two recent studies conducted at M.I.T. by Professor Carl V. Swanson (28) and Richard D. Wright (32) illustrate the usefulness of industrial dynamics for the analysis of current policies and for the design of improved policies. Swanson investigated the policies of long distance gas transmission companies in the activities of the acquisition of gas reserves and the marketing of new low-term sales contracts. In his study, Wright designed growth strategies for a medium-sized trucking firm. These strategies were implemented successfully, resulting in improved sales, profits, service levels and capacity utilization.

2.4.3 Intangible Factors and Organization Policy

More recent research in industrial dynamics has been directed toward simulation of factors other than tangible and physical flows such as inventories and people. The level of aggregation considered in industrial dynamic models permits inclusion of many intangible factors of managerial decisions and organizational behavior. Such factors are nearly impossible to measure accurately, but considerable progress has been made in representing some of the important influences on organizational behavior in simulation models. Several areas of research are under study. These include modeling the dynamics of a power structure in an organization, the incentive environment in an organization's system, and the implementation of organizational change (24). An example of an approach that has been used in modeling certain intangible factors is the adjustment to pressure. Both the growth system models and the project life cycle model mentioned earlier include factors creating pressure for change, such as pressure for expansion.

CHAPTER III

THE SYSTEM

One of the first steps in exploring the dynamic behavior of the system is to establish what factors are significant. Although the omission of a part of the system will eliminate from the model those modes of behavior which are dependent on that part, the area of consideration must be limited lest the study of a company expand to include the national or even international economic system.

3.1 System Boundaries

For the system to be defined, it must be enclosed by a closed boundary which implies that no influences from outside the boundary are necessary for generating the particular behavior being investigated. Figure 3.1 shows the major boundaries of the system.

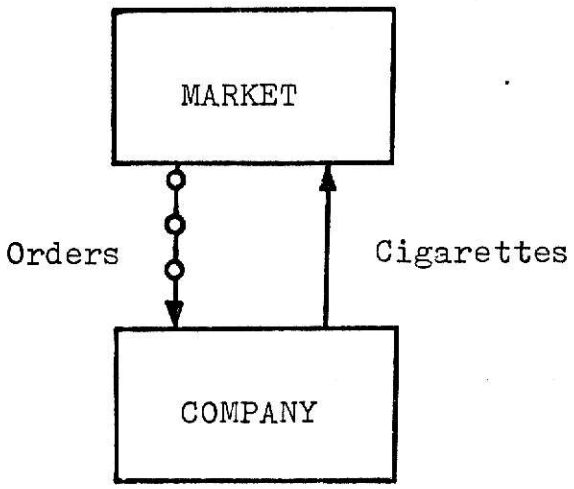


Figure 3.1: Major Boundaries of the System

It represents the market in which orders are generated and sent to the company, and the flow of cigarettes going back to the market in response to this order flow. Both the market and the company is included in the system, since their decisions are reciprocally influential.

3.2 System Structure

It seems evident that the model of such a system must incorporate all the major functions of the company and its market. Rather than attempt an all-inclusive description of company activity, the factors that are basic determinants of growth are isolated from the vast number of details that could influence the interactions between the market and the company. The hypothesis that is presented in this study emphasizes the impact of capacity acquisition and marketing policies on growth performance.

Figure 3.2 shows the interactions considered in the model. Two factors generated by the company are assumed to affect the market:

- marketing effort
- product availability

Marketing effort, which in the cigarette industry consists mainly of advertizing, creates potential customers for the company's brands. Product availability affects potential customers, since a shortage of the company's brands in the market causes an increasing fraction of potential buyers to turn to alternative brands. The order flow to the company therefore depends upon both the company's marketing effort and the availability of its brands of cigarettes.

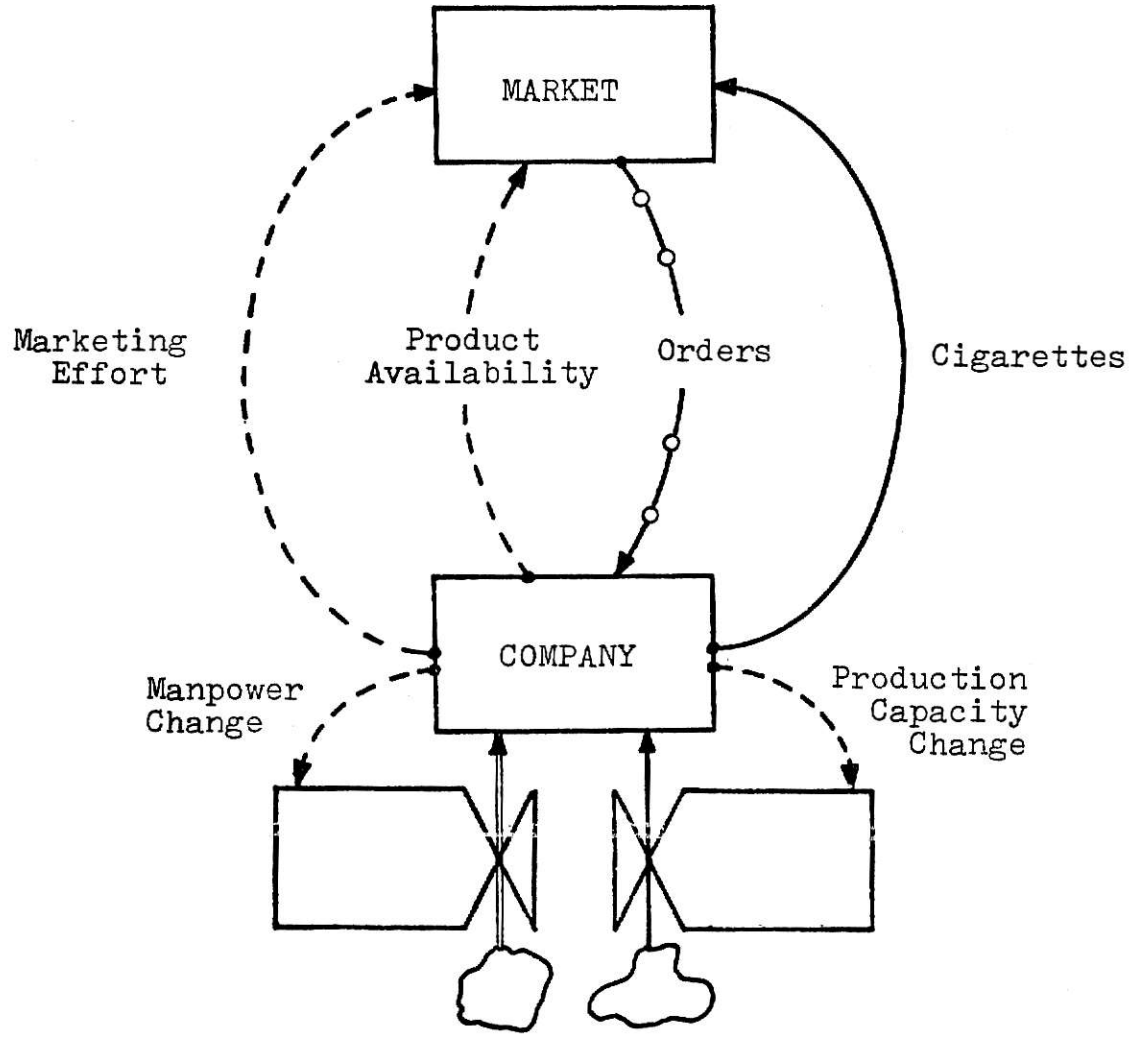


Figure 3.2: Interactions Considered

The company changes production capacity and manpower in response to conditions it appears to be facing. If demand exceeds capacity to produce, and if growth is desired, expansion proceeds through acquisition of additional production and manpower resources. The regenerative process creating growth becomes clear as these interactions are traced through time. Expansion of production

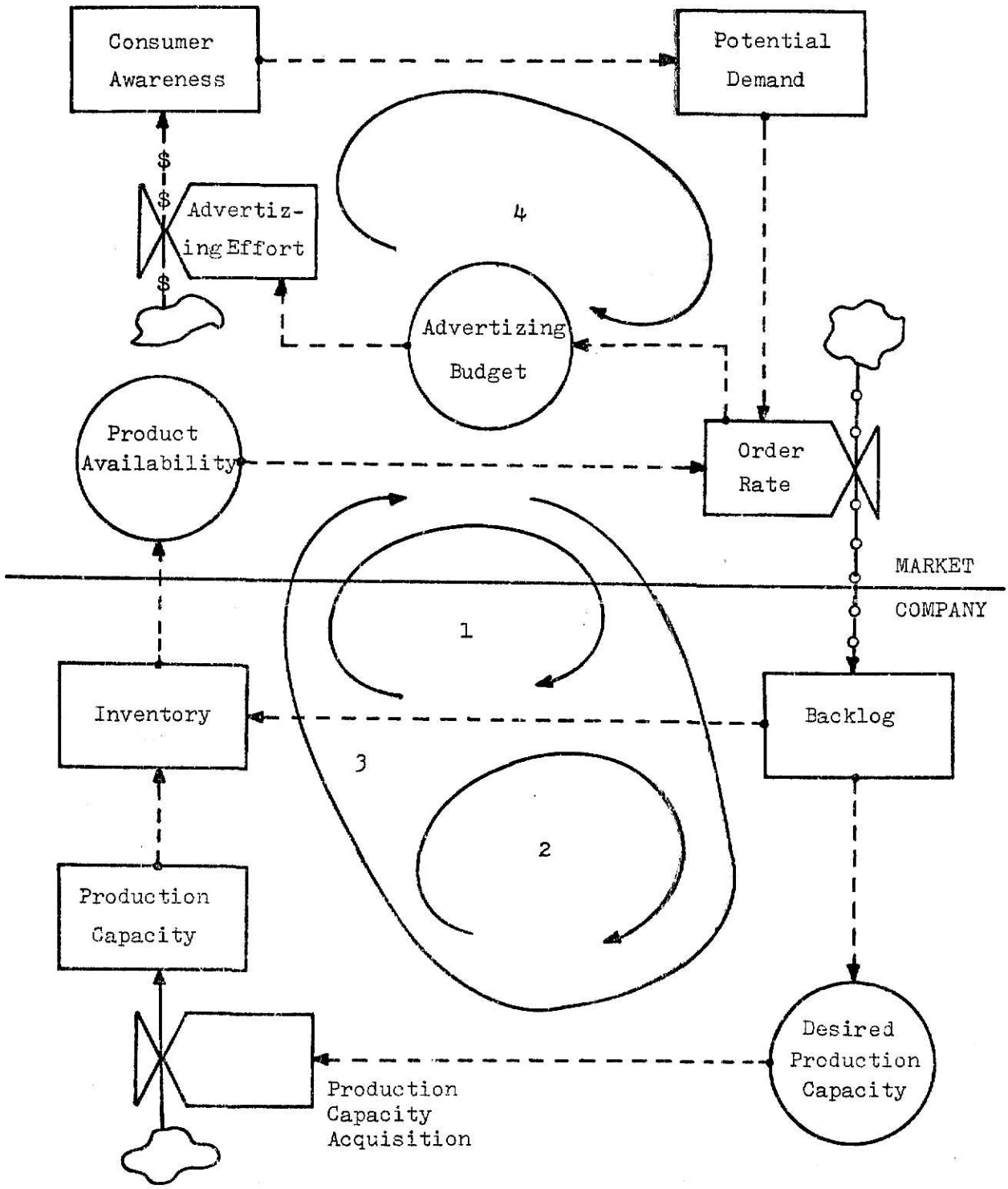


Figure 3.3: System Loop Structure

capacity and addition of manpower increases product availability. Expansion of the marketing effort increases market interest in the product. Both factors tend to increase the order flow to the company, which, in turn, leads it to expand its resources further, resulting in growth.

In order to understand the system outlined in Figure 3.2 and the growth difficulties it can experience, a closer look at the interactions involved must be taken. Figure 3.3 is a more detailed representation of the system considered in this study. Within the closed boundary, the system consists of interacting feedback loops. As can be recalled from Chapter I, the feedback loop is the structural setting within which all decisions are made. Four major loops are shown in the diagram. By viewing each loop separately, dynamic growth behavior and the influence of capacity acquisition and marketing policies on growth performance can be better understood.

Loop 1, Figure 3.4, links backlog of unfilled orders, inventory, product availability, and order rate. If the order rate should rise, backlog rises and inventory falls, thus decreasing shipments from the factory. This causes retailer stocks to become depleted, resulting in a decrease in product availability which depresses the order rate. This is a negative feedback loop since an increase in the order rate sets into motion a chain of events that eventually causes a decrease in the order rate. Negative feedback loops are goal-seeking and adjust activity toward some target level. The control exerted here by product

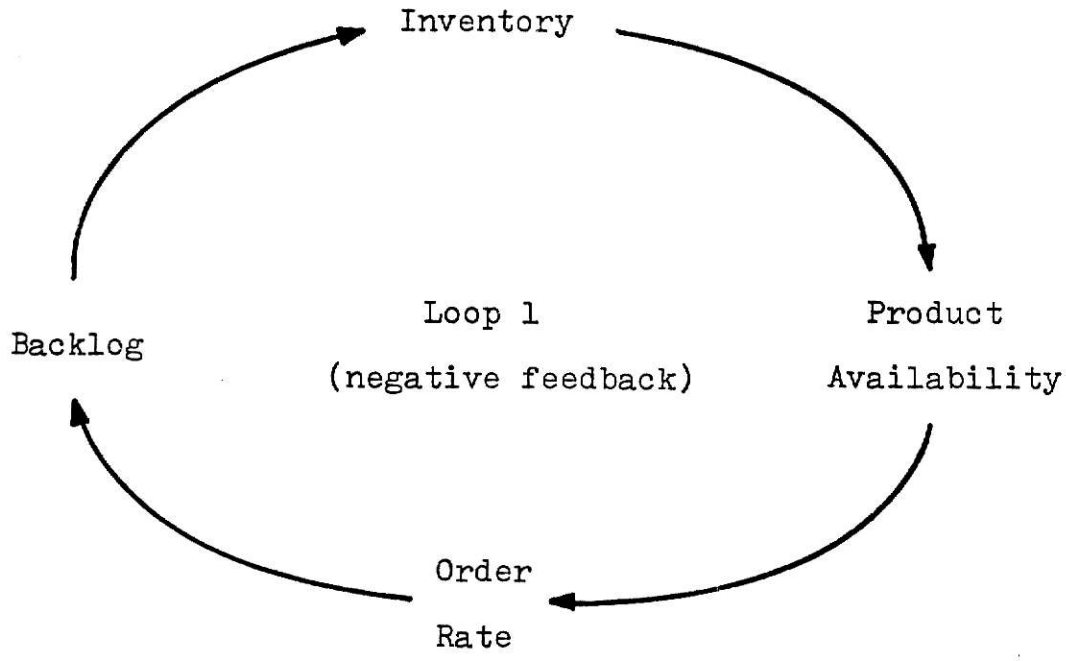


Figure 3.4: Product Availability Loop

availability serves to keep the order rate in line with production capacity. Should orders arrive at a rate greater than production, a falling product availability acts to decrease the incoming order flow.

Figure 3.5 shows the basic loop of the decision making process for addition of production capacity. The addition of capacity is of course contingent on many factors such as projection of sales trends, financial conditions, and, product profitability. However, the decision of whether to expand or not depends upon the adequacy of present capacity in terms of market demand. One of the most persuasive indicators of the adequacy of existing capacity is the

size of the order backlog. Loop 2 links inventory, backlog of unfilled orders, production capacity acquisition, and production capacity.

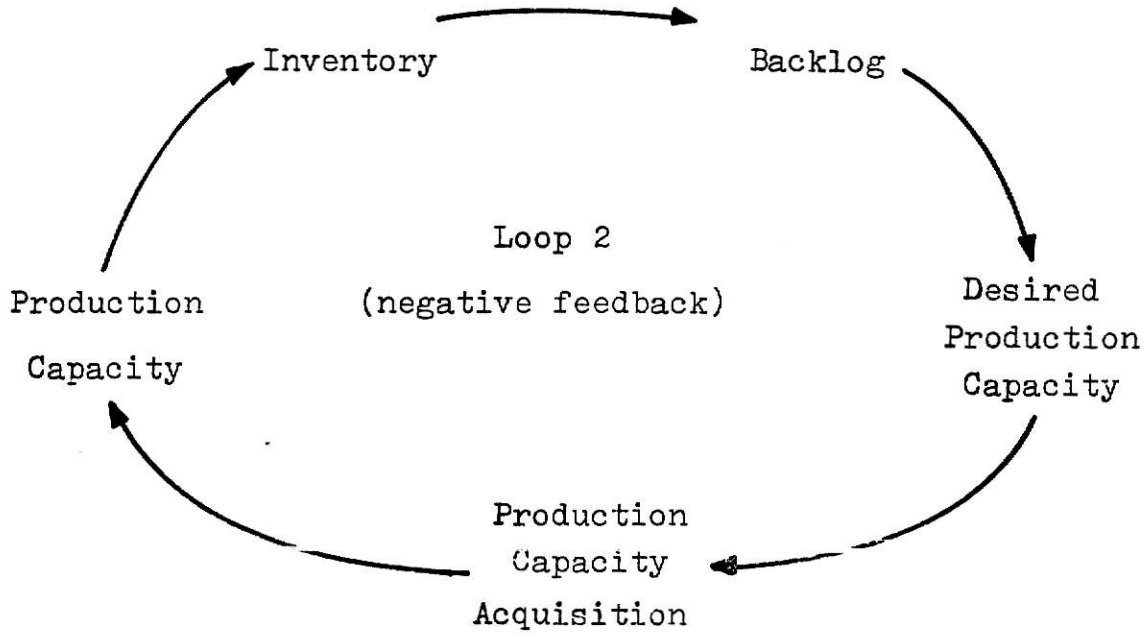


Figure 3.5: Production Capacity Acquisition Loop

A low inventory and a subsequent high backlog of unfilled orders results in a need for the increase in the productive capacity of the factory, since such conditions indicate inadequate capacity to meet demand. This need for expansion, represented by a high level of production capacity, stimulates capacity aquisition. Greater production capability increases order filling ability, building inventory and reducing backlog. This is also a negative feedback loop, since a decrease in inventory sets in motion a chain of events that tends to increase inventory. Loop 2 is attempting to change production capacity to adjust the order

backlog to a value determined by a management goal for an efficient order filling operation.

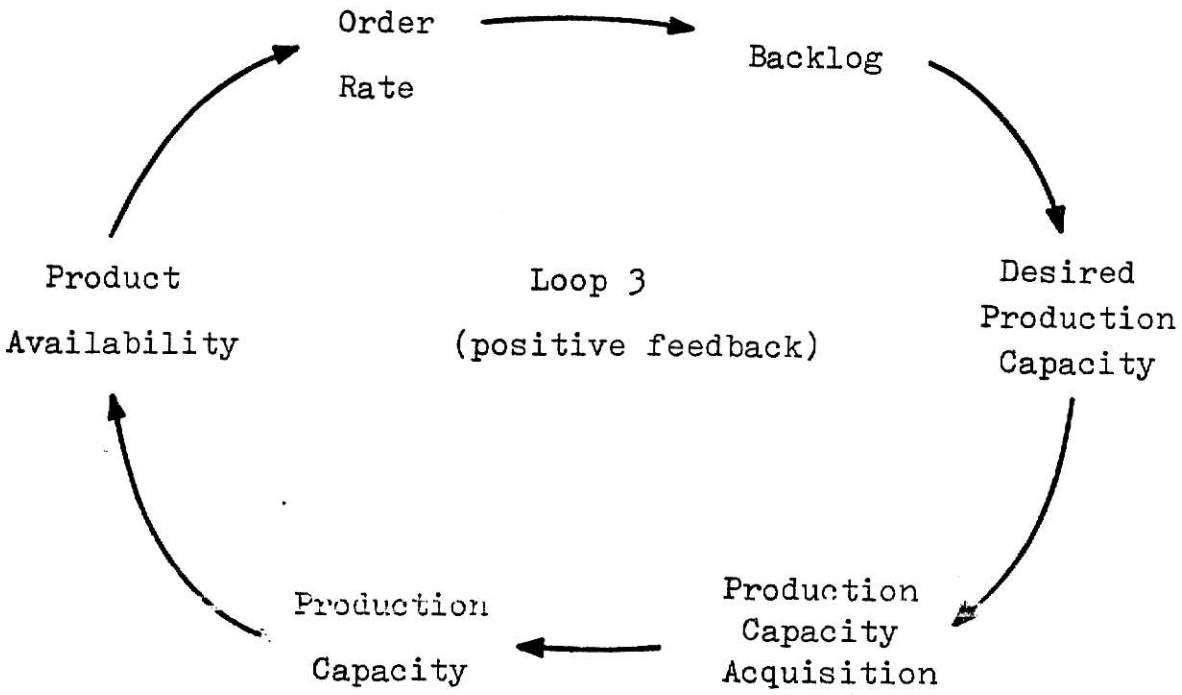


Figure 3.6: Growth Loop

Loop 3, Figure 3.6, contains variables of both loops 1 and 2. It links backlog, production capacity acquisition, production capacity, product availability, and order rate. An increase in the order rate causes backlog to rise, thus increasing the level of production capacity desired. This indicates a need to expand the productive capacity of the factory, and the resultant increased production increases the availability of the product in the market, thus raising the order rate. Loop 3 is a positive feedback loop, since an increase in the order rate generates a sequence of events

that tends to increase the order rate even further. Only positive feedback loops can produce sustained growth. A positive loop is one in which activity changes the condition of the system in such a way as to produce still further activity.

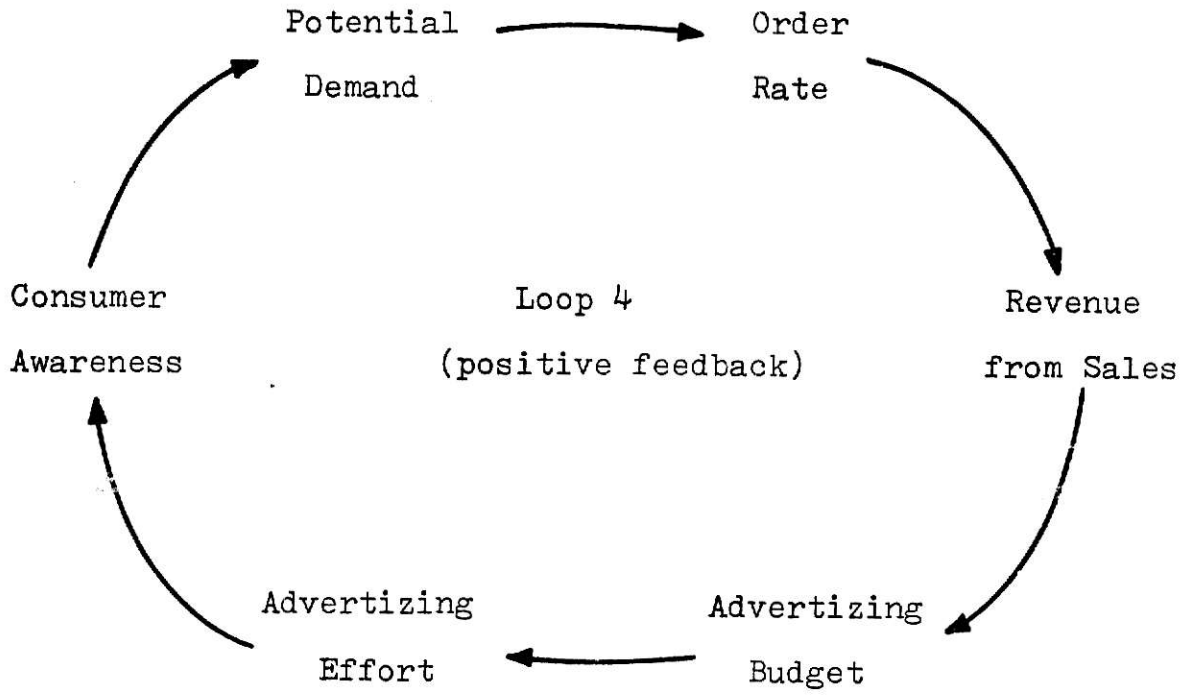


Figure 3.7: Promotional Effort Loop

Potential demand, as used in this model, denotes the order flow that would exist were the company's cigarette brands immediately available in the market. As long as the potential demand facing the company exceeds its production capability, the combined effect of these three loops produces sustained growth. Potential demand is not exogenous to the system; it is created by a number of factors, including product quality, product price, advertizing expenditure, and product innovation. All these factors, broadly speaking,

result from the marketing effort within th company. For reasons that shall be expounded in a later chapter, the quality and price level of cigarettes are considered fixed relative to competitors' brands, and therefore are assumed not to affect potential demand.

Loop 4, Figure 3.7, is a positive feedback loop involving marketing effort, here described in terms of advertizing expenditure. The loop links advertizing outlay, order rate, revenue from sales, and advertizing budget. A greater effort in advertizing results in more consumers becoming aware of the company's brands. This causes an increase in potential demand, resulting in a higher order rate. This increase in orders generates revenue which produces the advertizing budget which permits a greater advertizing effort. In short, advertizing produces revenue to pay for further expansion of the advertizing effort.

The model treats the personnel requirement policy of the company as being parasitic to the production capacity acquisition policy. In other words, production capacity needs determine the size of the workforce in the factory. However, the personnel requirement policy does not have any dynamic influence on the growth of the firm, since it is assumed that manpower availability is not a problem.

In addition to the above aspects of the company's operations, the model also includes certain financial factors used to generate monthly profit, or loss, figures. These factors, however, serve only a monitoring purpose. The various costs, for instance, play

a very important role in model validation, where historical data is compared to simulated data. Profit is used as an indicator of system performance. Financial aspects enter into the decisions of the system to a very limited extent. Although these factors often contribute to growth, it is felt that financial problems are but symptoms of difficulties whose causes lie elsewhere, such as in the interactions described in this chapter.

3.3 Assumptions

Before proceeding to a description of the model used to simulate the cigarette manufacturing company, the major assumptions carried through in this study must be stated. These assumptions limit the scope of the study to a certain extent, but permit clear focus on the interactions of the system considered above.

3.3.1 The Market

Major market assumptions pertain to its size, sensitivity, and competitiveness:

- Market size: The size of the market is assumed to grow at a fixed rate determined from historical data.
- Market sensitivity: The market responds only to the company's aggregate expenditure on marketing effort, and its ability to make its product available to the consumer. Apart from advertizing expenditures, other factors, such as price and product quality have no dynamic effect on demand.

- Competition: The company is assumed to be carving its potential market from sources that could turn to competitors for substitutable brands. Competitors are not, however, treated explicitly. It is assumed that market share is determined mainly by relative advertizing expenditures of the companies in the industry, and by product availability.

3.3.2 The Company

The following is a summary of the major assumptions about the company:

- Marketing effort: Component parts of advertizing effort are not treated explicitly in the model, but rather, it is assumed that the company maintains a balance among advertizing through the media and point-of-sale advertizing, so that increases in advertizing expenditures result in commensurate increases in potential demand.
- Production capacity: Production capacity is also treated in aggregate. The individual types and uses of production facilities are not distinguished. It is also assumed that the company can always purchase the equipment necessary to increase capacity. Financial restrictions do not hamper capacity acquisition, since external financing is obtainable.
- Product: The individual brands the company manufactures are not treated explicitly. The company's over-all performance is of more concern. The company's history includes the birth and death of several specific brands.

- Personnel: Personnel are subdivided into professional and technical employees. Within these subdivisions, however, employees are assumed to have the same average capabilities.
- Raw materials: It is assumed that raw materials are always available for purchase, and hence have no dynamic effect on growth. Raw materials are also treated in aggregate both as regards types and uses.

CHAPTER IV

MODEL FORMULATION

The formal DYNAMO model will now be described in terms of eighty variables each represented by an equation. The model depicts the physical operations of the cigarette manufacturing company, managerial control of operations, and the market of its cigarette brands. As discussed in the previous chapter, the model comprises of two major interacting sectors:

- the market
- the company

In order to facilitate description of the model, formulation is further subdivided into the various operation and policy loops within the system.

4.1 The Market

The market sector is divided into two subparts:

- generation of potential demand
- determination of actual retail sales and orders to the company

4.1.1 Potential Demand Generation

Potential demand is the order rate that would persist were cigarettes immediately available to the customer. It represents

potential market interest in the company's cigarette brands and derives from diverse factors. Some of the factors that could influence a smoker's choice of cigarette are:(3)

- price
- taste quality
- advertizing theme and brand personality
- advertizing quantity

Price competition is notably absent in the cigarette industry. The reason for this may be that companies are competing in a mainly oligopolistic industry. Due to their small number, companies recognize their interdependence, and tend to collude explicitly or implicitly on price. The cigarette industry therefore abstains from price competition entirely and restricts its sales effort to other kinds of pressure.

Taste would appear to be a very important factor, but all forces being favorable, a smoker will push through the 'taste change' barrier to suite his own requirements. For example, there is a vast difference in taste quality between the brands smoked by persons in their university-student days, and those they change to when they start their business careers. It's not quite done to offer the Chairman of the board a "Lucky Strike", so the man makes a violent taste change to "Benson and Hedges", to suit his purpose.

The advertizing theme and the personality usually attached to a particular brand are very important considerations. However, it would be very difficult to incorporate in this model the effect

that advertizing and brand personality have on the company's potential demand. For this reason, it is assumed that the three companies in the cigarette industry in Mozambique have equal brand launching capabilities and each has a range of brands to suit the personalities of a good cross-section of the smoking population.

Advertizing is the main competitive weapon by which oligopolists seek to increase their relative shares of the market. Even assuming that the three companies collude on price, it is not in their interest to suppress advertizing, for the same reason that a monopolist advertizes to increase sales.

The construction of a model for estimating the effect of advertizing on demand is made difficult by the lack of data that would allow the physical quantity of advertizing instead of the monetary expenditures on advertizing to be measured. The demand for cigarettes depends not so much on advertizing outlays as on the number of advertizing "messages" consumers receive. The company buys space in magazines and in newspapers or time on radio. Even supposing, however, that an estimate of the number of messages conveyed by these media could be made, there is no way of knowing how many of the audience of a given medium were exposed to the advertizement. In a study at the University of Chicago, Lester G. Telser (30) investigated various methods of estimating the effectiveness of advertizing on cigarette sales. In one particular method he hypothesized that advertizing outlays are a capital investment that depreciates and that requires maintenance. The rate of depreciation

of advertizing capital is deduced from estimates of the consumer repeat-purchase probability. That is, consumers display a certain amount of inertia in their buying behavior which implies a relation between current market share, lagged market share and relative advertizing expenditure. This allowed for estimation of repeat purchase probabilities for consumers taken in the aggregate. The same theory, makes it possible to estimate the propensity of consumers to transfer purchases from all other brands to a given brand, and gives a direct measure of the competition among brands. Telser obtained very encouraging results for these probabilities, which he estimated from data of sales and advertizing expenditures for the three major cigarette companies in America in the period before World War II. This research suggested a way for measuring the effectiveness of advertizing in the cigarette industry in Mozambique.

The company's sales come from three sources:

- sales to those who have not previously bought its product,
- sales to those who have previously purchased a competing brand, and,
- sales to those who are repeating their purchase

Let the probability of repeating the purchase of the company's brands be denoted by α and let the probability of sales being transfered to the company be denoted by β. Then the market share of the company at time t equals:

$$m_t = \alpha m_{t-1} + \beta(1 - m_{t-1}) \qquad (1)$$

Both α and β are conditional probabilities. They indicate, respectively, the probability of purchasing the company's product in period t conditional on having either purchased it in the preceding period or on having purchased some competing brand in that period. A logical supposition is that these probabilities are functions of the consumer's awareness of the company's product, which is here represented by the ratio of the company's advertizing outlay to the sum of the outlays of all the other companies in the industry.

$$\begin{aligned} \alpha_t &= f(r_t) \\ \beta_t &= g(r_t) \end{aligned} \qquad (2)$$

where,

r_t = relative advertizing expenditure (dimensionless)

Using available data on market share and relative advertizing outlays for the preceding five years, as shown in Table 4.1, a linear approximation to the parameters of f and g can be estimated.

Table 4.1: Market Share and Relative Advertizing Expenditures of Company from 1968 to 1973

Year	Market Share (m_t)	Relative Advertizing Expenditure (r_t)
1968	0.085	0.125
1969	0.144	0.123
1970	0.200	0.155
1971	0.224	0.257
1972	0.252	0.340
1973	0.297	0.378

The linear approximation to f and g is given by:

$$\alpha_t = a_o + a_1 r_t$$
$$\beta_t = b_o + b_1 r_t \qquad (3)$$

Substituting the linear approximations of f and g given by equations (3) into (1), we obtain:

$$m_t = b_o + (a_o - b_o)m_{t-1} + b_1 r_t + (a_1 + b_1)m_{t-1}r_t \qquad (4)$$

This implies that the current market share is a linear function of the lagged market share, relative advertizing expenditure, and the product of the two. Least squares estimates of the coefficients of equation (4) and the regression correlation coefficients are shown in Table 4.2.

Table 4.2: Estimates of Coefficients of Equation (4)

Coefficient	b_o	$a_o - b_o$	b_1	$a_1 + b_1$
Estimate	.109	.279	.163	.518
Correlation Coefficient	-	.978	.953	.967

From these results, equation (3) can be rewritten as:

$$\alpha_t = 0.39 + 0.36 r_t$$
$$\beta_t = 0.11 + 0.16 r_t \qquad (5)$$

The above theory and results will now be incorporated in the model. The flow diagram for the potential demand generation sector is shown in Figure 4.1.

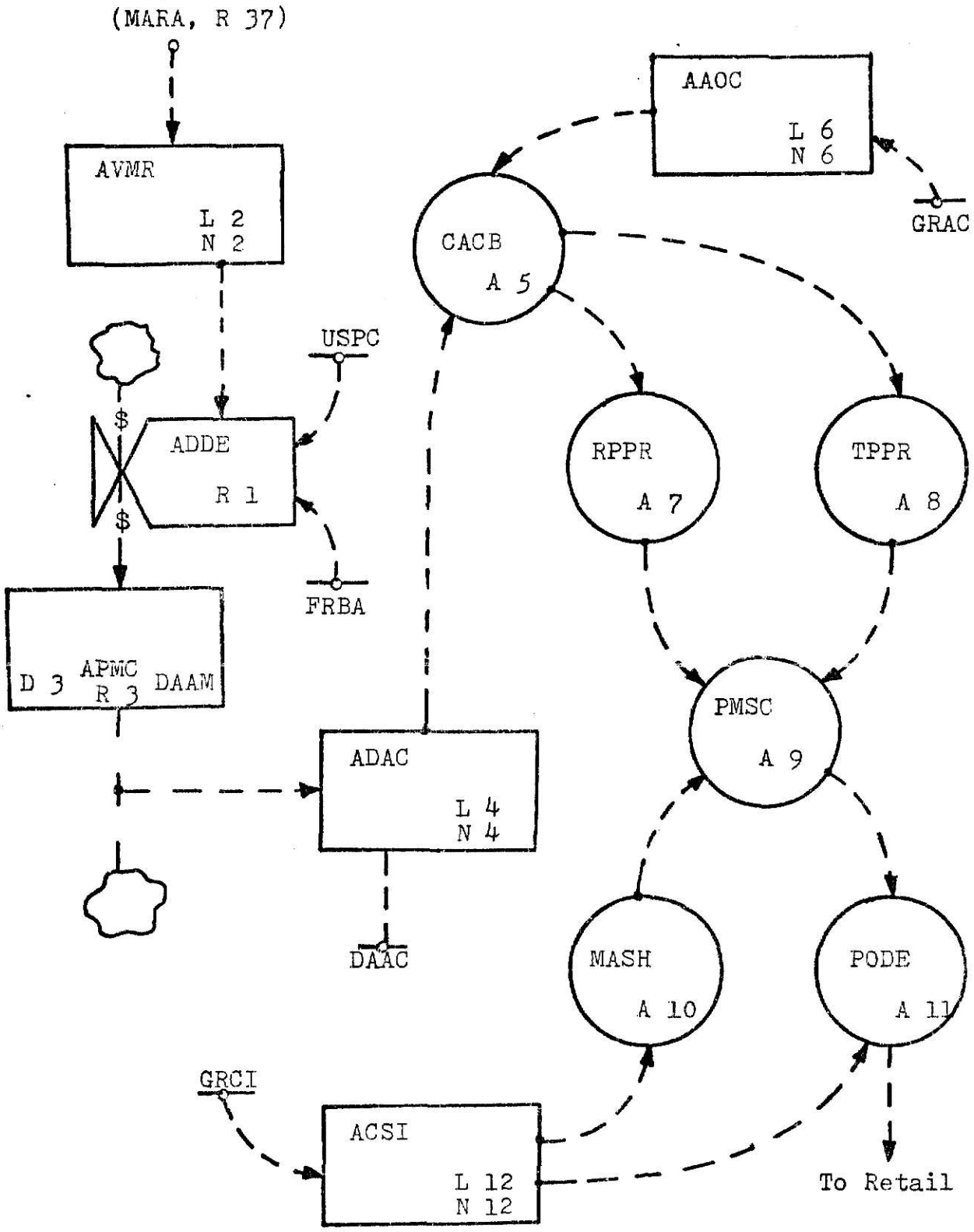


Figure 4.1: Potential Demand Generation Flow Diagram

The first consideration is management's policy for authorizing advertizing expenditure. The advertizing decision is dependent on the advertizing budget of the company, which is proportional to the anticipated gross sales, here taken to be equal to the manufacturing plans. The advertizing decision is therefore written as:

ADDE.KL = (FRBA)(USPC)(AVMR.K) R 1

ADDE ADvertizing DEcision taken at factory (escudos/month)
FRBA Fraction of Revenue Budgeted for Advertizing (dimensionless)
USPC Unit Selling Price of Cigarettes (escudos/cigarette)
AVMR AVerage Manufacturing Rate (cigarettes/month)

The smoothed manufacturing level is given by a first order exponential smoothing equation:

AVMR.K = AVMR.J + (DT)(MARA.JK - AVMR.J)/DAMR L 2
AVMR = MARA N 2

AVMR AVerage Manufacturing Rate (cigs/month)
MARA MAnufacturing RAte (cigs/month)
DAMR Delay in Averaging Manufacturing Rate (months)
DT Delta Time, the time increment (months)

Since a short-term average of recent production is needed, the value of the delay must be small:

DAMR = 1 month C 2

The flow of advertizing orders from the company is now put through a delay representing the time necessary for advertizing agencies and media to carry out their work. The resulting advertizing actually appearing before the public is given by:

APMC.KL = DELAY3(ADDE.JK,DAAM) R 3

APMC Advertizing Presented by Media to Consumer (esc./month)

ADDE ADvertizing DEcision (esc./month)

DAAM Delay at Advertizing Agencies and Media (months)

The average delay for the advertisement to reach the consumer is taken as:

DAAM = 0.25 month C 3

At this point, the question of the time response of the consumers to an advertizing campaign must be considered. The first issue of a series of newspaper advertisements does not create as much consumer awareness as a continued series of advertisements. There is therefore a gradual build-up of awareness, relatively rapidly at first and then leveling off as the saturation of awareness is approached (9). This is the general shape of a first order exponential equation shown in Figure 4.2. The slope of the curve is a maximum at the origin, indicating that the rate of awareness is largest initially and decreases gradually with the passage of time. In other words, the rate at which consumers respond to an advertisement decreases gradually to zero as the saturation level is reached.

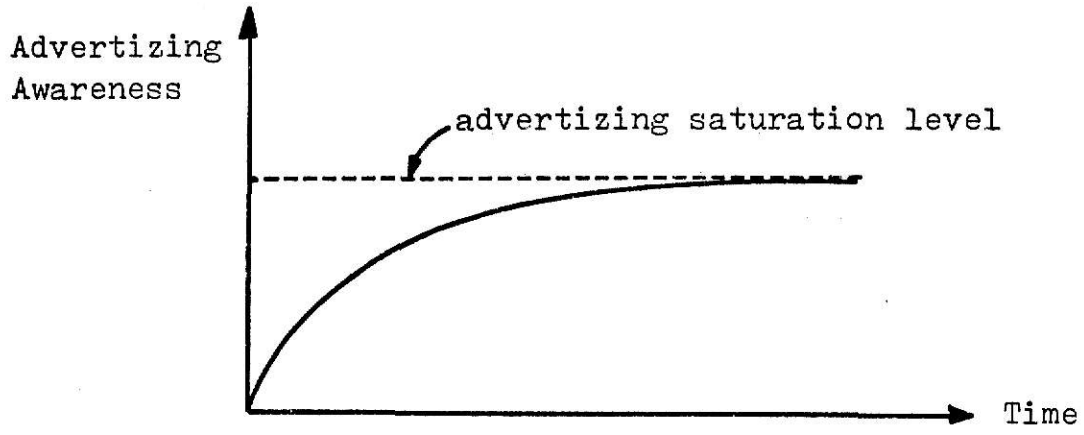


Figure 4.2: Response of Consumers to Advertizing

The response of consumer awareness to the advertizing rate is therefore written as:

ADAC.K = ADAC.J + (DT)(APMC.JK - ADAC.J)/DAAC L 4

ADAC = ADDE N 4

ADAC ADvertizing Awareness of Consumer (esc./month)

APMC Advertizing Presented by Media to Consumer (esc./month)

DAAC Delay in Advertizing Awareness of Consumer (months)

The average delay in the build-up of awareness of an advertizing campaign launched by the company is taken to be:

DAAC = 0.5 month C 4

As discussed earlier in the chapter, advertizing awareness is expressed in terms of monetary expenditures, since there is no other feasible measure of the amount of advertizing consumers are exposed to. The probability of a consumer purchasing the company's brands of cigarettes is dependent on his awareness of the existence

of its brands relative to competing brands. This awareness can be represented by the ratio of the level of advertizing awareness to the average advertizing outlay of the other companies in the cigarette industry.

$$CACB.K = \frac{ADAC.K}{AAOC.K} \qquad A\ 5$$

CACB Consumer Awareness of Company's Brands (dimensionless)

ADAC ADvertizing Awareness of Consumer (esc./month)

AAOC Average Advertizing Outlay of Competitors (esc./month)

The expression for the average advertizing expenditure of the competitors is derived from data shown in Table 4.3. A linear approximation is given by the following equation:

$$A = 13800000 + 709000t \qquad (6)$$

where,

A = Advertizing outlay of other companies (esc./year)

t = time period; zero corresponds to 1968 (years)

Table 4.3: Advertizing Expenditures of the Industry (in escudos)

Year	Industry	Company	Competitors
1968	16100000	1800000	14300000
1969	16300000	1800000	14500000
1970	17900000	2400000	15500000
1971	17600000	3600000	14000000
1972	23600000	6000000	17600000
1973	24400000	6700000	17700000

The regression correlation coefficient obtained was 0.796. The expression for the advertizing outlay of competitors is now written in the form of a level equation:

AAOC.K = AAOC.J + (DT)(GRAC) L 6

AAOC = IAOC N 6

AAOC Average Advertizing Outlay of Competitors (esc./month)

GRAC Growth Rate of Advertizing outlay of Competitors (esc./month/month)

IAOC Initial Advertizing Outlay of Competitors (esc./month)

The corresponding monthly growth rate of advertizing outlay is:

GRAC = 4920 esc./month/month C 6

From the theory derived previously, linear expressions for the repeat purchase and transfer purchase probabilities can now be written in the same form as equation (5):

RPPR.K = 0.39 + (0.36)(CACB.K) A 7

TPPR.K = 0.11 + (0.16)(CACB.K) A 8

RPPR Repeat Purchase PRobability (dimensionless)

TPPR Transfer Purchase PRobability (dimensionless)

CACB Consumer Awareness of Company's Brands (dimensionless)

As hypothesized earlier, potential market share can be calculated at every time period from the above purchasing probabilities and the lagged value of market share. The expression for potential market share is written in the same form as equation (1):

PMSC.K = (RPPR.K)(MASH.K) + (TPPR.K)(1 - MASH.K) A 9

PMSC = IMSH N 9

PMSC Potential Market Share of Company (dimensionless)

RPPR Repeat Purchase PRobability (dimensionless)

TPPR Transfer Purchase PRobability (dimensionless)

MASH MArket SHare (dimensionless)

IMSH Initial Market SHare (dimensionless)

The expression for the market share of the company is simply the sales rate divided by the average cigarette sales of the industry:

$$MASH.K = \frac{SARA.JK}{ACSI.K} \qquad A\ 10$$

MASH MArket SHare (dimensionless)

SARA SAles RAte (cigs/month)

ACSI Average Cigarette Sales of Industry (cigs/month)

The point has now been reached where the expression for potential demand can be formulated. The word 'potential' connotes the sales that would persist if the company's cigarettes were immediately available to the consumer, or put differently, if the stocks at all retail outlets were adequate. The potential demand for the company's brands is generated from the potential market share, and is written as:

PODE.K = (PMSC.K)(ACSI.K) A 11

PODE POtential DEmand (cigs/month)

PMSC Potential Market Share of the Company (dimensionless)

ACSI Average Cigarette Sales of Industry (cigs/month)

The average sales of the industry are extrapolated from data for the past six years as shown in Table 4.4.

Table 4.4: Average Annual Sales of the Cigarette Industry

Year	1968	1969	1970	1971	1972	1973
Sales (in millions of cigarettes)	623.8	858.6	1046.5	1091.8	997.5	1123.7

The linear expression obtained was:

$$I = 745500000 + 84600000t \qquad (7)$$

where,

I = Industry sales (cigarettes)

t = time period; zero corresponds to 1968 (years)

This is equivalent to an annual growth in sales of 11.5 %. The regression correlation coefficient was 0.843, which indicates an acceptable fit. The expression for the average sales of the industry is now written in the form of a level equation:

ACSI.K = ACSI.J + (DT)(GRCI) L 12

ACSI = ISCI N 12

ACSI Average Cigarette Sales of Industry (cigs/month)

GRCI Growth Rate of Cigarette Industry (cigs/month/month)

ISCI Initial Sales of Cigarette Industry (cigs/month)

The corresponding monthly growth rate is:

GRCI = 587500 cigs/month/month C 12

4.1.2 Retail Sales and Orders to the Company

Since potential demand has been established, the next step is to determine the sales rate and the order rate to the company. Figure 4.3 shows the flow diagram for this subsection.

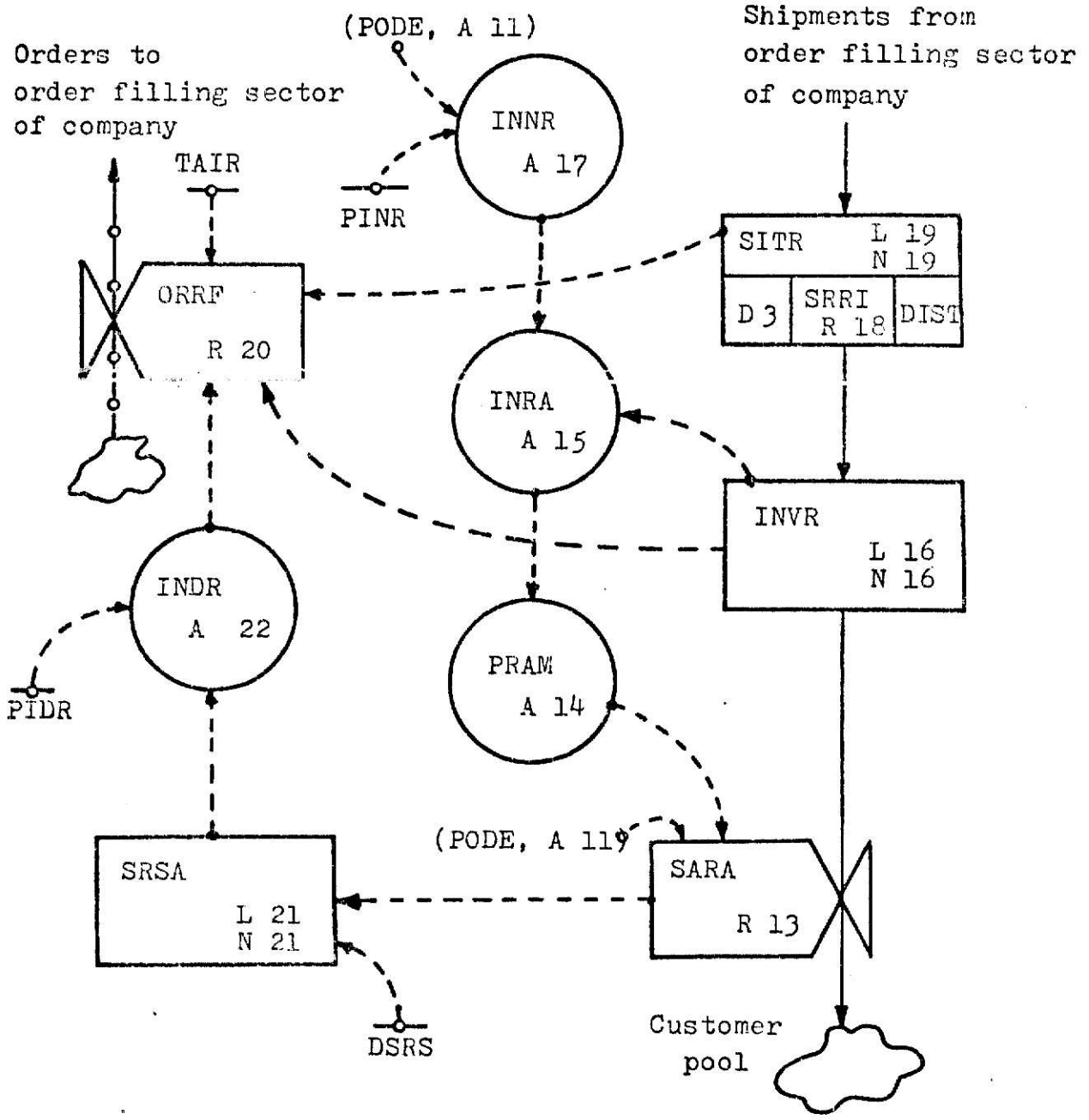


Figure 4.3: Retail Sales and Orders to the Company Flow Diagram

The amount of sales depends on the availability of the company's brands in the retailer inventories. The sales rate is therefore written as follows:

$$SARA.KL = (PODE.K)(PRAM.K) \qquad R\ 13$$

SARA SAles RAte (cigs/month)

PODE POtential DEmand (cigs/month)

PRAM PRoduct Availability Multiplier (dimensionless)

If the inventory levels at the retail outlets are greater or equal to the necessary inventory level then the sales rate would be equal to the potential demand since the company's cigarette brands are readily available. However, if the company cannot completely meet the retail orders, then retailer stocks will become depleted and this product unavailability will depress the sales rate. Figure 4.4 shows the general shape of the product availability curve.

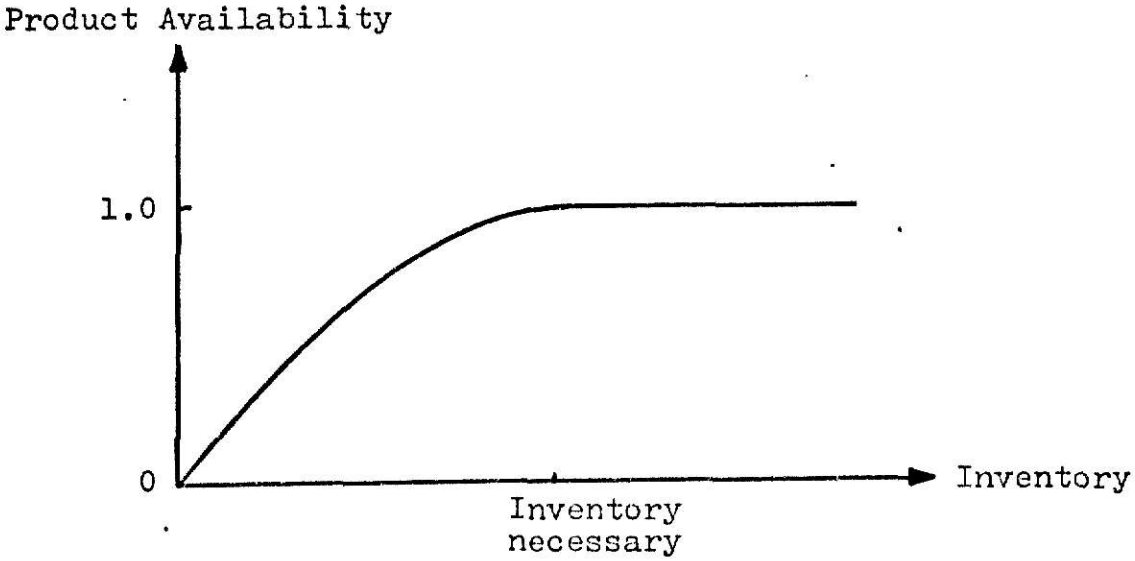


Figure 4.4: Product Availability Curve

This curve is not satisfactory, however, since the level of business is not taken into account. If the level of business is high, a higher amount of inventory is necessary to meet potential demand. Hence product availability is linked to both the level of inventory at the retail outlets and the necessary inventory level. The curve of product availability multiplier versus inventory ratio is shown in Figure 4.5.

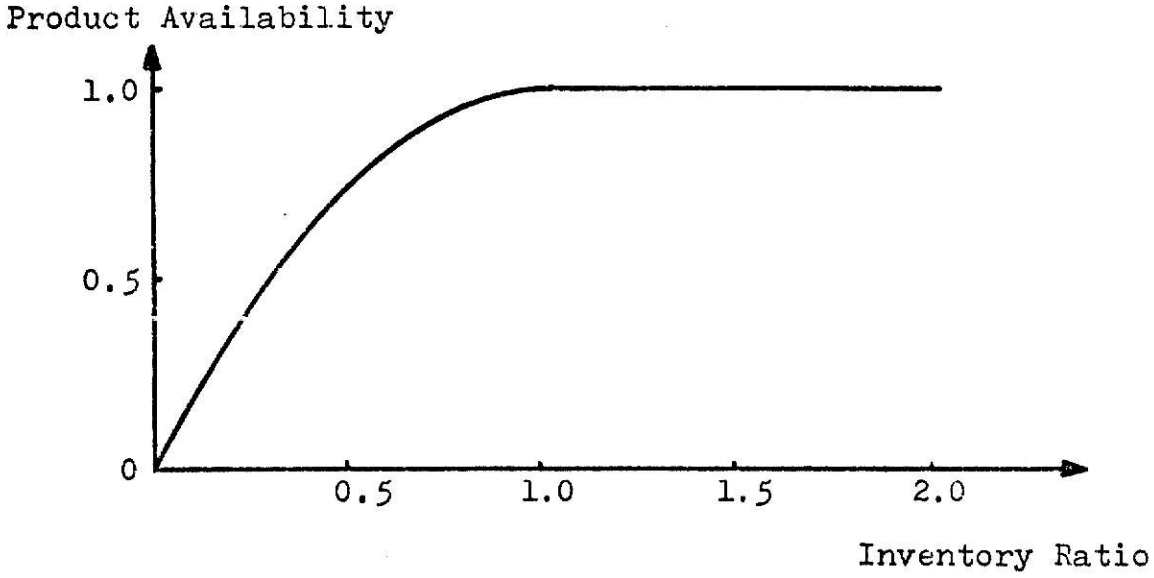


Figure 4.5: Product Availability Ratio versus Inventory Ratio

As the level of inventory at retail drops in relation to the necessary level, the ability to sell also drops and equals zero at zero inventory. It is likely that when the shortage first appears at a small number of retail outlets, the sales rate will not be affected greatly, since customers will probably seek and find their particular brands elsewhere. However, as the shortage becomes more

widespread, it will become increasingly more difficult for the customer to obtain his particular brand, thus forcing him to change brands. For this reason, the product availability curve has its maximum slope at zero inventory ratio.

If this relationship were needed with more precision, a functional relationship between product availability and inventory ratio could be generated by simulation of individual sales. Such a detailed simulation would be based on assumed or known probability distributions of customer arrivals, inventory reorder rules, and delays in obtaining new stock. Since, this type of information is not available, this relationship will be tested to determine the sensitivity of the model to reasonable changes in the shape of the general product availability curve. Figure 4.6 shows several possible curves that meet the requirements described above.

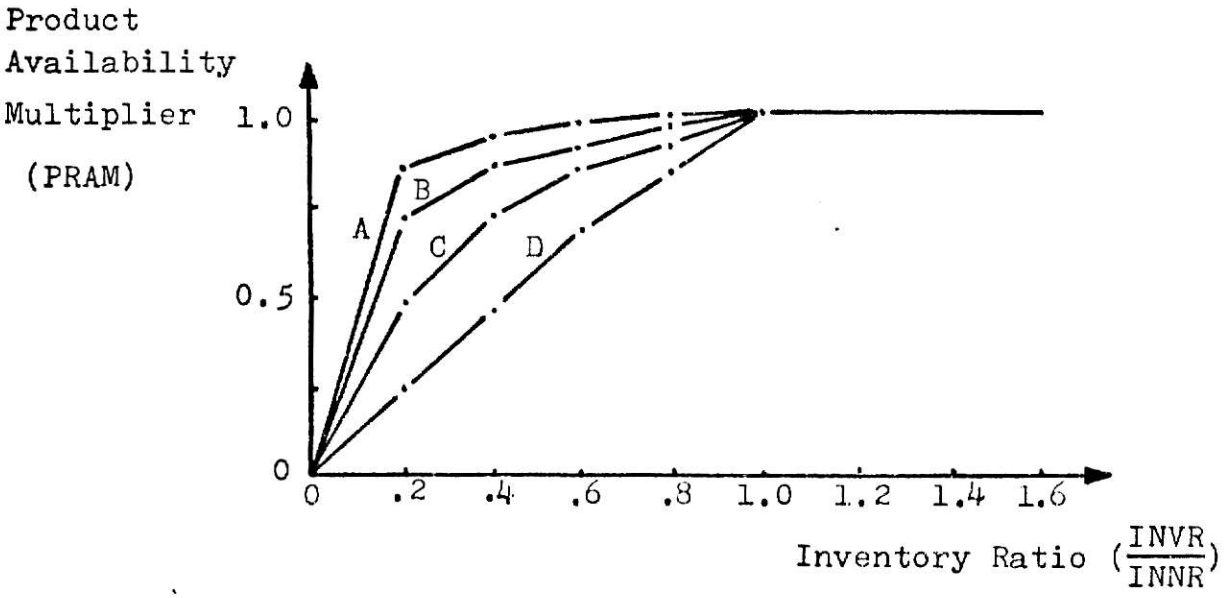


Figure 4.6: Possible Product Availability Curves

At this stage, the equation for the product availability multiplier refers simply to a table whose values will be determined from the results of the sensitivity test.

PRAM.K = TABHL(PRAT,INRA.K,0,1,0.2) A 14

PRAM PRoduct Availability Multiplier (dimensionless)

TABHL TABle, High, Low. A notation to express one variable as an arbitrary function of another variable. The values of the variable on the left side (here PRAM) are specified at regular intervals of the variable on the right side (here INRA). These interval values are stored in a table, named here PRAT. For values between the regular intervals DYNAMO interprets linearly. Outside the range of values specified for INRA, the higher and lower values of PRAM are used.

PRAT PRoduct Availability Table

INRA INventory RAtio (dimensionless)

0 first value of INRA (dimensionless)

1 last value of INRA (dimensionless)

0.2 interpolating interval (dimensionless)

The inventory ratio is written simply as:

$$INRA.K = \frac{INVR.K}{INNR.K} \qquad A\ 15$$

INRA INventory RAtio (dimensionless)

INVR INVentory at Retail (cigs)

INNR INventory Necessary at Retail (cigs)

The present level of inventory is represented by a level equation. Shipments from the company flow into retail inventories, which are in turn emptied by sales. The inventory level at retail is therefore given by:

INVR.K = INVR.J + (DT)(SRRI.JK - SARA.JK) L 16

INVR = INNR N 16

INVR INVentory at Retail (cigs)

SRRI Shipments Received at Retail Inventory (cigs/month)

SARA SAles RAte (cigs/month)

INNR INventory Necessary at Retail (cigs)

The necessary amount of inventory is linked to the potential demand. For high demand periods, inventory at retail outlets has to be relatively high to be able to maintain the availability of the product. The equation for the necessary level of inventory at retail is therefore written as:

INNR.K = (PINR)(PODE.K) A 17

INNR INventory Necessary at Retail (cigs)

PINR Period of time of Inventory Necessary at Retail (months)

PODE POtential DEmand (cigs/month)

The number of months of inventory necessary to supply the potential demand is:

PINR = 0.5 months C 17

The rate at which shipments arrive at the retail outlets is the delayed function of the factory shipping rate. The delay involved is the transportation delay. This delay is not constant; it is dependent on the distance between the factory and the various retail outlets. For a sudden batch of shipments from the factory, we should expect that the number arriving at the retailers is small at first, then increases to a maximum value, and finally falls off to zero, as seen in Figure 4.7.

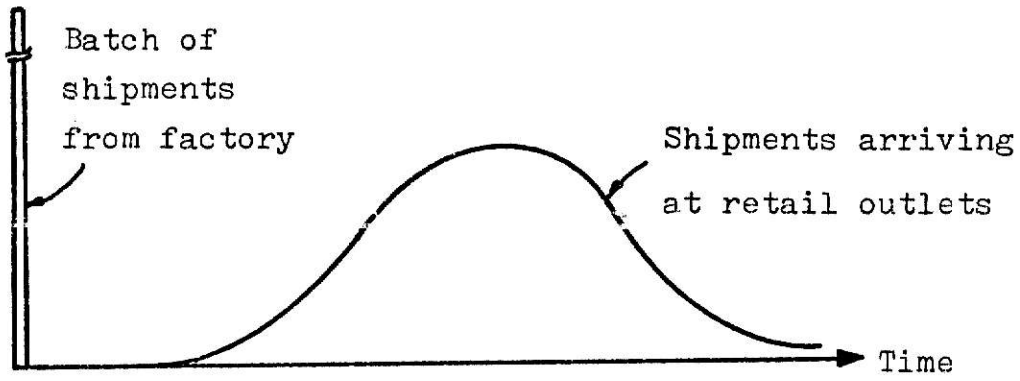


Figure 4.7: Arrival of Shipments at Retail Outlets in Response to a Batch of Shipments from the Factory

The rate of arrival of shipments is therefore formulated as a third order exponential delay (9, Chapter 9). The output response has the same general characteristics as Figure 4.7. The level of shipments in transit is then a regular level equation with the shipments sent from factory inventory flowing into it, and the shipments arriving at retail flowing out:

```
SRRI.KL = DELAY3(SSFI.JK,DIST)                    R 18
SITR.K = SITR.J + (DT)(SSFI.JK - SRRI.JK)         L 19
  SITR = ISIT                                     N 19
```

SRRI Shipments Received at Retail Inventory (cigs/month)

SSFI Shipments Sent from Factory Inventory (cigs/month)

DIST Delay In Shipment Transportation (months)

SITR Shipments In Transit to Retail (cigs)

ISIT Initial Shipments In Transit to retail (cigs)

DELAY3 functional notation to specify a third order delay

The order rate to the factory is dependent on a number of sources of information. First on the priority list is the replacement of cigarettes being sold. Beyond this, orders are necessary for the correction of differences between actual and ideal inventory. At the same time, shipments already on the way must be taken into account. The orders placed by the retailers are therefore written as:

ORRF.KL = SRSA.K + (INDR.K - INVR.K - SITR.K)/TAIR R 20

ORRF ORder Rate to Factory (cigs/month)

SRSA Smoothed Retail SAles (cigs/month)

INDR INventory Desired at Retail (cigs)

INVR INVentory at Retail (cigs)

SITR Shipments In Transit to Retail (cigs)

TAIR Time to Adjust Inventory at Retail (months)

The time constant TAIR represents the rate at which retailers, on the average, act on the inventory situation. They would not respond immediately to the full extent of any theoretical difference between desired and actual inventory. The time constant allows adjustment of this response time, and is taken to be:

TAIR = 0.5 months

Because the current sales rate will fluctuate from day to day and will not present a smooth flow of information, it is necessary to average the actual sales data to obtain a figure on which to base the inventory and order plans. A first order exponential smoothing equation is used to average the sales rate:

```
SRSA.K = SRSA.J + (DT)(SARA.JK - SRSA.J)/DSRS     L 21
  SRSA = PODE                                     N 21
```

SRSA Smoothed Retail SAles (cigs/month)
SARA SAles RAte (cigs/month)
DSRS Delay in Smoothing Retail Sales (months)
PODE POtential DEmand (cigs/month)

The time constant DSRS gives the monthly correction fraction of the difference between the sales rate during the last time interval and the previous average sales:

```
DSRS = 1 month                                    C 21
```

The desired amount of inventory is linked to the average level of business, since when this is high inventory has to be high enough to be able to meet the increased demand. The desired level of inventory at retail is therefore written as:

```
INDR.K = (PIDR)(SRSA.K)                           A 22
```

INDR INventory Desired at Retail (cigs)
PIDR Period of time of Inventory Desired at Retail (months)
SRSA Smoothed Retail SAles (cigs/month)

The time constant PIDR represents the number of months that the desired inventory could supply the average sales rate. Divided into twelve months, it would give the annual inventory turnover rate.

PIDR = 1 month C 22

This concludes the set of equations that describes the market subsystem. The equations are not self-contained, since they depend on the values of certain variables (factory shipping rate, SSFI, and manufacturing rate, MARA) that exist in the company subsystem.

4.2 The Company

The company sector in the model contains four major subsections:

- order filling
- manufacturing
- production capacity acquisition
- personnel requirement

4.2.1 Order Filling

The company attempts to maintain a sufficient inventory to deliver within a minimum time. Figure 4.8 shows the flow diagram for the order filling operation.

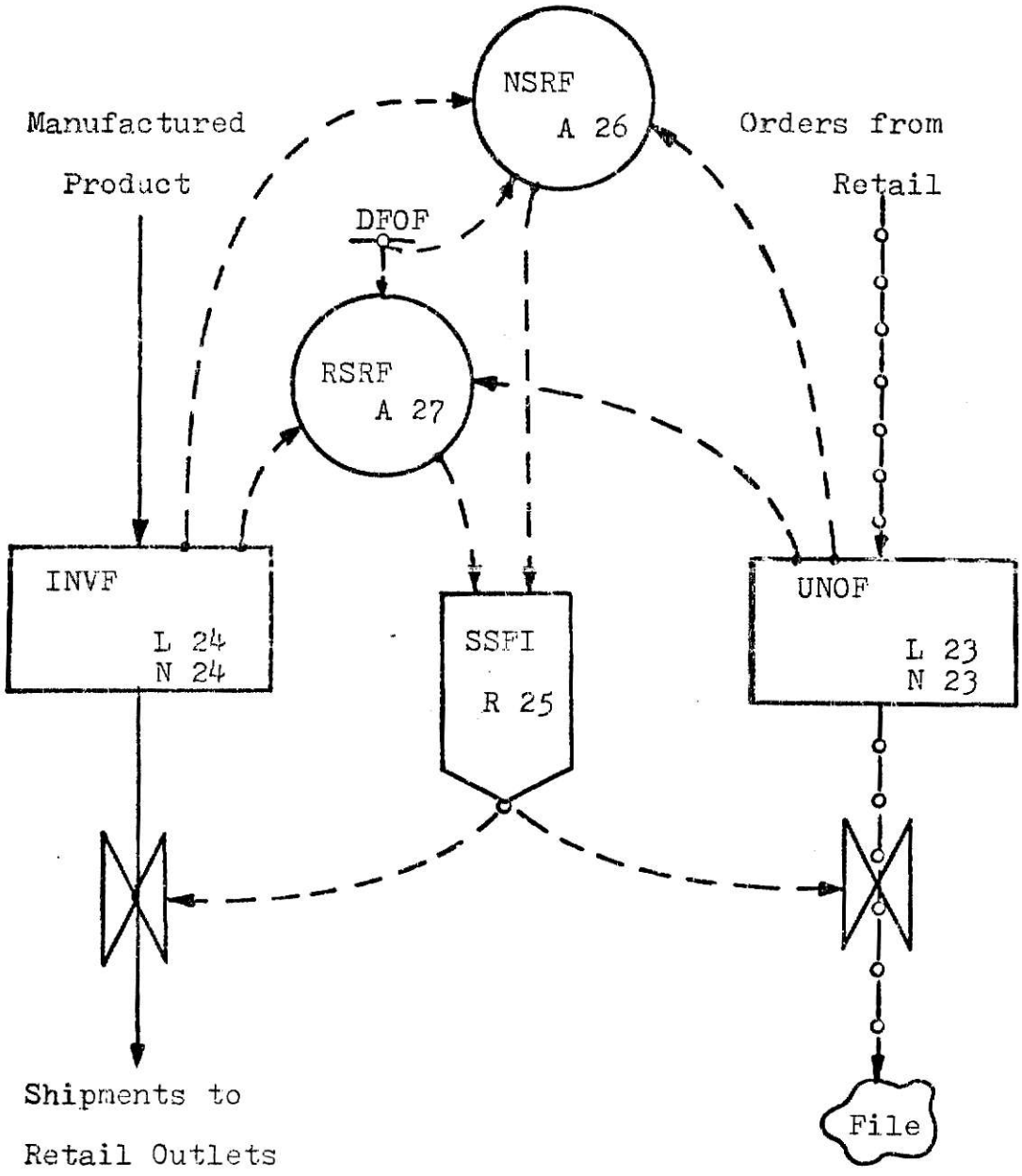


Figure 4.8: Order Filling Flow Diagram

Orders to the company flow into a pool that is emptied by the filling of orders as they are shipped. This pool of unfilled orders can be described by a regular level equation with orders placed flowing in and orders shipped flowing out:

```
UNOF.K = UNOF.J + (DT)(ORRF.JK - SSFI.JK)        L 23
  UNOF = UODF                                    N 23
```

UNOF UNfilled Orders at Factory (cigs)

ORRF ORder Rate to Factory (cigs/month)

SSFI Shipments Sent from Factory Inventory (cigs/month)

UODF Unfilled Orders Desired at Factory (cigs)

Similarly, the present level of inventory equals the previous level plus the change in inventory. Assuming that production always flows into inventory before it is shipped, the change equals finished products received at inventory per unit time minus the shipping rate from the factory:

```
INVF.K = INVF.J + (DT)(PRFI.JK - SSFI.JK)        L 24
  INVF = INDF                                    N 24
```

INVF INVentory at Factory (cigs)

PRFI Products Received at Factory Inventory (cigs/month)

SSFI Shipments Sent from Factory Inventory (cigs/month)

The rate of shipments to the market depends on the existence of an unfilled order pool. If there are no unfilled orders, the shipping rate would be zero. Furthermore, since the rate at which

orders are shipped depends on the delay in filling orders, the expression for the shipping rate is written as follows:

$$SSFI.KL = \frac{UNOF.K}{DFOF}$$

SSFI Shipments Sent from Factory Inventory (cigs/month)

UNOF UNfilled Orders at Factory (cigs)

DFOF Delay in Filling Orders at Factory (months)

The shipping rate, however, depends not only on the number of unfilled orders, but also on the amount of inventory on hand. The decision function is therefore formulated as follows:

$$SSFI.KL = \begin{cases} \frac{UNOF.K}{DFOF} & UNOF.K \leq INVF.K \\ \frac{INVF.K}{DFOF} & UNOF.K > INVF.K \end{cases}$$

This formulation prevents negative inventories by restricting shipping rate to an amount that does not deplete inventory within a given time. For the sake of more conformity with DYNAMO notation, the above equation is rewritten as:

$$SSFI.KL = \begin{cases} NSRF.K & UNOF.K \leq INVF.K \\ RSRF.K & UNOF.K > INVF.K \end{cases} \qquad R\ 25$$

where,

$$NSRF.K = \frac{UNOF.K}{DFOF} \qquad A\ 26$$

and,

$$RSRF.K = \frac{INVF.K}{DFOF} \qquad A\ 27$$

NSRF Normal Shipping Rate from Factory (cigs/month)

RSRF Restricted Shipping Rate from Factory (cigs/month)

INVF INVentory at Factory (cigs)

The delay in filling orders at the factory is a constant value, since orders can be filled as long as there is any inventory on hand:

DFOF = 0.1 month C 26

4.2.2 Manufacturing

There are two considerations that enter into the manufacturing rate decision of the company:

- The desired manufacturing rate, which is based upon the order rate, order backlog and inventory positions.
- The actual production capability of the factory, which is a function of the number of shifts and the maximum allowable overtime.

The flow diagram for the manufacturing decision process is shown in Figure 4.9.

The first formulation is the manufacturing rate desired by management. The main factor considered is the desire to produce to meet demand. To prevent fluctuations in the manufacturing rate due to daily variations in the order rate, the smoothed order rate is used as a basis for the desired manufacturing rate. Also the manufacturing rate should gradually adjust inventory and unfilled order backlog to the desired levels:

MRDF.K = SORF.K + (UNOF.K - UODF.K + INDF.K - INVF.K)/TAIB A 28

MRDF Manufacturing Rate Desired at Factory (cigs/month)

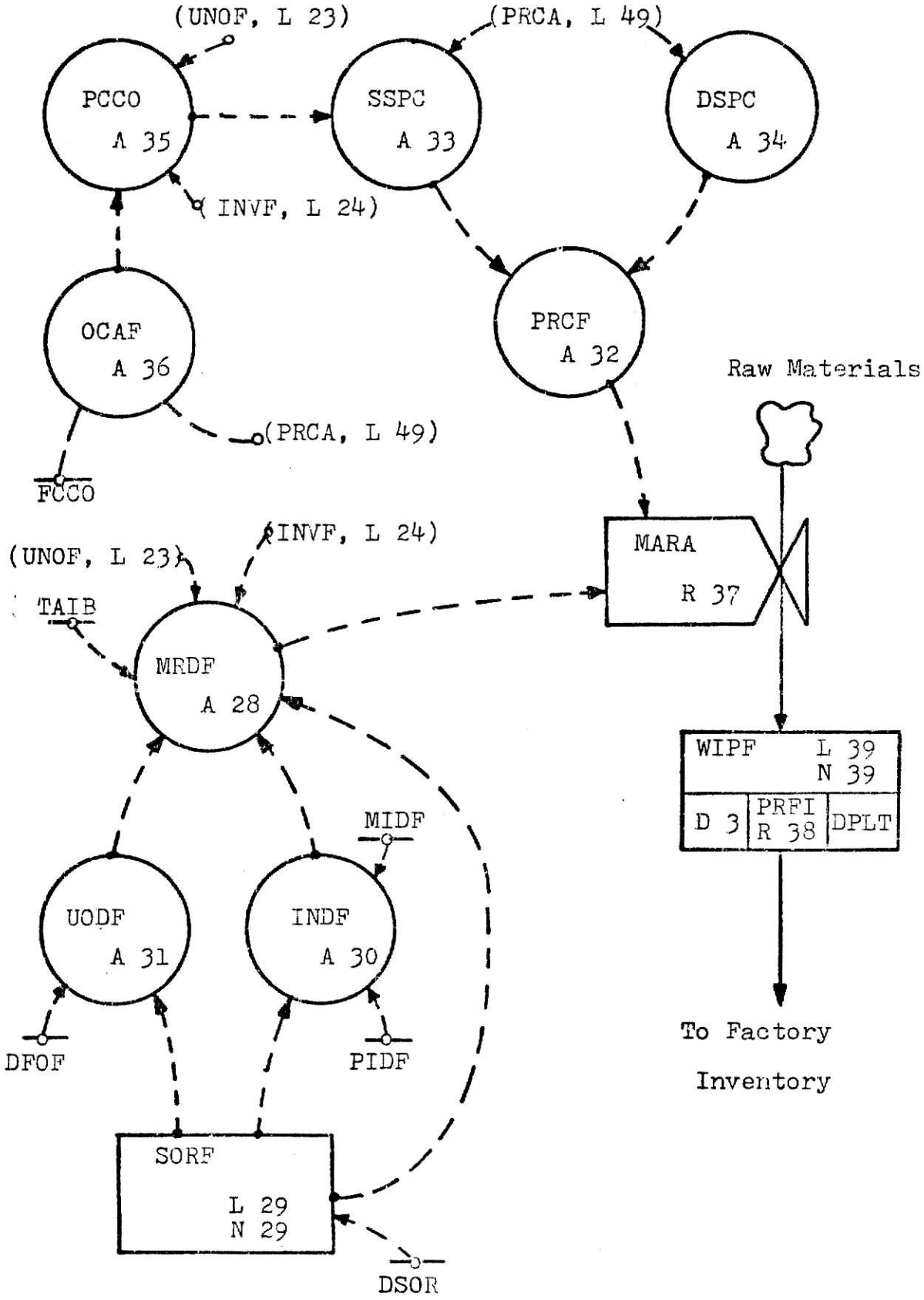


Figure 4.9: Manufacturing Decision Flow Diagram

SORF Smoothed Order Rate at Factory (cigs/month)

UNOF UNfilled Orders at Factory (cigs)

UODF Unfilled Orders Desired at Factory (cigs)

INDF INventory Desired at Factory (cigs)

INVF INVentory at Factory (cigs)

TAIB Time to Adjust Inventory and Backlog (months)

The time constant TAIB represents the rate at which management acts on the inventory and backlog situations. The adjustment time is taken as:

TAIB = 3 months C 28

The smoothed order rate is given by a first order exponential smoothing equation:

SORF.K = SORF.J + (DT)(ORRF.JK - SORF.J)/DSOR L 29

SORF = ORRF N 29

SORF Smoothed Order Rate at Factory (cigs/month)

ORRF ORder Rate to Factory (cigs/month)

DSOR Delay in Smoothing Order Rate (months)

The time constant DSOR represents the monthly correction fraction of the difference between the order rate during the last time interval and the previous average rate:

DSOR = 1 month C 29

The desired amount of inventory is linked to the level of business, since when this is high, the inventory has to be adequate to meet the increased order rate. A minimum inventory

level is included to take care of unorthodox demands. The equation for the desired inventory is therefore written as:

INDF.K = MIDF + (PIDF)(SORF.K) A 30

INDF INventory Desired at Factory (cigs)

MIDF Minimum Inventory Desired at Factory (cigs)

PIDF Period of time of Inventory Desired at Factory (months)

SORF Smoothed Order Rate at Factory (cigs/month)

The time constant PIDF represents the number of months that the desired inventory could supply the average order rate. The values for the constants of the above equation are as follows:

MIDF = 1000000 cigs C 30a

PIDF = 1.5 months C 30b

Similarly, the level of unfilled orders is also linked to the level of business. This is again represented by the average order rate at the factory. The equation for the desired level of unfilled orders is therefore written as:

UODF.K = (DFOF)(SORF.K) A 31

UODF Unfilled Orders Desired at Factory (cigs)

DFOF Delay in Filling Orders at Factory (months)

SORF Smoothed Order Rate at Factory (cigs/month)

The actual manufacturing rate is equal to the desired manufacturing rate only if the existing factory capability is not exceeded.

The production capability of the factory is a function of the number of shifts and the maximum overtime allowable. At present, the factory is rapidly approaching its capacity limit. This is due mainly to space restrictions. For this reason, once further expansion becomes unfeasible, production will be converted into a double shift operation. Both these situations are incorporated in the equation for production capability. In the case of a single shift, factory capability is equal to the sum of normal production capacity and production due to overtime. For double shift, it is simply double the normal production capacity of the factory. The expression for production capability is therefore written as:

$$PRCF.K = \begin{cases} SSPC.K & PRCA.K \leq PRCL \\ DSPC.K & PRCA.K > PRCL \end{cases} \qquad A\ 32$$

PRCF PRoduction Capability of Factory (cigs/month)

SSPC Single Shift Production Capability (cigs/month)

DSPC Double Shift Production Capability (cigs/month)

PRCA PRoduction CApacity (cigs/month)

PRCL PRoduction Capacity Limit (cigs/month)

where,

$$SSPC.K = PRCA.K + PCCO.K \qquad A\ 33$$

and,

$$DSPC.K = 2*PRCA.K \qquad A\ 34$$

PCCO Production Capacity Contributed by Overtime (cigs/month)

The production capacity limit of the factory is:

PRCL = 40000000 cigs/month C 32

Overtime is only scheduled when the inventory level at the factory reaches the point where normal shipping rate is not possible; that is, when inventory on hand is less than the order backlog. The equation that describes the overtime requirement decision is therefore:

$$PCCO.K = \begin{cases} 0 & UNOF.K \leq INVF.K \\ OCAF.K & UNOF.K > INVF.K \end{cases} \qquad A\ 35$$

PCCO Production Capacity Contributed by Overtime (cigs/month)

UNOF UNfilled Orders at Factory (cigs)

INVF INVentory at Factory (cigs)

OCAF Overtime Contribution Allowed at Factory (cigs/month)

The overtime contribution allowed is represented as a fraction of the normal production capacity at the factory:

OCAF.K = (FCCO)(PRCA.K) A 36

OCAF Overtime Contribution Allowed at Factory (cigs/month)

FCCO Fraction of Capacity Contributed by Overtime (dimensionless)

PRCA PRoduction CApacity (cigs/month)

The fraction of production hours allowed for overtime is:

FCCO = 0.4 C 36

The point has now been reached where the expression for the manufacturing decision can be formulated. The manufacturing rate is limited by the production capability of the factory. Consequently, the manufacturing rate will equal the desired level only during periods of overcapacity. The equation for the manufacturing rate is therefore written as:

$$MARA.KL = \begin{cases} MRDF.K & MRDF.K \leq PRCF.K \\ PRCF.K & MRDF.K > PRCF.K \end{cases} \qquad R\ 37$$

$$MARA = ORRF \qquad N\ 37$$

MARA MAnufacturing RAte (cigs/month)

MRDF Manufacturing Rate Desired at Factory (cigs/month)

PRCF PRoduction Capability of Factory (cigs/month)

ORRF ORder Rate to Factory (cigs/month)

Manufactured output is a delayed function of the manufacturing rate decision. A step input can represent management's plans for an increase in the manufacturing rate. As shown in Figure 4.10,

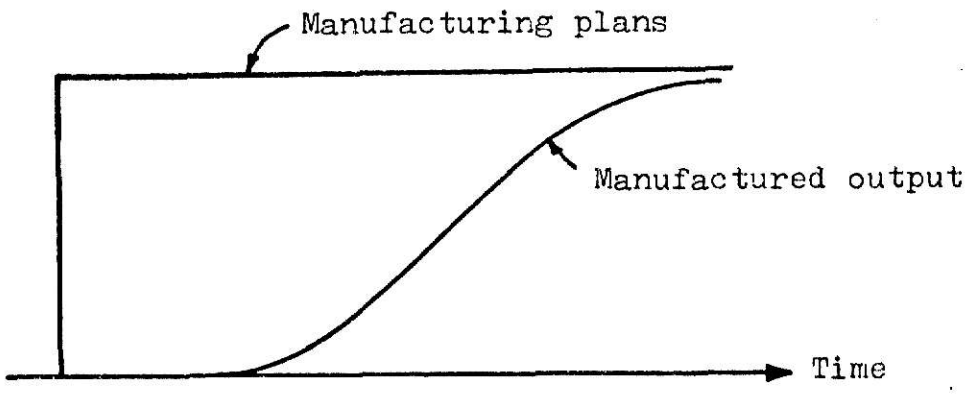


Figure 4.10: Manufactured Output in Response to an Increase in the Manufacturing Plans

there will be no manufactured output initially, due to the delay for production planning and related activities. Thereafter, output will rise gradually until the increase is met.

The rate of arrival of finished products at the factory inventory is formulated as a third order exponential delay of the manufacturing rate decision. The output response has the same general characteristics as Figure 4.10. The expression for the products received at the factory inventory is therefore given by:

PRFI.KL = DELAY3(MARA.JK,DPLT) R 38

PRFI Products Received at Factory Inventory (cigs/month)
MARA MAnufacturing RAte (cigs/month)
DPLT Delay in Production Lead Time (months)
DELAY3 functional notation representing third order delay

The delay, which represents the production lead time is:

DPLT = 0.1 month C 38

The work-in-progress is then a regular level equation with the manufacturing orders flowing in, and the products arriving at the factory inventory flowing out:

WIPF.K = WIPF.J + (DT)(MARA.JK - PRFI.JK) L 39
WIPF = IWPF N 39

WIPF Work-In-Progress at Factory (cigs)
MARA MAnufacturing RAte (cigs/month)
PRFI Products Received at Factory Inventory (cigs/month)
IWPF Initial Work-in-Progress at Factory (cigs/month)

4.2.3 Production Capacity Acquisition

The essential factors involved in the production capacity acquisition policy are:

- the desired production capacity level, which is based on an estimate of the future order rate to the factory,
- the production capacity ordering decision, which involves a comparison of the desired level of capacity and the actual level.

Figure 4.11 shows the flow diagram for the production capacity acquisition decision.

The first formulation is that of the desired production level which takes into account the capacity needed in the future. This is done by including into the desired capacity expression both the present smoothed order rate and the expected change in the order rate:

PCDF.K = SORF.K + ECOR.K A 40

PCDF Production Capacity Desired at Factory (cigs/month)
SORF Smoothed Order Rate at Factory (cigs/month)
ECOR Expected Change in Order Rate (cigs/month)

A study of the past trends of cigarette sales of the company showed that a linear extrapolation of historical data is justified, and can therefore be used to determine the expected change in the order rate.

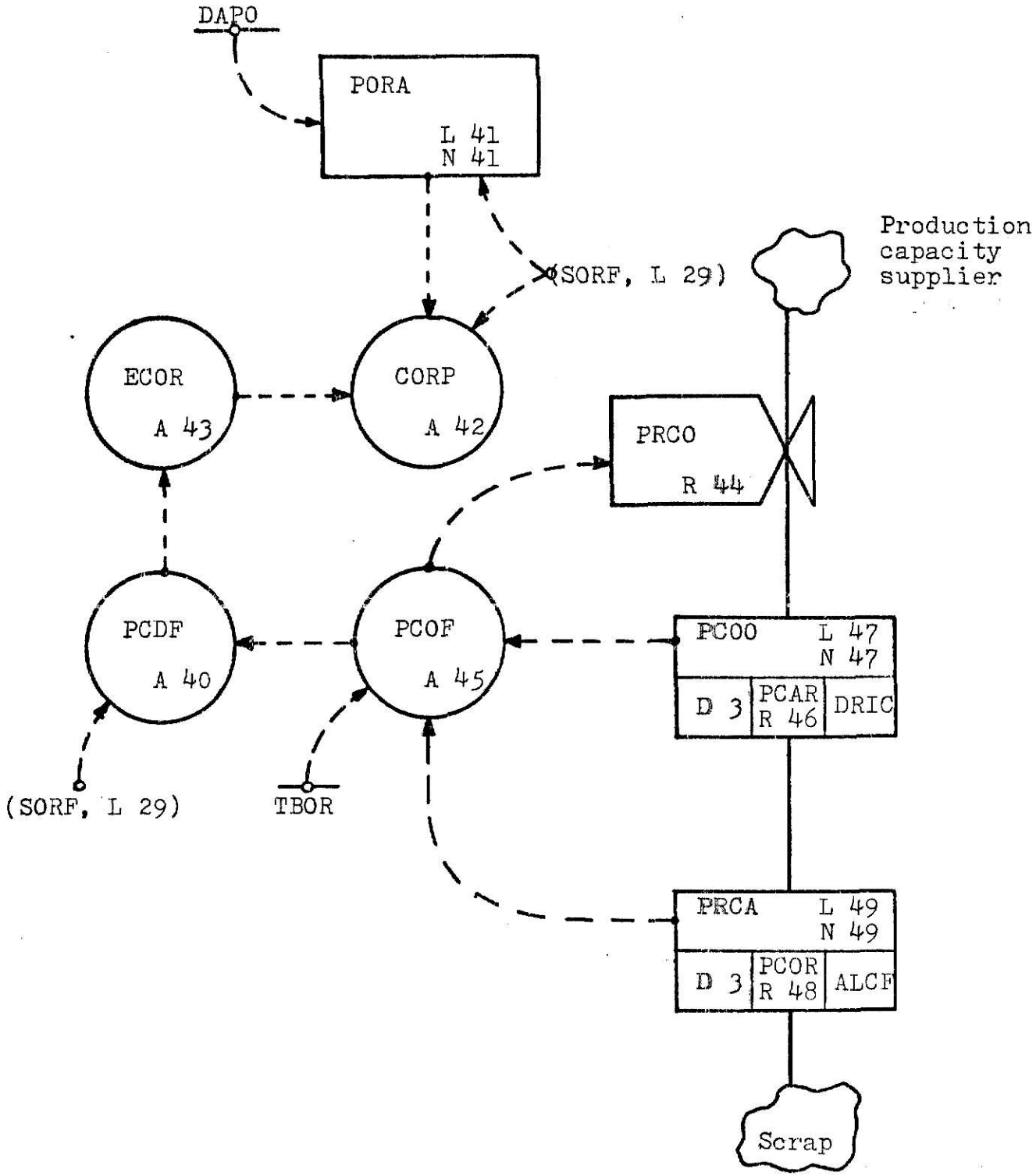


Figure 4.11: Production Capacity Acquisition Flow Diagram

Figure 4.12 shows the forecasting procedure used in this model.

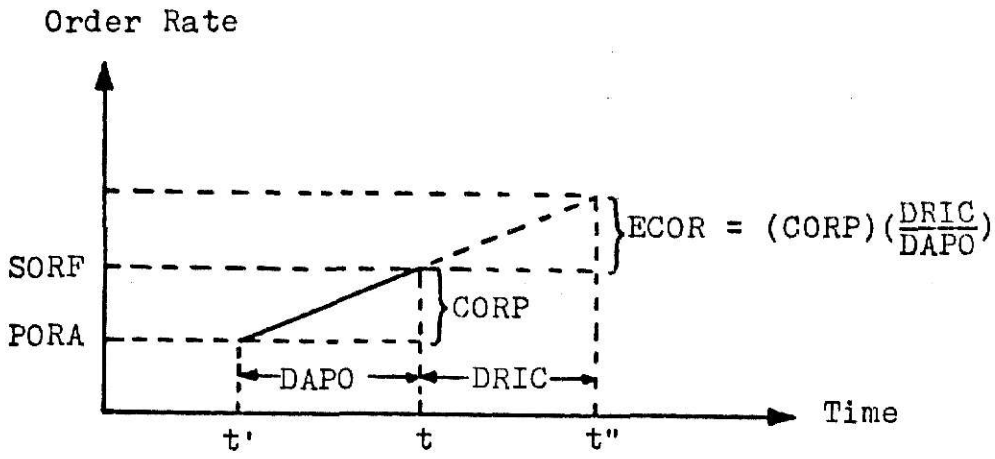


Figure 4.12: Forecasting Procedure in the Model

Since the company knows the past order rate, it can therefore readily calculate the expected change in time by a simple extrapolation of the order rate. Unfortunately, DYNAMO II does not have the facility of storing past values, and cannot therefore forecast from past trends. For extrapolation a recent and at least one past point of the order rate curve must be known. The most recent point is derived from the average order rate, and a past point is found by delaying this point further into the past. This technique by-passes the forecasting difficulty of DYNAMO. A first order exponential delay is therefore used to determine the past point:

```
PORA.K = PORA.J + (DT)(SORF.J - PORA.J)/DAPO      L 41
  PORA = SORF                                     N 41

  PORA   Past Order RAte (cigs/month)
  SORF   Smoothed Order Rate at Factory (cigs/month)
  DAPO   Delay in Averaging Past Orders (months)
```

The delay in averaging past orders is taken as:

DAPO = 12 months C 41

The above extrapolating technique requires further clarification. Let the time varying order rate be represented by the following relationship:

$$O = a + bt \tag{8}$$

where,

O = Order rate (cigs/month)

t = time (months)

Since we have assumed that a linear relationship is justified, the rate of change of the order rate is constant for all t. In other words,

$$\text{slope} = \frac{dO}{dt}_{t'} = \frac{dO}{dt}_{t} = \frac{dO}{dt}_{t''} = b \tag{9}$$

Refering to Figure 4.12, the slope b can be rewritten as:

$$b = \frac{SORF - PORA}{DAPO} \tag{10}$$

therefore,

$$\frac{dO}{dt}_{t'} = \frac{D(PORA)}{DT} = \frac{SORF - PORA}{DAPO} \tag{11}$$

which is equivalent to the DYNAMO equation L 41.

The past change in the order rate is now written as:

CORP.K = SORF.K - PORA.K A 42

CORP Change in Order Rate in the Past (cigs/month)

SORF Smoothed Order Rate at Factory (cigs/month)

PORA Past Order RAte (cigs/month)

The expected change in the order rate is obtained by simple geometry. This is written as:

$$ECOR.K = (CORP.K)\left(\frac{DRIC}{DAPO}\right) \qquad A\ 43$$

ECOR Expected Change in Order Rate (cigs/month)

CORP Change in Order Rate in the Past (cigs/month)

DRIC Delay in Receiving and Installing Capacity (months)

DAPO Delay in Averaging Past Orders (months)

The forecast time is equal to the delay in receiving capacity:

DRIC = 6 months C 43

The production capacity ordering policy consists of comparing present production capacity with that desired. The production capacity orders, therefore, equal the need for additional capacity divided by the amount of time between orders.

$$PRCO.KL = \begin{cases} 0 & PCOF.K \leq 0 \\ PCOF.K & PCOF.K > 0 \end{cases} \qquad R\ 44$$

where,

$$PCOF.K = \frac{PCDF.K - PRCA.K - PCOO.K}{TBOR} \qquad A\ 45$$

PRCO PRoduction Capacity Order rate (cigs/month/month)

PCOF Production Capacity Orders at Factory (cigs/month/month)

PCDF Production Capacity Desired at Factory (cigs/month)

PRCA PRoduction CApacity (cigs/month)

PCOO Production Capacity On Order (cigs/month)

TBOR Time Between ORders (months)

The amount of time between orders is:

The next task is to formulate the linkage between production capacity orders and the actual production capacity. The delay in receiving and installing production capacity involves mainly the suppliers delivery delay. For a sudden batch of orders, new capacity will be installed slowly at first, then increase to a maximum value and finally fall gradually to zero as seen in Figure 4.13.

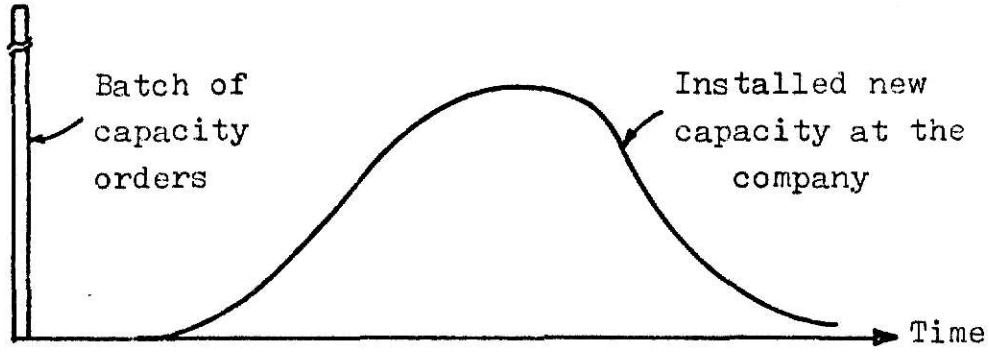


Figure 4.13: Installment of Capacity in Response to Capacity Orders

The rate of additions to production capacity is therefore formulated as a third-order exponential delay of the production capacity order rate, since the output response has the same general characteristics as Figure 4.13. The level of production capacity on order is then a regular level equation with the new capacity orders flowing into it and the additions of capacity flowing out:

```
PCAR.KL = DELAY3(PRCO.JK,DRIC)                    R 46

PCOO.K = PCOO.J + (DT)(PRCO.JK - PCAR.JK)         L 47
  PCOO = IPCO                                     N 47
```

PCAR Production Capacity Addition Rate (cigs/month/month)

PRCO PRoduction Capacity Order rate (cigs/month/month)

DRIC Delay in Receiving and Installing Capacity (months)

DELAY3 functional notation specifying a third-order DELAY

PCOO Production Capacity On Order (cigs/month)

IPCO Initial Production Capacity on Order (cigs/month)

Similarly, the rate at which procuction capacity becomes obsolete can be represented by a third-order exponential delay. Capacity will become obsolete slowly at first, then increase to a maximum in the vicinity of the average lifetime of equipment, and finally gradually decrease to zero.

PCOR.KL = DELAY3(PCAR.JK,ALCF) R 48

PCOR Production Capacity Obsolescence Rate (cigs/month/month)

PCAR Production Capacity Addition Rate (cigs/month/month)

ALCF Average Lifetime of Capacity at Factory (months)

DELAY3 function notation specifying third-order DELAY

The delay time depicts the average life of new capacity:

ALCF = 180 months C 48

The level of production capacity can now be formulated as a regular level equation with the inflow equal to the addition rate and the outflow equal to the obsolescence rate:

PRCA.K = PRCA.J + (DT)(PCAR.JK - PCOR.JK) L 49

PRCA = IPCA N 49

PRCA PRoduction CApacity (cigs/month)

PCAR Production Capacity Addition Rate (cigs/month/month)

PCOR Production Capacity Obsolescence Rate (cigs/month/month)

IPCA Initial Production CApacity (cigs/month)

4.2.4 Personnel Requirement

The supply of manpower and the policies governing changes in the work force do not appear to control other active decisions within the manufacturing operation. Nevertheless, the equations for the hiring and dismissal decisions of both technical and professional employees are included in this model so that they can generate figures for wages and salaries. The reason technical and professional employees are not treated in aggregate is because there is a considerable difference in both wages and productivity of these two groups in the company.

The personnel requirement formulations assume a large enough work force, so that the addition or loss of one employee does not affect the cost to the company to any considerable extent. This allows for the flow of people to be continuous. The flow diagram of personnel is shown in Figure 4.14.

The desired level of personnel is obviously dependent on the level of business. In the case of technical personnel, this is represented by the smoothed order rate if production capacity is not being fully utilized, and by the production capacity level if the factory has to resort to overtime production. Therefore, the desired level of technical personnel is written as:

$$TPDF.K = \begin{cases} TPDU.K & SORF.K \leq PRCA.K \\ TPDO.K & SORF.K > PRCA.K \end{cases} \qquad A\ 50$$

where,

$$TPDU.K = \frac{SORF.K}{PTPF} \qquad A\ 51$$

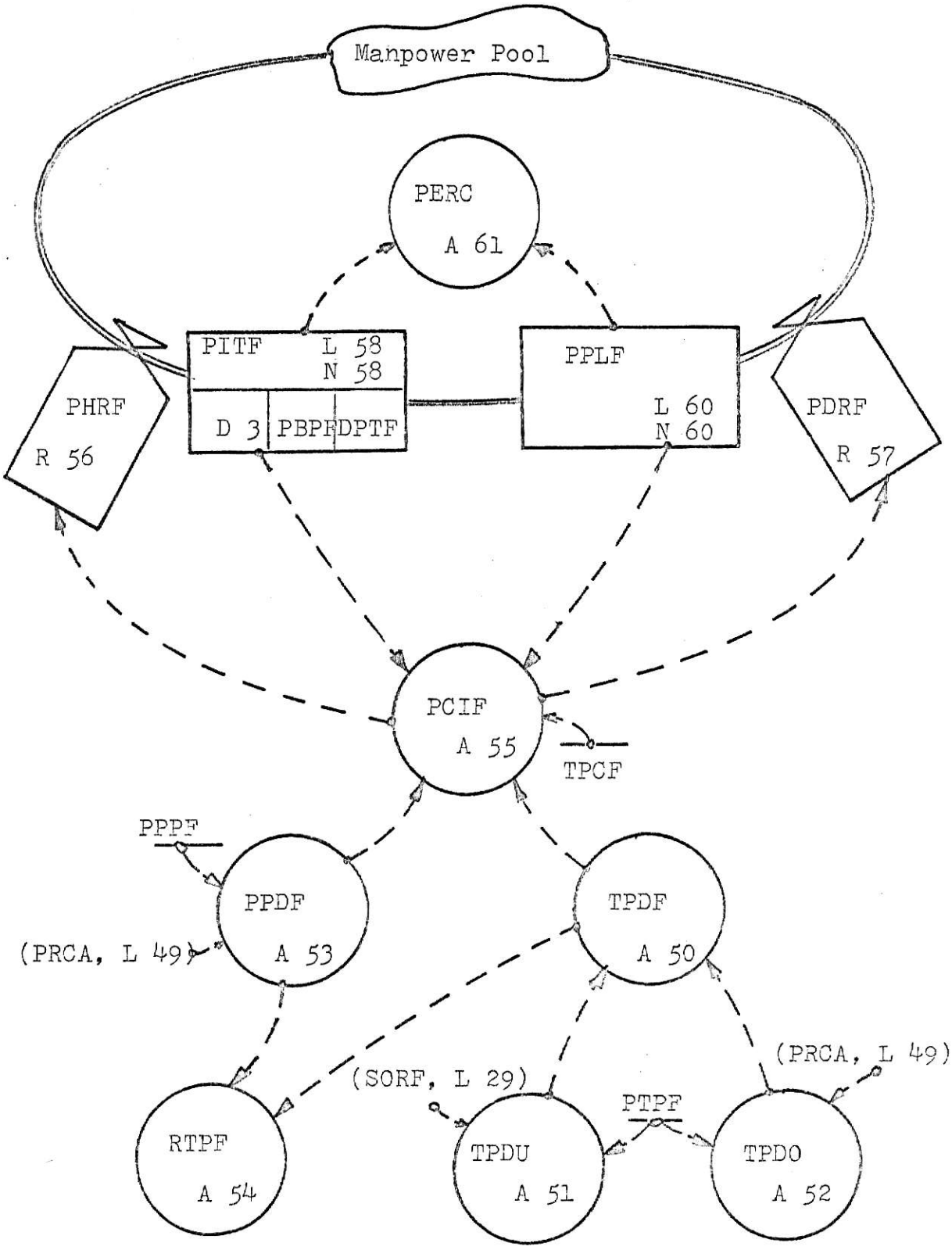


Figure 4.14: Personnel Requirement Flow Diagram

and,

$$TPDO.K = \frac{PRCA.K}{PTPF} \qquad A\ 52$$

TPDF Technical Personnel Desired at Factory (men)

TPDU Technical Personnel Desired during Undercapacity (men)

TPDO Technical Personnel Desired during Overcapacity (men)

SORF Smoothed Order Rate at Factory (cigs/month)

PRCA PRoduction CApacity (cigs/month)

PTPF Production of Technical Personnel at Factory (cigs/man-month)

The productivity of the technical personnel is:

PTPF = 300000 cigs/man-month C 51

In the case of professional personnel; their specialization and their limited supply make management reluctant to dismiss or replace them. For this reason the level of business is represented by the production capacity of the factory. The desired level of professional personnel is therefore written as:

$$PPDF.K = \frac{PRCA.K}{PPPF} \qquad A\ 53$$

PPDF Professional Personnel Desired at Factory (men)

PRCA PRoduction CApacity (cigs/month)

PPPF Productivity of Professional Personnel at Factory (cigs/man-month)

The productivity of the professional personnel is:

PPPF = 2400000 cigs/man-month C 53

The ratio of professional to technical personnel at the factory is given by:

$$RTPF.K = \frac{TPDF.K}{TPDF.K + PPDF.K} \qquad A\ 54$$

RTPF Ratio of Technical Personnel at Factory (dimensionless)

PPDF Professional Personnel Desired at Factory (men)

TPDF Technical Personnel Desired at Factory (men)

The decision to hire or dismiss employees is dependent on the difference between personnel desired and the actual number of personnel at the factory. The indicated change in personnel is therefore written as:

$$PCIF.K = \frac{TPDF.K + PPDF.K - PITF.K - PPLF.K}{TPCF} \qquad A\ 55$$

PCIF Personnel Change Indicated at Factory (men/month)

TPDF Technical Personnel Desired at Factory (men)

PPDF Professional Personnel Desired at Factory (men)

PITF Personnel In Training at Factory (men)

PPLF Productive Personnel Level at Factory (men)

TPCF Time for Personnel Change at Factory (months)

The time for personnel change at the factory is actually the time between changes in the work force.

TPCF = 1 month C 55

The hiring rate at the factory is therefore equal to the indicated change in personnel if that is positive:

$$PHRF.KL = \begin{cases} 0 & PCIF.K \leq 0 \\ PCIF.K & PCIF.K > 0 \end{cases} \qquad R\ 56$$

PHRF Personnel Hiring Rate at Factory (men/month)

PCIF Personnel Change Indicated at Factory (men/month)

Consequently, the dismissal rate is equal to the indicated change in personnel if that is negative:

$$PDRF.KL = \begin{cases} PCIF.KL & PCIF.K \leq 0 \\ 0 & PCIF.K > 0 \end{cases} \qquad R\ 57$$

Once the hiring decision is taken, there is a training interval delay when the hired employees are non-productive. This interval is adequately represented by a third-order exponential delay representing both the training period and the inefficiencies experienced due to the advent of new employees. In other words, personnel start to work as soon as they are employed, but their addition to the work force causes rearrangement of production processes, causing some lowering of effectiveness of the producing personnel. The level of training personnel is written as:

$$PITF.K = PITF.J + (DT)(PHRF.JK - PBPF.JK) \qquad L\ 58$$

$$PITF = 0 \qquad N\ 58$$

PITF Personnel In Training at Factory (men)

PHRF Personnel Hiring Rate at Factory (men/month)

PBPF Personnel Becoming Productive at Factory (men/month)

The rate at which personnel become productive is the delayed function of the hiring rate:

PBPF.KL = DELAY3(PHRF.JK,DPTF) R 59

PBPF Personnel Becoming Productive at Factory (men/month)

PHRF Personnel Hiring Rate at Factory (men/month)

DPTF Delay due to Personnel Training at Factory (months)

The delay due to training is taken to be:

DPTF = 0.5 month C 59

The number of personnel that are productive is therefore represented by a level equation as follows:

PPLF.K = PPLF.J + (DT)(PBPF.JK - PDRF.JK) L 60

PPLF = TPDF + PPDF N 60

PPLF Productive Personnel Level at Factory (men)

PBPF Personnel Becoming Productive at Factory (men/month)

PDRF Personnel Dismissal Rate at Factory (men/month)

TPDF Technical Personnel Desired at Factory (men)

PPDF Professional Personnel Desired at Factory (men)

Finally the total number of employees in the company is given by an auxillary equation which sums the personnel in training and those producing:

PERC.K = PITF.K + PPLF.K A 61

PERC PERsonnel in the Company (men)

PITF Personnel In Training at the Factory (men)

PPLF Productive Personnel Level at Factory (men)

4.3 Profit

The computation of current profit is generated to be used as an indicator of system performance. It is based on the accounting relationships incorporated in the cigarette company's profit and loss account. The profit calculation is shown in the flow diagram of Figure 4.15.

The revenue from sales is simply the selling price multiplied by the company sales. The monthly sales are given by the average shipping rate. The revenue from sales is therefore written as:

REVS.K = (USPC)(AVSR.K) A 62

REVS REVenue from Sales (esc./month)
USPC Unit Selling Price of Cigarettes (esc./cig.)
AVSR AVerage Shipping Rate (cigs/month)

The average shipping rate is formulated as a first-order exponential average of the actual shipping rate:

AVSR.K = AVSR.J + (DT)(SSFI.JK - AVSR.J)/DSSR L63
AVSR = SSFI N 63

AVSR AVerage Shipping Rate (cigs/month)
SSFI Shipments Sent from Factory Inventory (cigs/month)
DSSR Delay in Smoothing Shipping Rate (months)

The delay in smoothing the shipping rate is:

DSSR = 1 month C 63

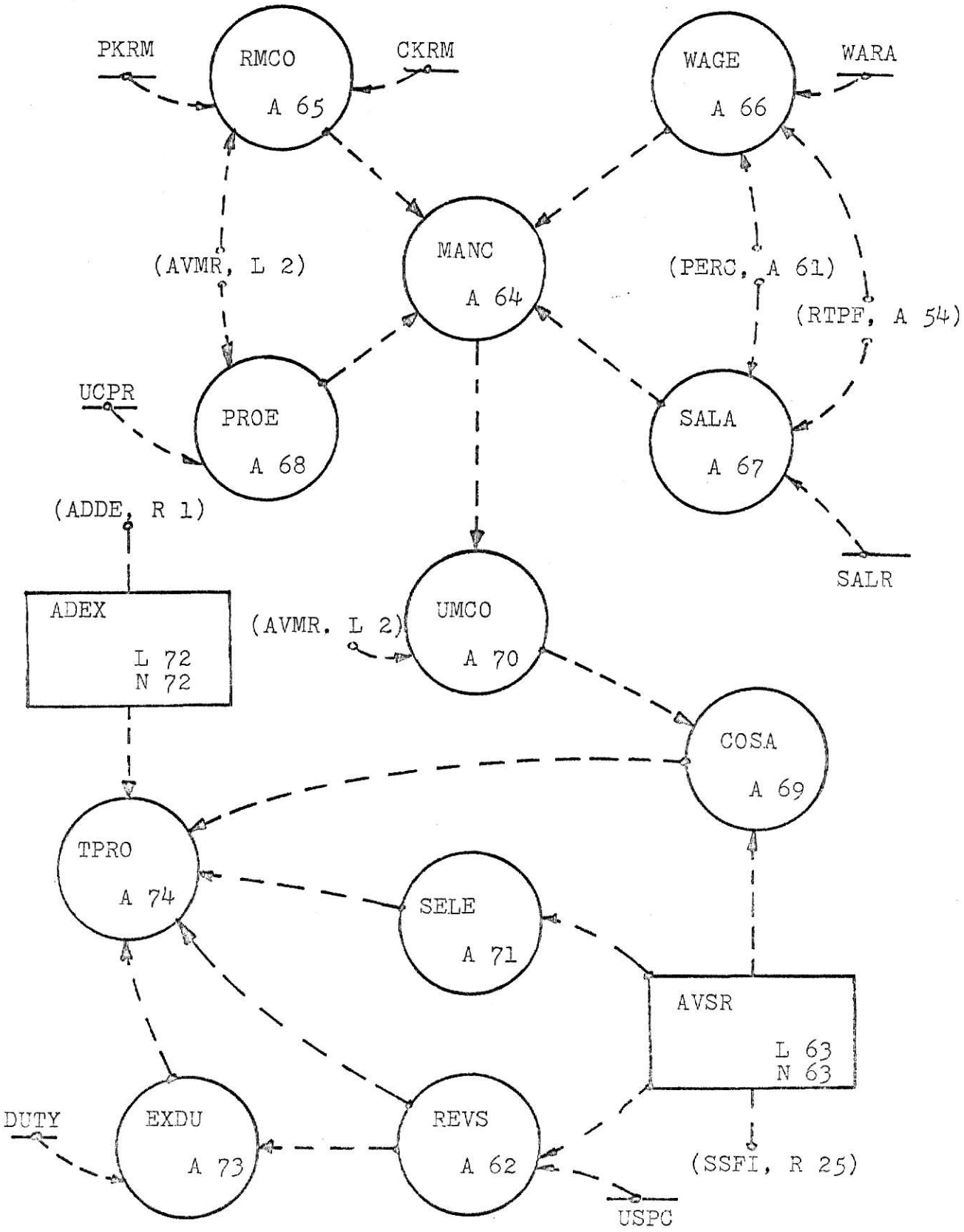


Figure 4.15: Profit Sector Flow Diagram

The manufacturing cost is the sum of the following expenses:

- raw material cost
- wages
- salaries
- production expenses

The manufacturing cost is therefore written as:

MANC.K = RMCO.K + WAGE.K + SALA.K + PROE.K A 64

MANC MANufacturing Cost (esc./month)
WAGE WAGEs (esc./month)
SALA SALAries (esc./month)
PROE PROduction Expenses (esc./month)

The equations for all these costs are now derived. The raw material cost is based on its usage rate which, in turn, depends on the average manufacturing rate. The raw material cost is given by:

$$RMCO.K = \left(\frac{PKRM}{CKRM}\right)(AVMR.K) \qquad A\ 65$$

RMCO Raw Material COst (esc./month)
PKRM Price per Kilogram of Raw Material (esc./kg.)
CKRM Cigarettes per Kilogram of Raw Material (cigs/kg.)
AVMR AVerage Manufacturing Rate (cigs/month)

The number of cigarettes that can be made from a kilogram of raw material is:

CKRM = 1000 cigs/kg. C 65

The wages paid by the company are based on the number of technical personnel at the factory:

WAGE.K = (WARA)(RTPF.K)(PERC.K) A 66

WAGE WAGEs (esc./month)

WARA WAge RAte (esc./man/month)

RTPF Ratio of Technical Personnel at Factory (dimensionless)

PERC PERsonnel in the Company (men)

Similarly, salaries are formulated as follows:

SALA.K = (SALR)(1 - RTPF.K)(PERC.K) A 67

SALA SALAries (esc./month)

SALR SALary Rate (esc./man/month)

RTPF Ratio of Technical Personnel at Factory (dimensionless)

PERC PERsonnel in the Company (men)

The final costs contributing to the total manufacturing cost are production expenses. Based on historical data, these are assumed to be proportional to the average manufacturing rate. The expression for production expenses is therefore:

PROE.K = (UCPR)(AVMR.K) A 68

PROE PROduction Expenses (esc./month)

UCPR Unit Cost of PRoduction (esc./cig.)

AVMR AVerage Manufacturing Rate (cigs/month)

The unit cost of production is:

UCPR = 0.015 esc./cig C 68

The next formulation is that of cost of sales. This is equal to the current unit manufacturing cost multiplied by average shipping rate of the factory. The expression for cost of sales is written as:

$$COSA.K = (UMCO.K)(AVSR.K) \qquad A\ 69$$

COSA COst of SAles (esc./month)

UMCO Unit Manufacturing COst (esc./cig.)

AVSR AVerage Shipping Rate (cigs/month)

The unit cost of manufacturing is simply the manufacturing cost divided by the average manufacturing rate:

$$UMCO.K = \frac{MANC.K}{AVMR.K} \qquad A\ 70$$

UMCO Unit Manufacturing COst (esc./cig.)

MANC MANufacturing Cost (esc./month)

AVMR AVerage Manufacturing Rate (cigs/month)

Two more expenditures need still to be considered. These are selling and advertizing expenses. The selling expenditure budget is proportional to revenue from sales. Thus, the expression for selling expenditures is:

$$SELE.K = (FRSE)(REVS.K) \qquad A\ 71$$

SELE SELling Expenditures (esc./month)

FRSE Fraction of Revenue for Selling Expenditures (dimensionless)

REVS REVenue from Sales (esc./month)

An expression for the advertizing decision has already been formulated. However, in order to eliminate the daily fluctuations in the advertizing rate, a first-order exponential smoothing equation is used:

ADEX.K = ADEX.J + (DT)(ADDE.JK - ADEX.J)/DSAE L 72

ADEX = ADDE N 72

ADEX ADvertizing EXpenditures (esc./month)

ADDE ADvertizing DEcision (esc./month)

DSAE Delay in Smoothing Advertizing Expenditures (months)

The delay in smoothing advertizing expenditures is:

DSAE = 1 month C 72

The final factor that needs to be considered before profit can be calculated is excise duty. This is simply the excise duty rate multiplied by the revenue from sales. The amount of excise duty paid by the company, is therefore given by:

EXDU.K = (DUTY)(REVS.K) A 73

EXDU EXcise DUty (esc./month)

DUTY DUTY rate (dimensionless)

REVS REVenue from Sales (esc./month)

The aggregate excise duty on sales in Mozambique comes to approximately 28 %.

DUTY = 0.28 C 73

The equation for profit can now be formulated. It is the difference between revenue from sales and the various costs and expenditures described above. The expression for trade profit is therefore written as:

TPRO.K = REVS.K - COSA.K - EXDU.K - SELE.K - ADEX.K A 74

TPRO Trade PROfit (esc./month)

REVS REVenue from Sales (esc./month)

EXDU EXcise DUty (esc./month)

SELE SELling Expenditures (esc./month)

ADEX ADvertizing EXpenditures (esc./month)

The preceding equations complete the description of the system under study. Some of the constants used in the model have not been assigned values. This was done purposefully in order to add a greater degree of flexibility to the model. The values of these constants are dependent on prevailing conditions and policies at the time of simulation. Table 4.5 gives a list of constants whose values need to be specified before simulation can proceed.

The equations described in the market and company subsystems are completely self-contained. Using information about the company's ability to meet demand and its effort to promote its brands of cigarettes, the market sector generates orders to the factory. This order rate is the input to the company sector, and sets in motion a chain of events that determines how well the company meets demand, and how much effort it puts into promoting its product. As a result, the company's growth characteristics are determined.

Table 4.5: Constant Dependent on Time of Simulation

Contents	Symbol	Equation
Fraction of Revenue Budgeted for Advertizing	FRBA	R 1
Unit Selling Price of Cigarettes	USPC	R 1
Initial Advertizing Outlay of Competitors	IAOC	N 6
Initial Market SHare	IMSH	N 9
Initial Sales of Cigarette Industry	ISCI	N 12
Initial Shipments in Transit to retail	ISIT	N 19
Initial Work-in-Progress at Factory	IWPF	N 39
Initial Production Capacity on Order	IPCO	N 47
Price per Kg. of Raw Material	PKRM	A 65
WAge RAte	WARA	A 66
SALary Rate	SALR	A 67
Fraction of Revenue for Selling Expenditure	FRSE	A 71

4.4 Basic Assumptions for the Model

The model presented in this chapter is based upon a number of assumptions, the major ones of which are summarized here:

- All quatities can be treated in an aggregate manner.
- All quatities can be treated in a continuous manner.
- The potential demand for the product is a function only of the advertizing outlay of the company.

CHAPTER V

MODEL VALIDATION

The difficulties involved in validating simulation models and interpreting their results have presented practical and theoretical questions about the use of simulation techniques that have not been completely resolved. Although knowledge about appropriate statistical tests for validating simulations is increasing, testing suffers from the standard problems of empirical research:

- small samples due to the high cost of data
- data is too aggregate
- data whose own validity is questionable

In industrial dynamic models, where data availability is not insisted upon, validation is usually attempted in two levels of testing:

- sensitivity testing
- performance testing

The sensitivity of system behavior to changes in the various components of the system is an important check on model validity. The reason for this is that changes in model behavior resulting from changes in model assumptions can often be evaluated against the likelihood of similar real world sensitivity. Factors to which the system is sensitive must be carefully controlled, or else the system should be redesigned to reduce sensitivity (9).

In a sensitivity test, parameters are changed to determine if they affect the output, or if they help make the model produce results that match historical data more closely.

Performance testing is one of the most stringent tests of model validity. This type of testing focuses on the ability of the system to duplicate historical behavior at a particular point in time. The model is initialized with parameter values equivalent to those existing in the actual environment at a particular time. Inputs duplicating those supplied to the real world environment during the test period, for example, advertizing, are also supplied to the simulation. The response of the simulation manifest in the time paths of relevant variables is then compared with data describing the response of the actual environment. The validity of the model is evaluated in terms of the correspondence between simulated and actual conditions. Comparison consists of examining all aspects of the model behavior, in particular, phase relationships between simulated and actual variables.

In this study validation incorporated both the above levels of testing. Sensitivity tests of important parameters in the system were performed on the complete model. Performance testing involved dividing the model into its two subsystems and using different inputs to stimulate system behavior. The methods of testing and the results of these tests are described in the following sections of this chapter.

5.1 Sensitivity Tests

The model was initialized with values existing in the system's environment in the period following 1968. Table 5.1 shows the values given to the constants for this set of simulation runs. The entire equation system used for these tests is given in Appendix A.

The system was found to be insensitive to the majority of equation parameters. Sensitivity tests were conducted by making changes of a factor of two in the important parameters. The levels of company sales and production capacity were used as indicators of system sensitivity and stability.

Table 5.1: Values Assigned to Constants for Sensitivity Testing

Constant	Symbol	Value
Fraction of Revenue for Advertizing	FRBA	0.10
Unit Selling Price of Cigarettes	USPC	0.22 esc./cig.
Initial Advertizing of Competitors	IAOC	1100000 esc./month
Initial Market Share	IMSH	0.05
Initial Sales of Cigarette Industry	ISCI	61500000 cigs/month
Initial Shipments in Transit to Retail	ISIT	0
Initial Work-in-progress at Factory	IWPF	0
Initial Production Capacity on Order	IPCO	0
Price per Kg. of Raw Material	PKRM	70 esc./kg.
Wage Rate	WARA	1200 esc./man/month
Salary Rate	SALR	120000 esc./man/month
Fraction of Revenue for Selling	FRSE	0.10

Changes of a factor of two made very little difference to the output of the system in most cases. For changes greater than this, however, system behavior was affected. In particular, the modification of factors such as smoothing time constants and adjustment time constants tended to make the system less stable. The amount of desired inventory at the company and at the retail outlets also affected the sensitivity of the system. However, only under extreme circumstances, when the system begins to react to a shortage of available inventory, does the response differ appreciably.

The average delay times were also changed to examine their significance in the system. Modifications of a factor of two had no substantial effect on system stability although response was appreciably affected by larger changes in the values of most delays.

The effect of product availability was also examined. The four curves shown in Figure 4.6 were incorporated in the model independently, and the system output was compared to actual system behavior. It was found that curve D produced results that more closely matched historical data. This implied that even a slight shortage of the company's brands in the market affects company sales considerably. The complete equation for the product availability multiplier is therefore:

```
PRAM.K = TABHL(PRAT,INRA.K,0,1,0.2)          A 14
  PRAT = 0.0,0.32,0.55,0.85,1.0.             T 14
```

PRAM PRoduct Availability Multiplier (dimensionless)

PRAT PRoduct Availability Table

INRA INventory RAtio (dimensionless)

The sensitivity tests performed prompted two further alterations to the equation system described in Chapter 4. The output of wages and salaries of the company's personnel did not correlate well with actual system output, when other important variables performed satisfactorily.

Political pressures caused the actual wage rate to climb steeply in 1973. This made an average value for the wage rate inaccurate. The problem was rectified by making the wage rate a variable, which remains at an average value upto the end of 1972, and subsequently increases at a constant rate to its present level. The wage equation thus becomes:

WAGE.K = (WARA.K)(RTPF.K)(PERC.K) A 66

where,

WARA.K = TABHL(WRTA,TIME.K,55,67,12) A 66a

WRTA = 1000,1500 T 66a

WAGE WAGEs (esc./month)

WARA WAge RAte (esc./man/month)

RTPF Ratio of Technical Personnel at Factory (dimensionless)

PERC PERsonnel in the Company (men)

WRTA Wage Rate TAble

TABHL TABle, High, Low; functional notation

In the case of salaries, the problem was that the initial number of professional personnel in the company did not correspond to the actual case. Since the number of professional personnel was made dependent on the level of production capacity at the factory, which was unusually low initially, the anomaly was remedied by including a minimum in the personnel desired equation:

$$PPDF.K = MPPD + \frac{PRCA.K}{PPPF} \qquad A\ 53$$

where,

MPPD = 8 men

PPDF Professional Personnel Desired at Factory (men)

MPPD Minimum number of Professional Personnel Desired (men)

PRCA PRoduction CApacity (cigs/month)

PPPF Productivity of Professional Personnel at Factory (cigs/man-month)

Having satisfied the requirements of stability and sensitivity, the model was then subjected to performance testing.

5.2 Performance Testing

The model was divided into its two subsections for this type of testing:

- The company sector alone was first tested using actual orders to the factory as the input to the model.
- The complete model, with market sector now included, was tested using the company's actual advertizing outlay as the input to the model.

5.2.1 Performance Tests on the Company Sector

Historical data of the actual order rate to the company, for the period between May 1968 and December 1973, were used as the input to the company sector of the model. Data for that period were also incorporated in the form of supplementary equations for the purpose of comparing simulated output to real-world output of relevent variables. The complete equation system for this test is given in Appendix B.

Figure 5.1 shows the actual and simulated outputs of manufacturing rate at the factory. The order rate input is also included in order to observe the phase relationship between these two variables. As can be seen, the simulated manufacturing rate compares very favorably with actual manufacturing figures. The slump in sales in 1972 is attributed to the closing of the Angola market to Mozambique cigarette manufacturers. The validity of the production capacity acquisition policy incorporated in the model is confirmed by the output shown in Figure 5.2. As can be seen, the company's actual production capacity for the 1968 to 1973 period correlates very closely to the simulated capacity time path.

The outputs for the various costs that sum up to the monthly manufacturing cost also performed well when compared to actual figures. These outputs are shown in Appendix B. This indicated that the company sector subsystem has met the requirements of validity.

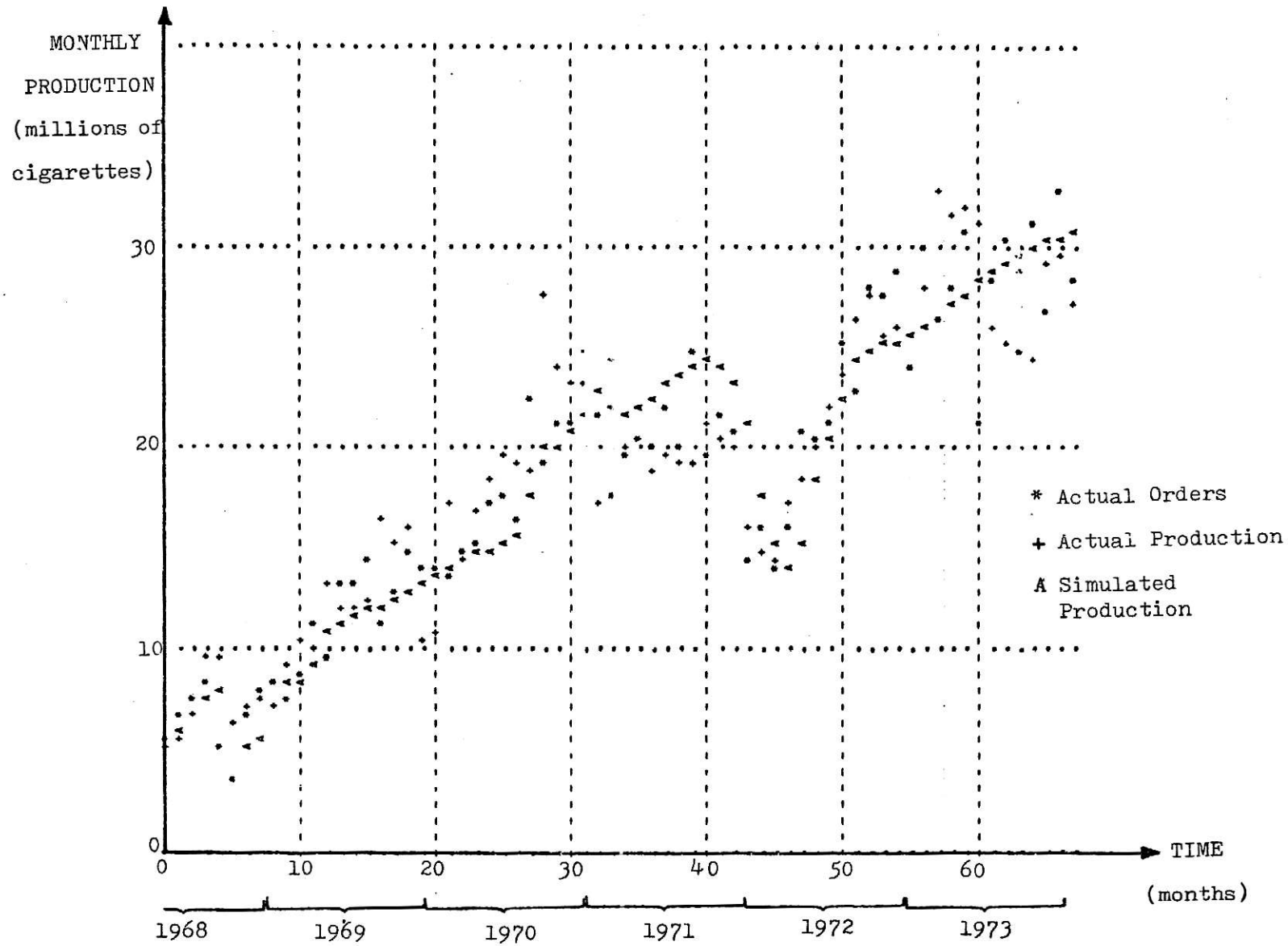


Figure 5.1: Company Sector Performance Test

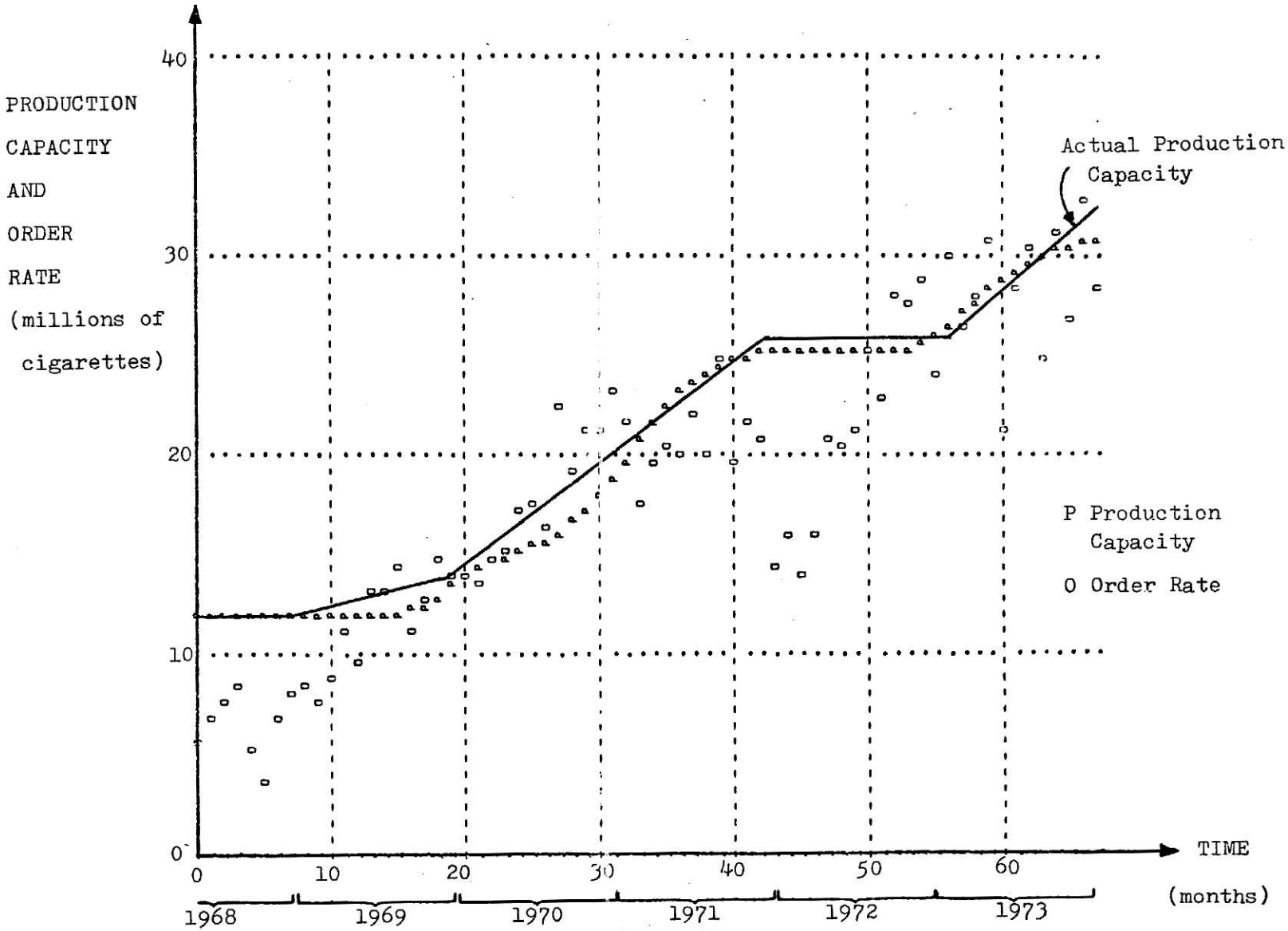


Figure 5.2: Company Sector Performance Test

5.2.2 Performance Tests on the Market Sector

The market sector was then included in the system in order to test its ability to generate an order rate similar to the actual rate under the same environmental conditions. The only input to the model was the actual advertizing expenditure of the company for the period between May 1968 and December 1973. Again, historical data of relevent variables were included for comparative purposes. Figure 5.3 shows the actual and simulated outputs for the retail sales rate. The general trend and the phase relationship between the time paths meet every expectation. The assumption that the advertizing expenditure of a company in the cigarette industry is the major weapon of competition appears to be a very valid one. In addition, the close correlation of these outputs indicates that the advertizing model of repeat and transfer purchase probabilities is quite adequate for generating potential demand.

The simulated production capacity of the factory again correlates very well with the actual case. In 1973, however, simulated production capacity does not increase at nearly the same rate as actual capacity. This is due to the fact that the order rate to the company for that time period is low compared to the actual monthly orders, and consequently the pressure for expansion in the simulated case is not as great as in the real-world situation. There is a very valid explanation for this occurance. An increase in the excise duty on cigarettes due to become effective January 1974 prompted a buying spree by both retailers and smokers resulting in an average monthly increase of approximately 8 % for the year. The model has

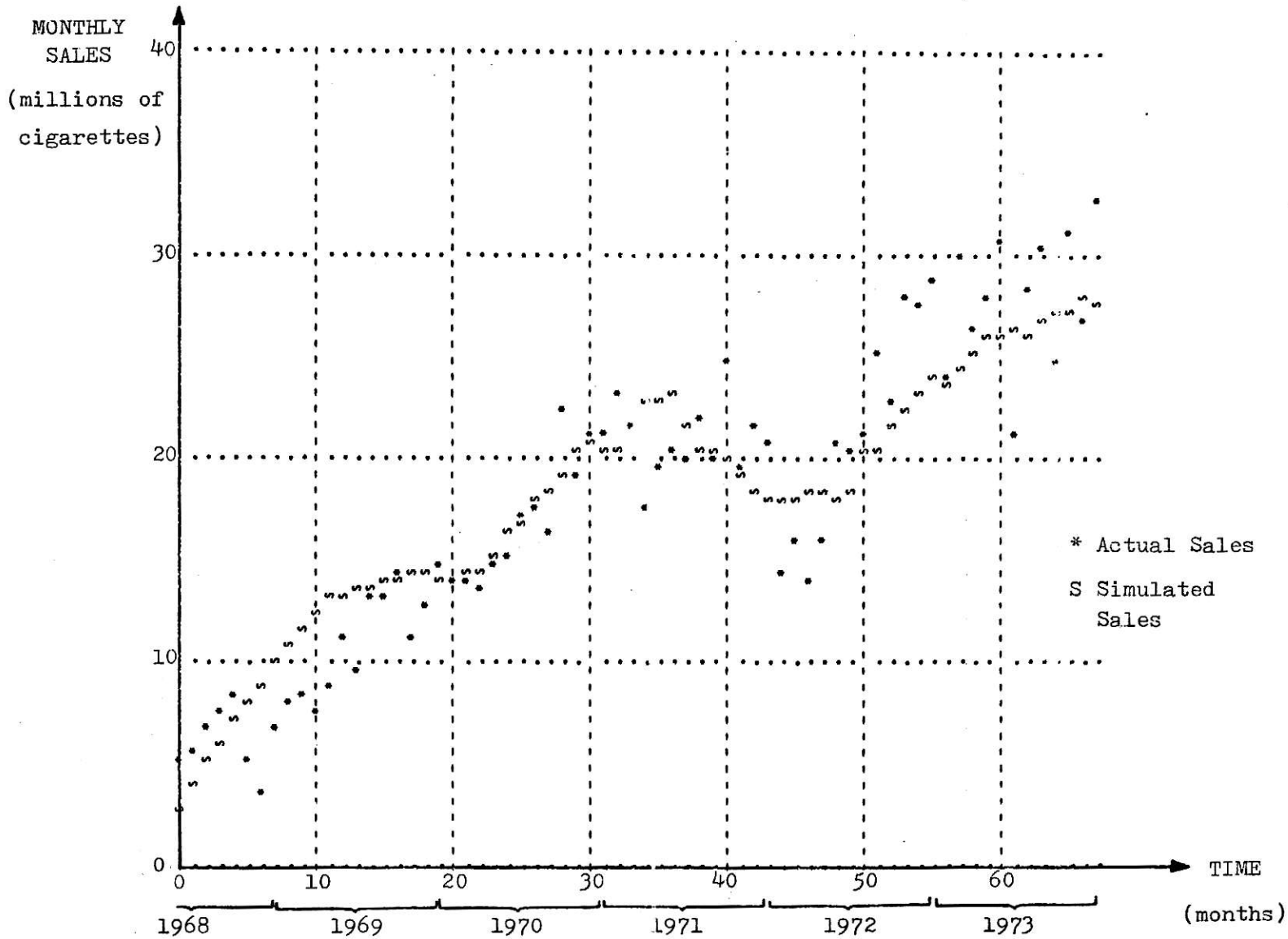


Figure 5.3: Model Performance Test

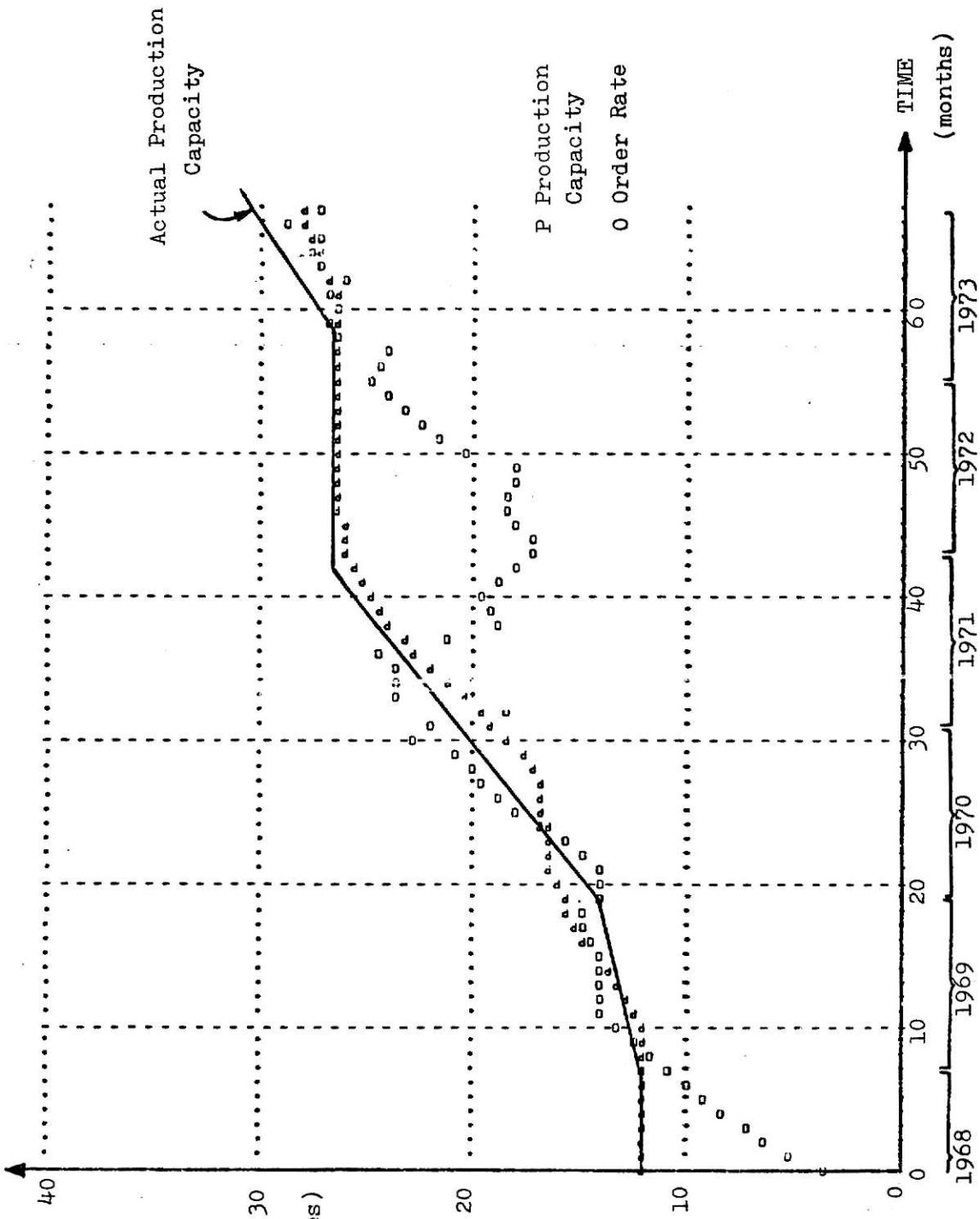


Figure 5.4: Model Performance Test

no way of anticipating this price increase, and cannot, therefore, react accordingly.

The time paths of the various financial variables can be seen in Appendix C. Although most perform well, the large scatter in the actual salary figures causes a corresponding scatter in the monthly profit. The profit rate time path does, however, follow the general trend of the actual figures.

The results obtained in these tests have helped to build an acceptable level of confidence in the model formulations and assumptions. The final validation, however, rests in its ability to predict specific situations satisfactorily.

CHAPTER VI

POLICY FORMULATION

The purpose of this chapter is to establish what factors have limited the company's growth in the past, and to suggest changes in the company's current policies if these are warranted. As indicated in Chapter I, the company's major problem areas are advertizing expenditures and capacity expansion. Using the model as a tool, alternative policies in these two areas are tested, and the system performance examined in order to establish a measure of the affect of these policies on growth.

6.1 Advertizing Outlay Policy

The tests performed in the previous chapter supported the hypothesis that advertizing in the cigarette industry is the main competitive weapon by which oligopolists seek to increase their relative shares. This section seeks to determine precisely how advertizing affects sales and profitability.

In the United States, for instance, more money is spent on advertizing cigarettes than any other individual item (30). This in itself demonstrates the important role advertizing plays in the cigarette industry. However, a company should not have to spend increasing sums of money on advertizing to be able to maintain its share of the market. There must be a point where the return on

investment does not warrant such excess spending, and at the other end, since advertizing plays such a prominent role in a cigarette company's growth there must also exist a lower limit.

With this in mind the model was used to determine the effect different levels of advertizing outlay have on the company's growth and profits. The fraction of revenue the company budgets for advertizing, as defined in equation (R 1), was used as the test variable. The model was initialized with the same values as in the sensitivity tests, and run for the same period. FRBA, the fraction of revenue budgeted for advertizing, took on values from 0.00 to 0.30. Figures 6.1 and 6.2 summarize the results of these tests.

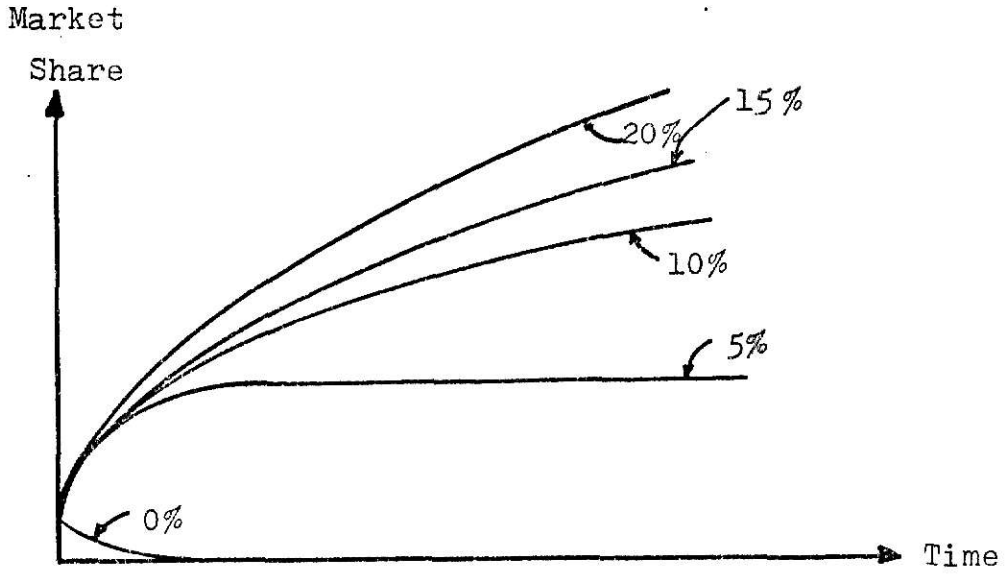


Figure 6.1: Time Paths of Market Share for Different Fractions of Revenue Budgeted for Advertizing

In Figure 6.1, the time paths of market share are shown for different fractions of revenue budgeting for advertizing. For zero spending, the company's share will drop gradually to zero. For FBRA = 0.05, the market share increases initially and then continues at a constant value. The reason for this is that the advertizing expenditure of competitors, comes to approximately 5 % of their revenue from sales. The implication is that a company needs to spend at least the same fraction of its revenue as its competitors on advertizing if it is to maintain its market share. For higher values FRBA, the market share increases indefinitely. However, this assumes that the company can afford to spend that amount of money on advertizing. Figure 6.2 looks at the effect the different advertizing outlays have on profits.

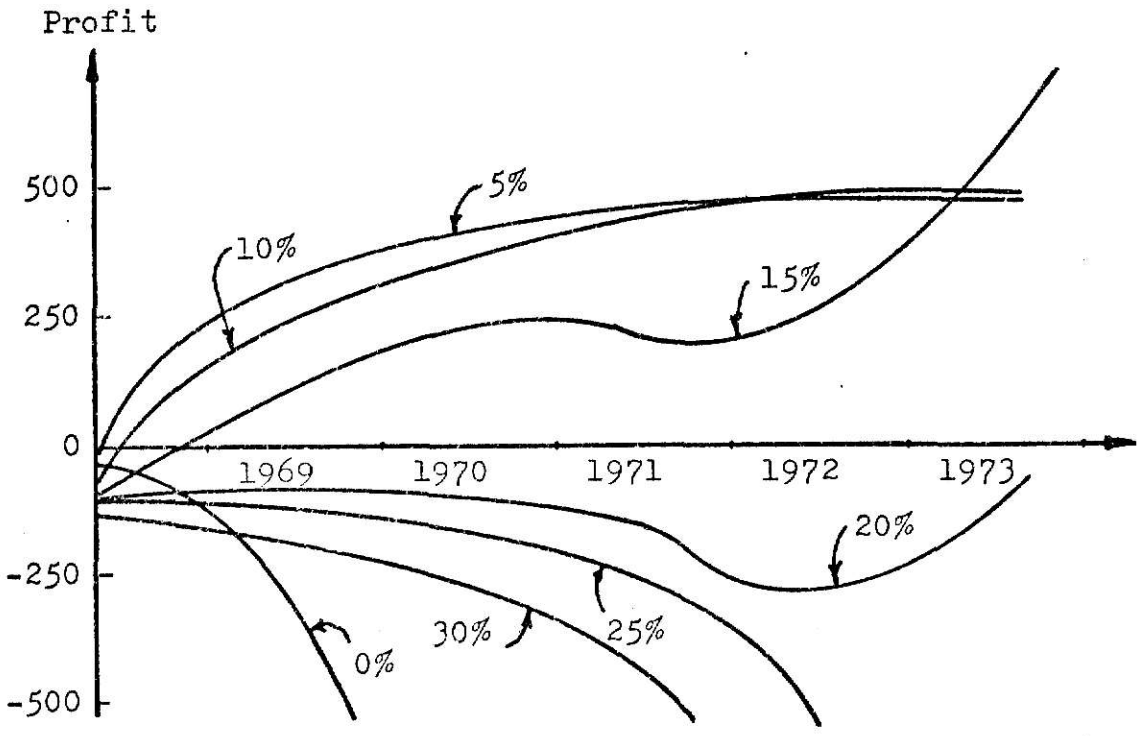


Figure 6.2: Time Paths of Profit for Different Fractions of Revenue Budgeted for Advertizing

In the case of zero advertizing, losses become increasingly more acute. For FRBA = 0.05, profits increase steadily and reach a plateau very close to the curve for FRBA = 0.10. This implies that profits are not greatly affected in this range. For a fraction of revenue of 0.15, profits are small initially, but, after a slump in the third year they begin to increase rapidly. The slump and the subsequent increase in profits signify the introduction of a second shift. This increase in factory production capability removes the restrictions on growth caused by undercapacity and allows order rate to grow as rapidly as potential demand. This last surge in profits is, therefore, not directly attributed to advertizing outlay. All FRBA's greater than 0.15 produce losses.

Over the past six years, the company has spent an equivalent of 10 % of its revenue from sales on advertizing. According to the above results, the company could decrease this figure by up to 5 % without seriously affecting profits. Sales will be considerably lower, however. This model is not suited for an explanation of the hidden financial implications of such a step. What has come out of these tests, is that the company's outlay over the past six years has been in the "optimum" range and that management may have to turn elsewhere in curbing expenditures. Salaries, which include management expenses, is a possible source of over-spending. This is demonstrated through the large amount of scatter observed in these figures. To conclude, although the company's advertizing policies in the past may have resulted in excess expenditures, they in no way limited the company's growth rate.

6.2 Capacity Expansion Policy

The ability of the company to meet demand is essential to its growth. The company's production capability is the determining factor of the product's availability in the market, and consequently the rate of flow of orders to the factory. For this reason, the capacity acquisition policy is very important and will be closely examined in this section to determine whether past policies have inhibited growth.

In the production capacity acquisition policy described in Chapter 4, production capacity orders were placed as a result of estimating the expected order rate at some future time. The forecasting technique used employed a linear extrapolation of past trends to determine the expected change in the order rate. The performance tests showed that this formulation provided a good correlation between simulated and actual production capacity levels.

During periods of undercapacity, however, forecasting from past trends will badly underestimate the potential growth of the order rate. This causes the order rate to be further suppressed. For this reason, alternative ways of handling the problem of deciding future needs of capacity must be investigated.

The old forecasting procedure used two reference points; the past order rate and the present smoothed order rate, to estimate the expected change in the order rate. Instead of using the

smoothed order rate as a reference point in its forecasting procedure management could estimate the effect factory production capability has on order rate to arrive at an estimate for the potential order rate. This point could then be used as the most recent point in the forecast to give a more optimistic estimate of expected order rate. Figure 6.3 illustrates this new policy.

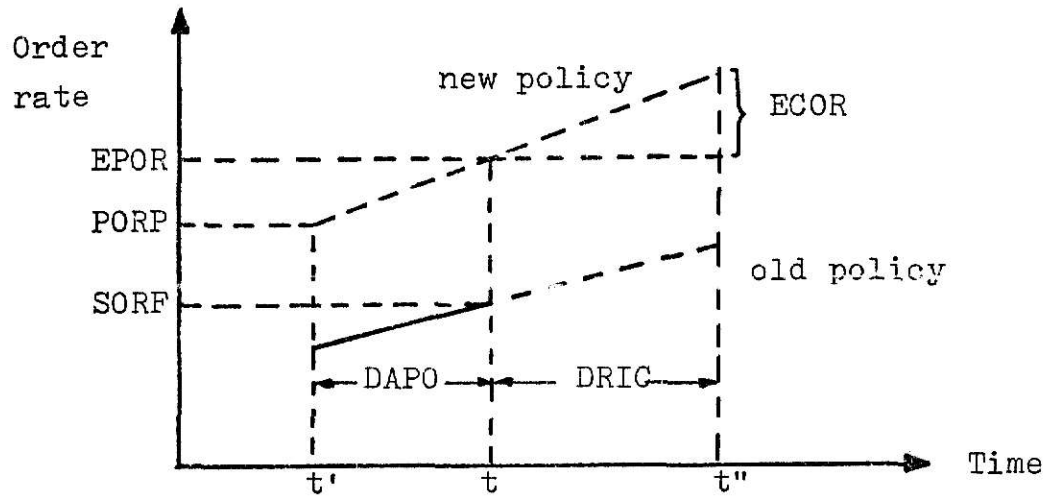


Figure 6.3: Forecasting Technique in New Policy

The demand level of production capacity would then become:

$$PCDF.K = EPOR.K + ECOR.K \qquad A\ 40a$$

PCDF Production Capacity Desired at Factory (cigs/month)

EPOR Estimated Potential Order Rate (cigs/month)

ECOR Expected Change in Order Rate (cigs/month)

Potential order rate could be obtained from an estimate of how well the company is meeting demand, or put differently, what is the factory's efficiency in meeting demand. This estimation cannot be obtained very accurately, but the company can make estimates within some range. Management knows that the company will not lose orders for a very small inefficiency in meeting demand. But as this efficiency drops, an increasing number of orders are lost. A good indicator of the factory's performance in meeting demand is the backlog of unfilled orders. Factory efficiency drops when the unfilled order level becomes significantly larger than the desired level. The relationship between factory efficiency in meeting demand and the ratio of desired to actual unfilled orders can be given by a curve whose general shape in shown in Figure 6.4.

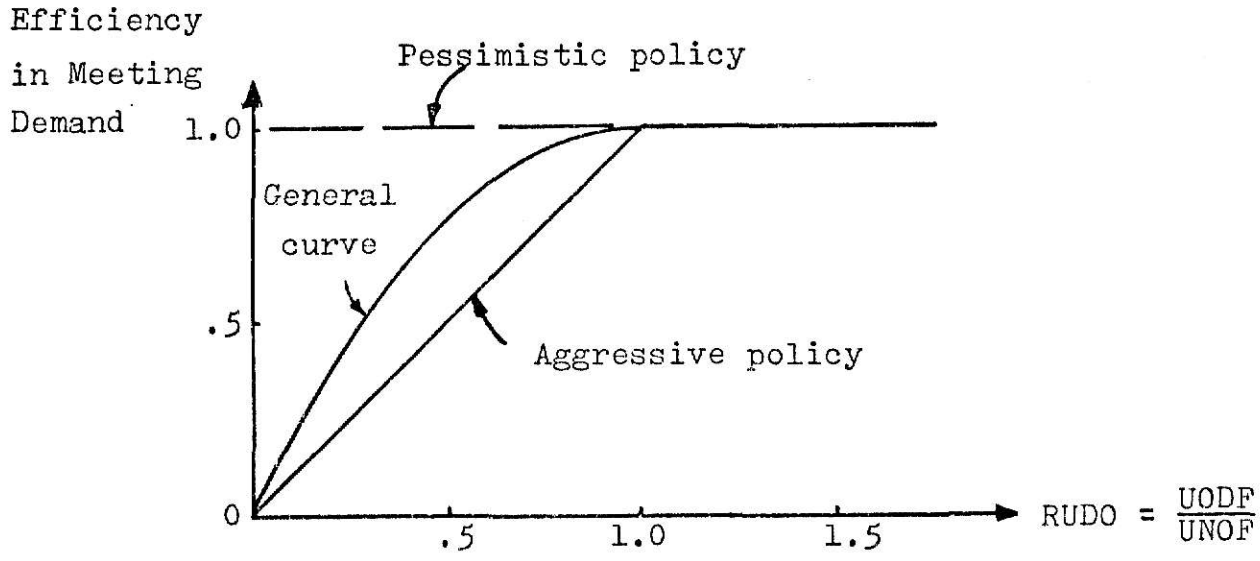


Figure 6.4: General Curve of Efficiency in Meeting Demand

Management can therefore estimate factory efficiency within a broad range and can use this information when forecasting. The model, however, must be tested for different estimates to determine the effect of an error in the estimate on the growth behavior. Figure 6.5 shows some of the curves that are used to estimate the efficiency of the factory in meeting demand.

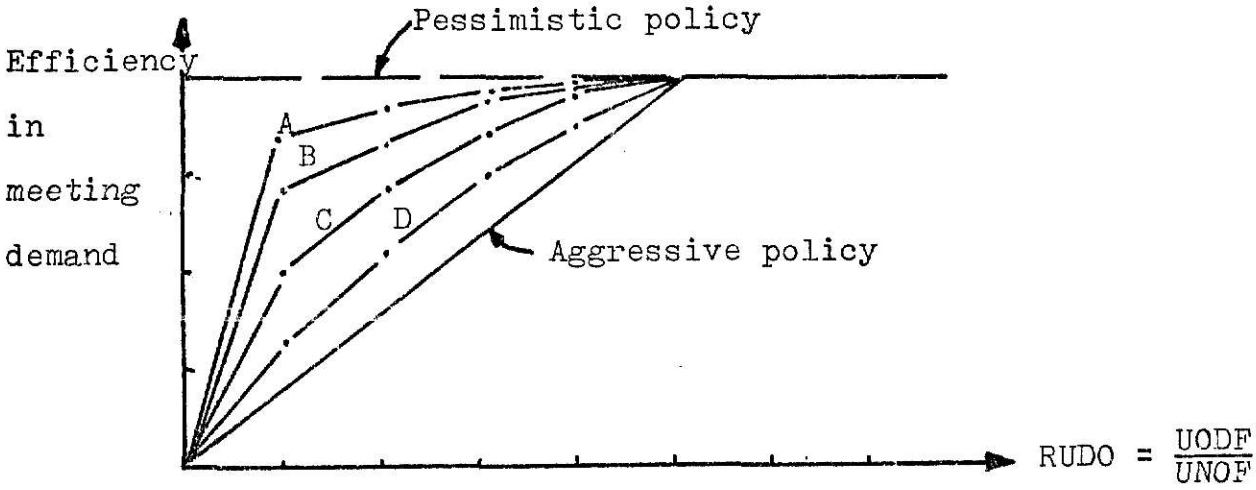


Figure 6.5: Possible curves for Efficiency in Meeting Demand

At this stage, factory efficiency simply refers to a table:

EFMD.K = TABHL(EFFT,RUDO.K,0,1,0.2) A 40b

EFMD Efficiency of Factory in Meeting Demand (dimensionless)

RUDO Ratio of Unfilled orders Desired to unfilled Orders (dimensionless)

EFFT EFFiciency Table

The ratio of unfilled orders is written as:

$$RUDO.K = \frac{UODF.K}{UNDF.K} \qquad A\ 40c$$

RUDO Ratio of Unfilled orders Desired to unfill Orders (dimensionless)

UODF Unfilled Orders Desired at Factory (cigs)

UNOF UNfilled Orders at Factory (cigs)

The potential order rate would then be given by:

$$EPOR.K = \frac{SORF.K}{EFMD.K} \qquad A\ 40d$$

EPOR Estimated Potential Order Rate (cigs/month)

SORF Smoothed Order Rate at Factory (cigs/month)

EFMD Efficiency of Factory in Meeting Demand (dimensionless)

The value for the past point of potential order rate is obtained in the same manner as for the case of order rate. A first-order exponential delay is used to delay this point into the past.

PORP.K = PORP.J + (DT)(EPOR.J - PORP.J)/DAPO L 41

PORP = SORF N 41

PORP Potential Order Rate in the Past (cigs/month)

EPOR Estimated Potential Order Rate (cigs/month)

SORF Smoothed Order Rate at Factory (cigs/month)

This set of equations representing the new policy was

substituted for the old set, and the simulations, incorporating each curve of Figure 6.5 independently, were performed. The curve that minimized both undercapacity in the growth stage and overcapacity in the saturation stage was B. Figure 6.6 shows the output of the simulation using curve B. The table equation is therefore given by:

```
EFFT = 0.7,0.83,0.92,0.97,1.0                                    T 40b
EFFT   EFFiciency Table
```

The more aggressive policy in ordering capacity puts the company in a relatively better capacity position, so that it can benefit more from potential demand. In addition to reducing overcapacity at market saturation, the model shows improved growth with the new policy.

The system of equations used in this new policy formulation is shown in Appendix D.

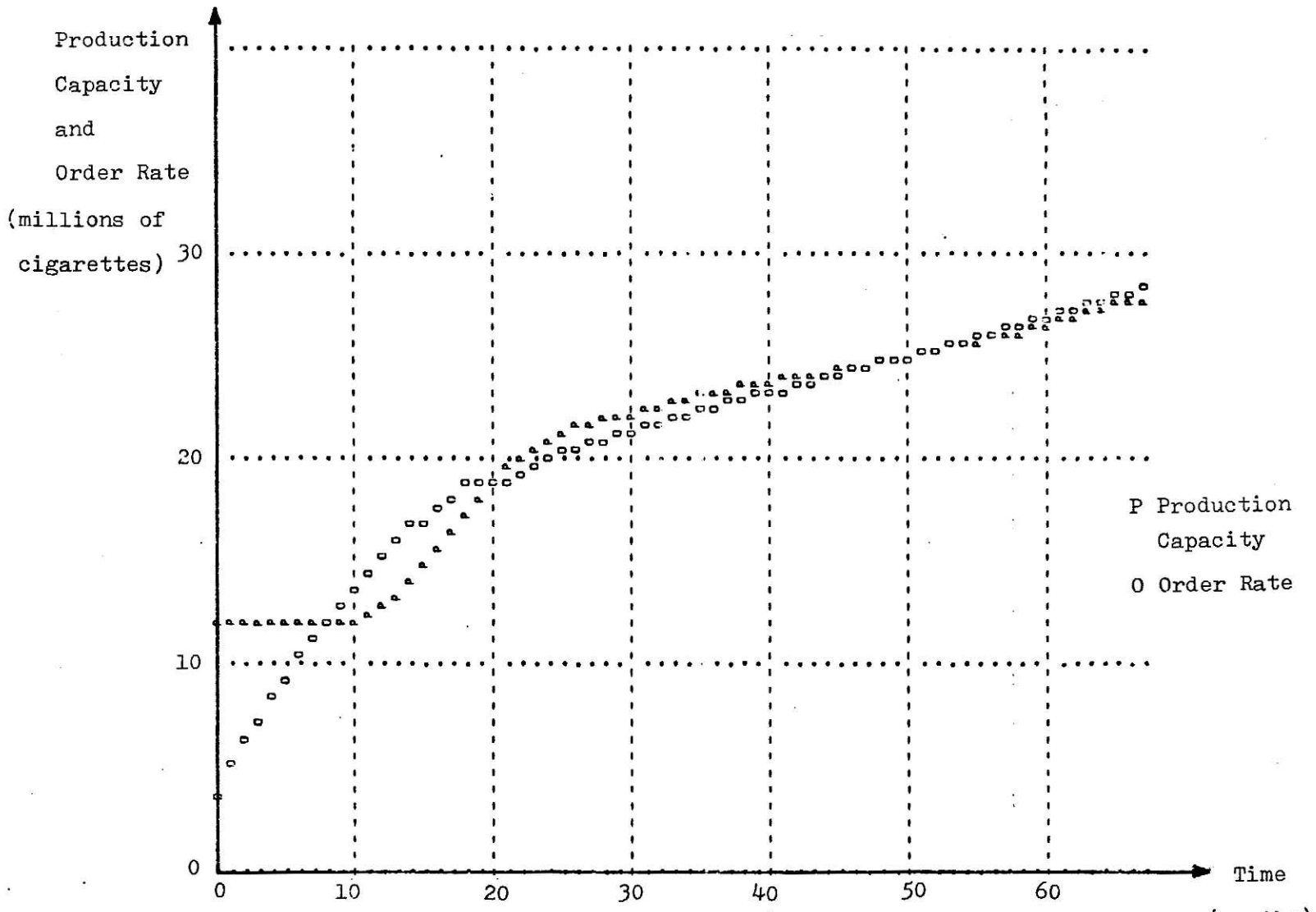


Figure 6.6: Simulation Output for New Policy

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APPENDIX A

Computer Program for Model

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```
NOTE*****************************************************************
NOTE
NOTE        MODEL OF CIGARETTE MANUFACTURING COMPANY IN MOZAMBIQUE
NOTE
NOTE*****************************************************************
NOTE
NOTE                          THE MARKET
NOTE
NOTE*****************************************************************
NOTE
NOTE     POTENTIAL DEMAND GENERATION SECTOR
NOTE
R     ADDE.KL=(FRBA)(USPC)(AVMR.K)            ADVERTIZING DECISION
C     FRBA=0.10              FRACTION OF REVENUE BUDGETED FOR ADVERTIZING
C     USPC=0.22                UNIT SELLING PRICE OF CIGARETTES
L     AVMR.K=AVMR.J+(DT)(MARA.JK-AVMR.J)/DAMR   AVERAGE MANUFACTURING RATE
N     AVMR=MARA
C     DAMR=1                          DELAY IN AVERAGING MANUFACTURING RATE
R     APMC.KL=DELAY3(ADDE.JK,DAAM)              ADVERTIZING PRESENTED BY
NOTE                                            MEDIA TO CONSUMER
C     DAAM=0.25              DELAY AT ADVERTIZING AGENCIES AND MEDIA
L     ADAC.K=ADAC.J+(DT)(APMC.JK-ADAC.J)/DAAC   ADVERTIZING AWARENESS
N     ADAC=ADDE                                 OF CONSUMER
C     DAAC=0.5               DELAY IN ADVERTIZING AWARENESS OF CONSUMER
A     CACB.K=ADAC.K/AADC.K            CONSUMER AWARENESS OF COMPANY'S BRANDS
L     AADC.K=AADC.J+(DT)(GRAC)     AVERAGE ADVERTIZING OUTLAY OF COMPETITORS
N     AADC=1100000
C     GRAC=4400              GROWTH RATE IN ADVERTIZING OF COMPETITORS
A     RPPR.K=0.39+(0.36)(CACB.K)      REPEAT PURCHASE PROBABILITY
A     TPPR.K=0.11+(0.16)(CACB.K)      TRANSFER PURCHASE PROBABILITY
A     PMSC.K=(RPPR.K)(MASH.K)+(TPPR.K)(1-MASH.K)      POTENTIAL MARKET SHARE
N     PMSC=.03
A     MASH.K=SARA.JK/ACSI.K                     MARKET SHARE
A     PODE.K=(PMSC.K)(ACSI.K)                   POTENTIAL DEMAND
L     ACSI.K=ACSI.J+(DT)(GRCI)        AVERAGE CIGARETTE SALES OF INDUSTRY
N     ACSI=61500000
C     GRCI=583000                     GROWTH RATE OF CIGARETTE INDUSTRY
NOTE
NOTE     RETAIL SECTOR
NOTE
R     SARA.KL=(PODE.K)(PRAM.K)                  SALES RATE
A     PRAM.K=TABHL(PRAT,INRA.K,0,1,0.2)      PRODUCT AVAILABILITY MULTIPLIER
A     INRA.K=INVR.K/INNR.K                      INVENTORY RATIO
L     INVR.K=INVR.J+(DT)(SRRI.JK-SARA.JK)       INVENTORY AT RETAIL
N     INVR=INNR
A     INNR.K=(PINR)(PODE.K)           INVENTORY NECESSARY AT RETAIL
C     PINR=0.5             PERIOD OF INVENTORY NECESSARY AT RETAIL
R     SRRI.KL=DELAY3(SSFI.JK,DIST)    SHIPMENTS RECEIVED AT RETAIL INVENTORY
C     DIST=0.5                        DELAY IN SHIPMENT TRANSPORTATION
L     SITR.K=SITR.J+(DT)(SSFI.JK-SRRI.JK)     SHIPMENTS IN TRANSIT TO RETAIL
N     SITR=0
R     ORRF.KL=SRSA.K+(INDR.K-INVR.K-SITR.K)/TAIR       ORDER RATE AT FACTORY
C     TAIR=0.5                        TIME TO ADJUST INVENTORY AT RETAIL
L     SRSA.K=SRSA.J+(DT)(SARA.JK-SRSA.J)/DSRS   SMOOTHED RETAIL SALES
N     SRSA=PODE
C     DSRS=1                          DELAY IN SMOOTHING RETAIL SALES
A     INDR.K=(PIDR)(SRSA.K)                     INVENTORY DESIRED AT RETAIL
C     PIDR=1                          PERIOD OF INVENTORY DESIRED AT RETAIL
```

```
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE                              THE COMPANY
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE     ORDER FILLING SECTOR
NOTE
L     UNOF.K=UNOF.J+(DT)(ORRF.JK-SSFI.JK)        UNFILLED ORDERS AT FACTORY
N     UNOF=UODF
L     INVF.K=INVF.J+(DT)(PRFI.JK-SSFI.JK)        INVENTORY AT THE FACTORY
N     INVF=INDF
R     SSFI.KL=CLIP(NSRF.K,RSRF.K,INVF.K,UNOF.K) SHIPMENTS SENT FROM FACTORY
A     NSRF.K=UNOF.K/DFOF                NORMAL SHIPPING RATE FROM FACTORY
A     RSRF.K=INVF.K/DFOF                RESTRICTED SHIPPING RATE FROM FACTORY
C     DFOF=0.1                          DELAY IN FILLING ORDERS AT FACTORY
NOTE
NOTE     MANUFACTURING SECTOR
NOTE
A     MRDF.K=SORF.K+(UNOF.K-UODF.K+INDF.K-INVF.K-WIPF.K)/TAIB MANUFACTURING
NOTE                                            RATE DESIRED AT FACTORY
C     TAIB=3                            TIME TO ADJUST INVENTORY AND BACKLOG
L     SORF.K=SORF.J+(DT)(ORRF.JK-SORF.J)/DSOR SMOOTHED ORDER RATE AT FACTORY
N     SORF=ORRF
C     DSOR=1                            DELAY IN SMOOTHING ORDER RATE
A     INDF.K=MIDF+(PIDF)(SORF.K)              INVENTORY DESIRED AT FACTORY
C     MIDF=1000000                      MINIMUM INVENTORY DESIRED AT FACTORY
C     PIDF=1.5                          PERIOD OF INVENTORY DESIRED AT FACTORY
A     UODF.K=(DFOF)(SORF.K)             UNFILLED ORDERS DESIRED AT FACTORY
A     PRCF.K=CLIP(DSPC.K,SSPC.K,PRCA.K,PRCL)    PRODUCTION CAPABILITY
A     DSPC.K=2*PRCA.K                   DOUBLE SHIFT PRODUCTION CAPABILITY
A     SSPC.K=PRCA.K+PCCO.K              SINGLE SHIFT PRODUCTION CAPABILITY
C     PRCL=40000000                           PRODUCTION CAPCITY LIMIT
A     PCCO.K=CLIP(0.0,OPAF.K,INVF.K,UNOF.K)  PRODUCTION CAPACITY CONTRIBUTED
NOTE                                          BY OVERTIME
A     OPAF.K=(FCCO)(PRCA.K)             OVERTIME PRODUCTION ALLOWED AT FACTORY
C     FCCO=0.4              FRACTION OF CAPACITY CONTRIBUTED BY OVERTIME
R     MARA.KL=CLIP(MRDF.K,PRCF.K,PRCF.K,MRDF.K) MANUFACTURING RATE
N     MARA=ORRF
R     PRFI.KL=DELAY3(MARA.JK,DPLT)    PRODUCTS RECEIVED AT FACTORY INVENTORY
C     DPLT=0.1                        DELAY DUE TO PRODUCTION LEAD TIME
L     WIPF.K=WIPF.J+(DT)(MARA.JK-PRFI.JK)       WORK-IN-PROGRESS AT FACTORY
N     WIPF=0
NOTE
NOTE     PRODUCTION CAPACITY ACQUISITION SECTOR
NOTE
A     PCDF.K=SORF.K+ECOR.K              PRODUCTION CAPACITY DESIRED AT FACTORY
L     PORA.K=PORA.J+(DT)(SORF.J-PORA.J)/DAPO    PAST ORDER RATE
N     PORA=SORF
C     DAPO=12                           DELAY IN AVERAGING PAST ORDERS
A     CORP.K=SORF.K-PORA.K              CHANGE IN ORDER RATE IN THE PAST
A     ECOR.K=(CORP.K)(DRIC)/DAPO        EXPECTED CHANGE IN ORDER RATE
C     DRIC=6                  DELAY IN RECEIVING AND INSTALLING CAPACITY
R     PRCO.KL=CLIP(PCDF.K,0.0,PCDF.K,0.0)     PRODUCTION CAPACITY ORDER RATE
A     PCOF.K=(PCDF.K-PRCA.K-PCOO.K)/TAPC          PRODUCTION CAPACITY ORDERS
C     TAPC=1                            TIME TO ADJUST PRODUCTION CAPACITY
R     PCAR.KL=DELAY3(PRCO.JK,DRIC)      PRODUCTION CAPACITY ADDITION RATE
```

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```
L     PCOO.K=PCOO.J+(DT)(PRCO.JK-PCAR.JK)        PRODUCTION CAPACITY ON ORDER
N     PCOO=0
R     PCOR.KL=DELAY3(PCAR.JK,ALCF)    PRODUCTION CAPACITY OBSOLESCENCE RATE
C     ALCF=180                AVERAGE LIFETIME OF CAPACITY AT FACTORY
L     PRCA.K=PRCA.J+(DT)(PCAR.JK-PCOR.JK)        PRODUCTION CAPACITY
N     PRCA=12000000
NOTE
NOTE     PERSONNEL REQUIREMENT SECTOR
NOTE
A     TPDF.K=CLIP(TPDU.K,TPDO.K,PRCA.K,AVMR.K)  TECHNICAL PERSONNEL DESIRED
A     TPDU.K=AVMR.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING UNDERCAPACITY
A     TPDO.K=PRCA.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING OVERCAPACITY
C     PTPF=300000            PRODUCTIVITY OF TECHNICAL PERSONNEL AT FACTORY
A     PPDF.K=MPPD+(PRCA.K/PPPF)        PROFESIONAL PERSONNEL DESIRED
C     MPPD=8                 MINIMUM NUMBER OF PROFESSIONAL PERSONNEL DESIRED
C     PPPF=2400000          PRODUCTIVITY OF PROFESSIONAL PERSONNEL AT FACTORY
A     RTPF.K=TPDF.K/(TPDF.K+PPDF.K)   RATIO OF TECHNICAL TO PROFESSIONAL
NOTE                                  PERSONNEL AT FACTORY
A     PCIF.K=(TPDF.K+PPDF.K-PITF.K-PPLF.K)/TPAF PERSONNEL CHANGE INDICATED
C     TPAF=1                 TIME FOR PERSONNEL ADJUSTMENT AT FACTORY
R     PHRF.KL=CLIP(PCIF.K,0,PCIF.K,0) PERSONNEL HIRING RATE AT FACTORY
R     PDRF.KL=CLIP(0,-PCIF.K,PCIF.K,0)  PERSONNEL DISMISSAL RATE AT FACTORY
L     PITF.K=PITF.J+(DT)(PHRF.JK-PBPF.JK)        PERSONNEL IN TRAINING
N     PITF=0
R     PBPF.KL=DELAY3(PHRF.JK,DPTF)     PERSONNEL BECOMING PRODUCTIVE
C     DPTF=0.5               DELAY DUE TO PERSONNEL TRAINING AT FACTORY
L     PPLF.K=PPLF.J+(DT)(PBPF.JK-PDRF.JK)        PRODUCTIVE PERSONNEL LEVEL
N     PPLF=TPDF+PPDF
A     PERC.K=PITF.K+PPLF.K                       PERSONNEL IN THE COMPANY
NOTE
NOTE
NOTE     PROFIT SECTOR
NOTE
A     REVS.K=(USPC)(AVSR.K)                      REVENUE FROM SALES
L     AVSR.K=AVSR.J+(DT)(SSFI.JK-AVSR.J)/DSSR    AVERAGE SHIPPING RATE
N     AVSR=SSFI
C     DSSR=1
A     MANC.K=RMCO.K+WAGE.K+SALA.K+PROE.K                    MANUFACTURING COST
A     RMCO.K=(PKRM)(AVMR.K)/CKRM                            RAW MATERIAL COST
C     CKRM=1000                          CIGARETTES PER KG. OF RAW MATERIAL
C     PKRM=70                            PRICE PER KG. OF RAW MATERIAL
A     WAGE.K=(WARA.K)(RTPF.K)(PERC.K)            WAGES
A     WARA.K=TABHL(WRTA,TIME.K,55,67,12)         WAGE RATE
A     SALA.K=(SALR)(1-RTPF.K)(PERC.K)            SALARIES
C     SALR=12000                                 SALARY RATE
A     PROE.K=(UCPR)(AVMR.K)                      PRODUCTION EXPENSES
C     UCPR=.015                                  UNIT COST OF PRODUCTION
A     COSA.K=(UMCO.K)(AVSR.K)                    COST OS SALES
A     UMCO.K=MANC.K/AVMR.K                       UNIT MANUFACTURING COST
A     EXDU.K=(DUTY)(USPC)(AVSR.K)                EXCISE DUTY
C     DUTY=.28                                   DUTY RATE
A     SELE.K=(FRSE)(USPC)(AVSR.K)                SELLING EXPENDITURES
C     FRSE=0.1              FRACTION OF REVENUE FOR SELLING EXPENDITURES
L     ADEX.K=ADEX.J+(DT)(ADDE.JK-ADEX.J)/DSAE    ADVERTIZING EXPENDITURES
N     ADEX=ADDE
C     DSAE=1                DELAY IN SMOOTHING ADVERTIZING EXPENDITURES
A     TPRO.K=REVS.K-COSA.K-EXDU.K-SELE.K-ADEX.K TRADE PROFIT
NOTE
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NOTE
NOTE      TABLES AND SUPPLEMENTARY EQUATIONS
NOTE
T       PRAT=0.0,.32,.55,.72,.85,1.0
T       WRTA=1000,1500
S       SALE.K=TABLE(STAB,TIME.K,0,67,1)
T       STAB=5301120,5743960,6884420,7470580,8352800,5383000,3798000,
X       6677000,7891000,8415230,7631540,8692900,11151520,9691160,13204800,
X       13011200,14236350,11379190,12709210,14790290,13915990,13806920,
X       13541090,14913780,15017140,17111640,17400920,16491540,22604960,
X       19007000,21377100,21368200,23371000,21720000,17682000,19576000,
X       20280000,19974000,21829050,20086125,24741950,19553700,21517650,
X       20721500,14326000,16119000,13902000,16136000,21024000,20328000,
X       21136000,25337000,2265100C,28104000,27640000,28737000,23891000,
X       29910000,26364000,28127000,30686000,20939000,28541000,30561000,
X       24710000,31084000,26790000,32701000
S       MANF.K=TABLE(MTAB,TIME.K,0,67,1)
T       MTAB=5234080,5774320,6896300,9755300,9527100,6313220,7084540,
X       7761760,7398910,9008700,1035540C,9915150,13398710,12155730,
X       12093630,12235000,16595320,15061790,16151800,10325290,10915150,
X       17067100,14418120,16861400,18268800,19403400,19124400,18769430,
X       27506300,23888200,23336350,24658000,16989400,24377550,20174800,
X       2035840C,18972550,19444600,19188250,19301500,21280000,20518500,
X       20096200,15944800,14697000,14442000,17110000,18502000,20133000,
X       22146000,23814000,26441000,27739000,2569800C,26098000,24014000,
X       27916000,32670000,31401000,31837000,31025000,26023000,25109000,
X       28970000,2427200C,29325000,29616000,27181000
S       CORM.K=TABLE(RTAB,TIME.K,0,67,1)
T       RTAB=323000,320000,350000,572000,513000,345000,388000,462000,
X       523000,608000,621000,702000,731000,798000,832000,916000,1102000,
X       941000,934000,622000,918000,962000,1006000,1050000,1038000,
X       1112000,1190000,1323000,1616000,1447000,1470000,960000,1492000,
X       1354000,1432000,1583000,1621000,1267000,1186000,1390000,1353000,
X       1292000,1311000,1050000,963000,1009000,1140000,1214000,1213000,
X       1436000,1556000,1731000,1866000,1726000,1734000,1565000,1877000,
X       2149000,2083000,2315000,2068000,1657000,1687000,1974000,1651000,
X       2081000,2136000,2181000
S       WAGS.K=TABLE(WTAB,TIME.K,0,67,1)
T       WTAB=29100,17800,19150,20820,16929,15219,16595,18513,21730,25910,
X       26230,29120,35180,36030,37180,38250,43500,47800,43100,42700,43800,
X       44900,46300,48200,50100,51400,50600,55100,59200,53800,46000,40900,
X       50000,55000,55000,60000,65000,69400,62400,55500,60000,55200,56900,
X       41900,54000,55000,60000,60000,59000,61000,73000,85000,80000,98000,
X       97000,87000,130000,122000,122000,116000,122000,123000,129000,
X       143000,129000,164000,139000,142000
S       SALS.K=TABLE(SALT,TIME.K,0,67,1)
T       SALT=155000,206000,124000,133000,148000,122000,115000,216000,
X       135000,124000,152000,131000,157000,163000,145000,185000,198000,
X       194000,239000,147000,153000,142000,186000,172000,191000,203000,
X       200000,220000,282000,244000,247000,133000,196000,198000,209000,
X       200000,250000,271000,250000,288000,311000,184000,181000,310000,
X       248000,244000,292000,253000,262000,289000,261000,269000,263000,
X       254000,257000,221000,168000,195000,197000,205000,188000,171000,
X       207000,215000,187000,216000,232000,220000
S       MACO.K=TABLE(MANT,TIME.K,0,67,1)
T       MANT=607000,669000,709000,870000,899000,663000,671000,887000,
X       902000,1003000,1032000,1090000,1143000,1190000,1240000,1311000,
X       1447000,1409000,1427000,984000,1030000,1102000,1309000,1451000,
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X     1505000,1662000,1895000,1807000,2185000,1958000,1990000,1327000,
X     2265000,2095000,2318000,2065000,2531000,2611000,1698000,1761000,
X     1907000,1827000,1842000,1623000,1470000,1509000,1722000,1792000,
X     1857000,2039000,2183000,2399000,2524000,2389000,2389000,2095000,
X     2537000,2881000,2892000,3128000,2882000,2503000,2445000,2789000,
X     2402000,2981000,2971000,2983000
S     SACO.K=TABLE(COST,TIME.K,0,67,1)
T     COST=518000,671000,713000,685000,784000,566000,398000,720000,
X     900000,1000000,1050000,1100000,1140000,1200000,1200000,1200000,
X     1300000,1329000,1053000,1139000,1377000,1100000,1200000,1300000,
X     1400000,1500000,1600000,1700000,1800000,1865000,1559000,1775000,
X     1816000,1500000,1600000,1700000,1750000,1800000,1854000,2031000,
X     1852000,2249000,1760000,1953000,1983000,1406000,1637000,1406000,
X     1637000,1405000,1592000,2313000,2059000,2582000,2534000,2569000,
X     2164000,2668000,2385000,2691000,2879000,2005000,2726000,2934000,
X     2416000,3078000,2712000,3408000
S     TRPR.K=TABLE(PROT,TIME.K,0,67,1)
T     PROT=-114000,-139726,-141550,183560,-1686,-134602,-195000,
X     -361900,15600,-16300,-2630,145200,225300,35000,25600,23400,38267
X     33400,2280,33530,52300,59400,128000,286000,432000,568000,283000,
X     543000,795200,282700,527000,660500,532000,415000,65200,315000,
X     295000,202000,227000,230000,501000,231000,411000,211000,-134,
X     50000,30300,137000,514000,462000,220000,499000,431000,589000,
X     481000,832000,579000,680000,589000,456000,633000,262000,606000,
X     669000,319000,459000,483000,428000
NOTE
NOTE      CONTROL CARDS
NOTE
PRINT 1)SALE/2)MANF/3)CORM/4)WAGS/5)SALS/6)MACO/7)SACO/8)TRPR
PRINT 1)SARA/2)AVMR/3)RMCO/4)WAGE/5)SALA/6)MANC/7)COSA/8)TPRO
PLOT CACB=A,MASH=M,PMSC=P
PLOT SALE=*,SARA=S
PLOT MANF=+,AVMR=A
PLOT CORM=*,RMCO=R
PLOT WAGS=*,WAGE=W
PLOT SALS=*,SALA=S
PLOT MACO=*,MANC=M
PLOT SACO=*,COSA=C
PLOT TRPR=$,TPRO=P
PLOT ORRE=O,PRCA=P
SPEC DT=0.05/LENGTH=67/PRTPER=1/PLTPER=1
RUN STD
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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
E+00	E+06 E+06	E+06 E+06	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03
.0	5.301 2.845	5.234 3.690	323.0 258.3	29.10 12.30	155.00 156.00	607.0 481.9	518.0 481.9	-114.00 -59.81
1.	5.744 3.922	5.774 3.971	320.0 277.9	17.80 12.86	206.00 151.59	669.0 502.0	671.0 528.5	-139.73 -40.72
2.	6.884 5.054	6.896 4.919	350.0 344.4	19.15 15.07	124.00 143.35	709.0 576.6	713.0 595.5	-141.55 5.05
3.	7.471 6.086	9.755 6.223	572.0 435.6	20.82 18.49	133.00 139.03	870.0 686.4	685.0 674.3	183.55 46.78
4.	8.353 7.136	9.527 7.589	513.0 531.2	16.93 22.50	148.00 138.74	899.0 806.3	784.0 759.7	-1.68 76.60
5.	5.383 8.161	6.313 8.920	345.0 624.4	15.22 26.70	122.00 140.10	663.0 925.0	566.0 849.7	-134.59 100.46
6.	3.798 9.132	7.084 10.166	388.0 711.6	16.59 30.85	115.00 142.02	671.0 1037.0	398.0 937.7	-195.00 120.26
7.	6.877 10.069	7.762 11.236	462.0 786.5	18.31 34.68	215.99 144.47	887.0 1134.2	720.0 1023.4	-361.80 136.87
8.	7.891 10.961	7.399 11.727	523.0 820.9	21.73 37.36	135.01 149.13	902.0 1183.3	900.0 1114.1	15.56 149.15
9.	8.415 11.829	9.009 11.918	608.0 834.3	25.91 38.81	124.00 152.63	1003.0 1204.5	1000.0 1202.3	-16.30 166.15
10.	7.632 12.662	10.355 12.042	621.0 842.9	26.23 39.58	152.00 154.70	1032.0 1217.8	1050.0 1287.2	-2.63 188.56
11.	8.693 13.468	9.915 12.208	702.0 854.6	29.12 40.16	131.00 156.04	1090.0 1233.9	1100.0 1367.6	145.18 213.55
12.	11.151 14.249	13.398 12.472	731.0 873.0	35.18 40.86	157.00 157.24	1143.0 1258.2	1140.0 1443.4	225.29 239.08
13.	9.691 15.008	12.156 12.853	798.0 899.7	36.03 41.85	163.00 158.71	1190.0 1293.1	1200.0 1515.1	35.04 263.76
14.	13.204 15.657	12.094 15.027	832.0 1051.9	37.18 44.27	145.00 158.11	1240.0 1479.7	1200.0 1557.7	25.60 302.88
15.	13.011 16.443	12.235 16.384	916.0 1146.9	38.25 46.59	184.99 161.85	1311.0 1601.1	1200.0 1565.2	23.40 289.70
16.	14.236 17.167	16.594 17.410	1102.0 1218.7	43.50 48.98	198.00 165.43	1447.0 1694.2	1300.0 1694.8	38.26 322.58

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
17.	11.381	15.063	941.1	47.80	194.00	1409.0	1329.0	2.30
	17.724	17.803	1246.2	51.50	169.18	1733.9	1765.7	326.33
17.999	12.708	16.151	934.0	43.10	238.97	1427.0	1053.2	33.51
	18.069	18.694	1308.6	54.10	173.16	1816.3	1768.2	319.36
18.999	14.788	10.331	622.3	42.70	147.09	984.4	1138.9	52.28
	18.417	18.891	1322.4	56.74	177.28	1839.8	1811.9	317.88
19.999	13.917	10.914	917.6	43.80	152.99	1029.9	1376.7	59.39
	18.492	18.418	1289.2	59.28	181.91	1806.7	1842.7	311.86
20.999	13.807	17.058	961.9	44.90	142.02	1101.9	1100.4	127.90
	18.557	18.708	1309.6	60.91	187.36	1838.5	1843.5	307.37
21.998	13.542	14.423	1005.9	46.30	185.93	1308.6	1199.8	285.73
	18.816	19.223	1345.6	62.54	190.16	1886.6	1842.9	304.08
22.998	14.911	16.857	1049.9	48.20	172.03	1450.7	1299.8	431.72
	19.154	19.758	1383.0	64.29	192.65	1936.3	1865.0	306.62
23.998	15.017	18.266	1038.0	50.10	190.96	1504.9	1399.8	567.70
	19.497	20.236	1416.5	65.99	195.06	1981.1	1899.7	312.35
24.998	17.107	19.401	1111.8	51.40	202.97	1661.6	1499.8	282.69
	19.818	20.635	1444.5	67.52	197.26	2018.8	1935.6	318.41
25.997	17.400	19.125	1189.8	50.60	200.01	1894.4	1599.7	542.31
	20.105	20.957	1467.0	68.80	199.17	2049.3	1967.6	323.66
26.997	16.494	18.770	1322.6	55.09	219.94	1807.3	1699.7	794.46
	20.360	21.218	1485.3	69.86	200.79	2074.2	1994.4	328.06
27.997	22.586	27.479	1615.1	59.19	281.80	2183.8	1799.7	284.32
	20.592	21.443	1501.0	70.74	202.17	2095.5	2017.1	331.92
28.997	19.019	23.900	1447.6	53.82	244.13	1958.8	1864.8	526.17
	20.809	21.649	1515.4	71.50	203.37	2115.0	2037.0	335.57
29.996	21.368	23.338	1469.9	46.03	246.99	1989.9	1560.1	660.01
	21.020	21.848	1529.3	72.20	204.46	2133.7	2055.7	339.27
30.996	21.368	24.653	962.0	40.92	133.44	1329.6	1774.2	532.50
	21.227	22.042	1543.0	72.87	205.48	2152.0	2074.2	343.18
31.996	23.363	17.021	1489.8	49.96	195.74	2261.1	1815.8	415.48
	21.433	22.232	1556.2	73.52	206.45	2169.7	2092.8	347.31
32.996	21.727	24.345	1354.6	54.98	197.99	2095.7	1501.4	66.73
	21.637	22.414	1569.0	74.15	207.39	2186.7	2111.6	351.61
33.995	17.701	20.194	1431.6	55.00	208.95	2317.0	1599.5	313.85
	21.837	22.587	1581.1	74.75	208.28	2202.9	2130.4	356.03

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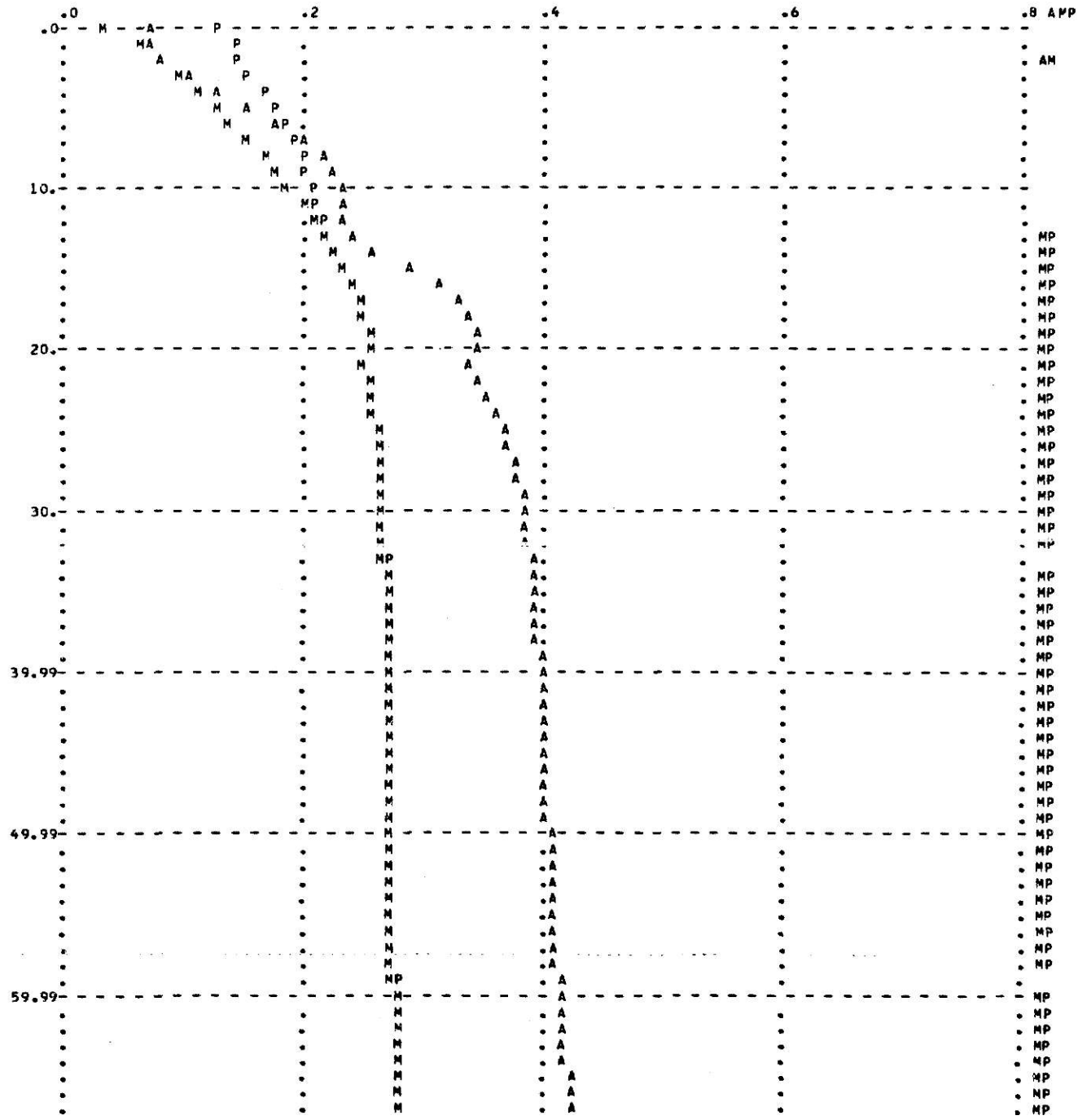
TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
34.995	19.567	20.358	1582.3	59.98	200.04	2066.2	1699.5	295.10
	22.033	22.750	1592.5	75.33	209.13	2218.2	2149.0	360.48
35.995	20.276	18.980	1620.8	64.97	249.74	2528.6	1749.7	202.48
	22.225	22.904	1603.3	75.87	209.94	2232.6	2167.2	364.94
36.995	19.976	19.442	1268.9	69.38	270.89	2610.6	1799.7	226.87
	22.413	23.051	1613.6	76.38	210.71	2246.4	2185.0	369.40
37.994	21.819	19.190	1186.5	62.44	250.12	1703.1	1853.7	229.98
	22.599	23.193	1623.5	76.87	211.45	2259.7	2202.5	373.86
38.994	20.096	19.301	1388.8	55.54	287.78	1760.6	2030.0	499.42
	22.782	23.332	1633.2	77.34	212.17	2272.7	2219.7	378.33
39.994	24.714	21.268	1353.2	59.97	310.86	1906.1	1853.1	232.64
	22.964	23.467	1642.7	77.81	212.87	2285.4	2236.8	382.82
40.994	19.587	20.523	1292.4	55.23	184.80	1827.5	2246.5	409.86
	23.144	23.602	1652.1	78.26	213.55	2297.9	2253.8	387.34
41.993	21.505	20.099	1310.9	56.89	181.02	1841.9	1763.2	212.32
	23.325	23.734	1661.4	78.71	214.22	2310.3	2270.7	391.89
42.993	20.727	19.973	1051.8	47.88	309.12	1624.5	1991.7	1.31
	23.504	23.866	1670.6	79.15	214.89	2322.7	2287.6	396.46
43.993	14.371	14.706	963.6	53.91	248.44	1471.1	1982.8	49.65
	23.684	23.998	1679.8	79.59	215.55	2335.0	2304.5	401.05
44.993	16.106	14.444	1008.7	54.99	244.03	1508.7	1410.2	30.44
	23.863	24.129	1689.1	80.03	216.22	2347.2	2321.4	405.66
45.992	13.919	17.090	1139.0	59.96	291.64	1720.4	1635.3	136.19
	24.043	24.262	1698.3	80.47	216.88	2359.6	2338.3	410.28
46.992	16.119	18.491	1213.4	60.00	253.30	1791.5	1407.8	511.06
	24.223	24.395	1707.6	80.91	217.55	2372.0	2355.2	414.92
47.992	20.985	20.120	1213.0	59.01	261.93	1856.5	1635.1	462.42
	24.403	24.529	1717.0	81.35	218.22	2384.5	2372.2	419.57
48.992	20.334	22.129	1434.2	60.98	288.78	2037.5	1406.9	222.01
	24.585	24.665	1726.5	81.80	218.90	2397.2	2389.3	424.24
49.991	21.129	23.800	1555.0	72.90	261.24	2181.8	1590.4	496.62
	24.767	24.803	1736.2	82.25	219.58	2410.0	2406.5	428.92
50.991	25.300	26.418	1729.5	84.89	268.93	2397.1	2306.7	431.60
	24.951	24.942	1746.0	82.71	220.28	2423.1	2423.7	433.62
51.991	22.675	27.727	1864.8	80.05	263.05	2522.9	2061.3	587.58
	25.136	25.085	1755.9	83.18	220.99	2436.4	2441.1	438.34

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
52.991	28.053	25.717	1727.3	97.83	254.08	2390.3	2577.2	482.00
	25.322	25.229	1766.1	83.66	221.71	2449.9	2458.6	443.07
53.99	27.644	26.094	1733.9	97.01	256.97	2389.0	2534.5	828.66
	25.509	25.377	1776.4	84.14	222.44	2463.6	2476.2	447.82
54.99	28.726	24.034	1566.6	87.10	221.35	2097.9	2568.7	581.47
	25.698	25.527	1786.9	84.63	223.18	2477.6	2493.9	452.58
55.99	23.939	27.877	1873.9	129.57	168.53	2532.6	2168.0	678.99
	25.889	25.680	1797.6	88.64	223.94	2495.4	2515.4	453.82
56.99	29.848	32.621	2146.2	122.08	194.72	2877.5	2662.8	589.93
	26.081	25.836	1808.5	92.74	224.72	2513.5	2537.0	454.98
57.99	26.401	31.414	2083.7	122.00	196.98	2891.9	2388.0	457.39
	26.275	25.994	1819.6	96.89	225.50	2531.9	2558.9	456.12
58.989	28.108	31.832	2312.5	116.06	204.91	3125.5	2687.7	631.10
	26.471	26.156	1830.9	101.10	226.31	2550.7	2581.0	457.21
59.989	30.658	31.034	2070.7	121.93	188.19	2884.7	2876.9	266.07
	26.668	26.321	1842.5	105.37	227.12	2569.8	2603.3	458.26
60.989	21.048	26.079	1661.6	122.99	171.19	2507.3	2014.8	602.14
	26.867	26.489	1854.2	109.69	227.96	2589.2	2625.8	459.28
61.989	28.454	25.119	1686.7	128.93	206.59	2445.7	2717.7	668.28
	27.068	26.660	1866.2	114.07	228.81	2609.0	2648.6	460.26
62.988	30.537	28.925	1970.6	142.84	214.91	2785.0	2931.6	323.10
	27.271	26.834	1878.4	118.51	229.67	2629.0	2671.5	461.19
63.988	24.780	24.328	1654.9	129.17	187.33	2406.6	2422.2	457.33
	27.476	27.011	1890.8	123.01	230.55	2649.5	2694.7	462.09
64.988	31.006	29.263	2075.8	163.57	215.65	2973.9	3069.9	482.71
	27.682	27.191	1903.3	127.57	231.44	2670.2	2718.1	462.95
65.988	26.843	29.612	2135.3	139.31	231.80	2971.1	2716.6	428.68
	27.890	27.374	1916.1	132.20	232.35	2691.3	2741.7	463.76
66.987	32.626	27.212	2180.4	141.96	220.15	2982.8	3399.2	428.00
	28.100	27.559	1929.2	136.89	233.27	2712.7	2765.6	464.53

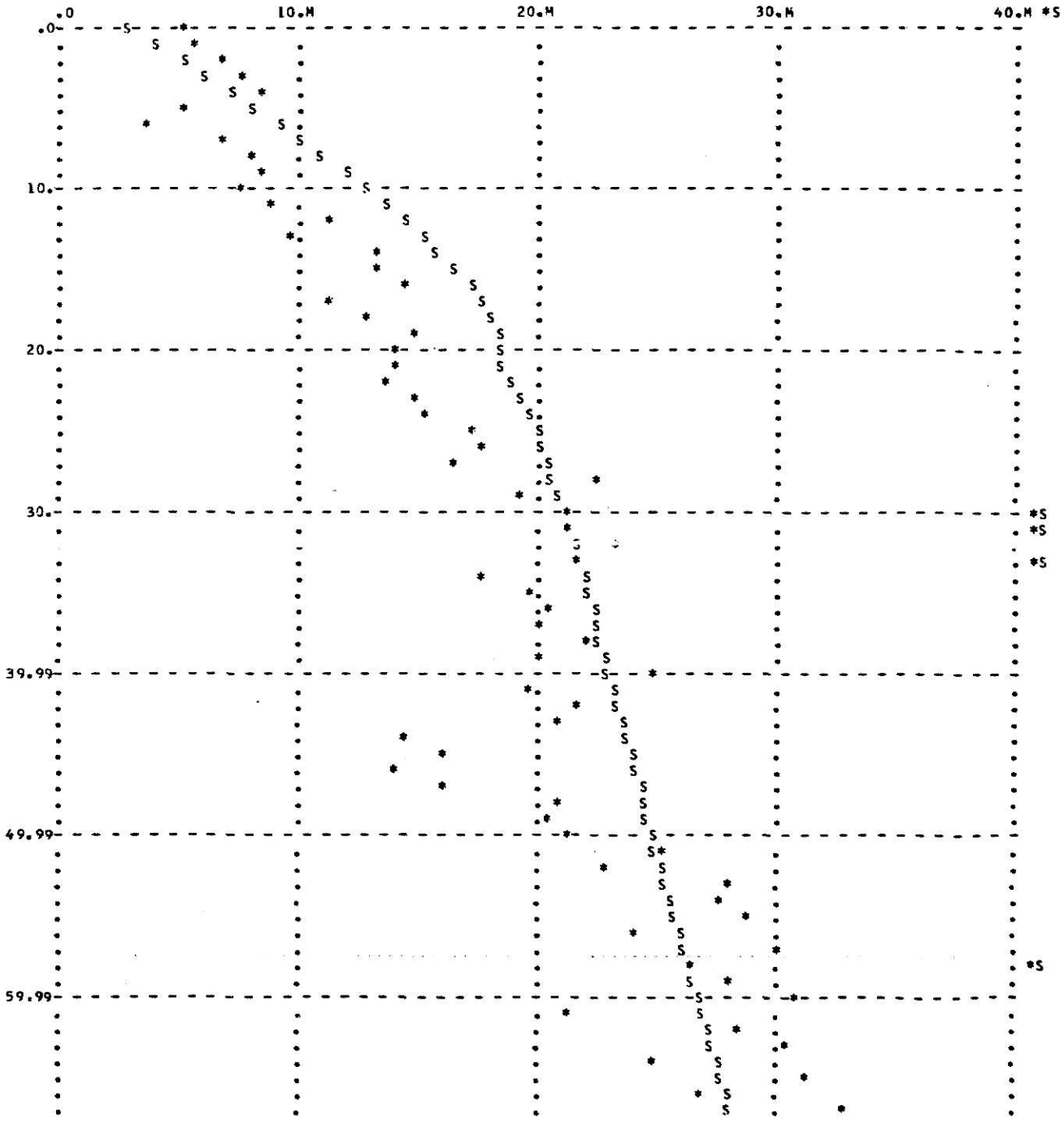
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CACB=A,MASH=M,PMSC=P



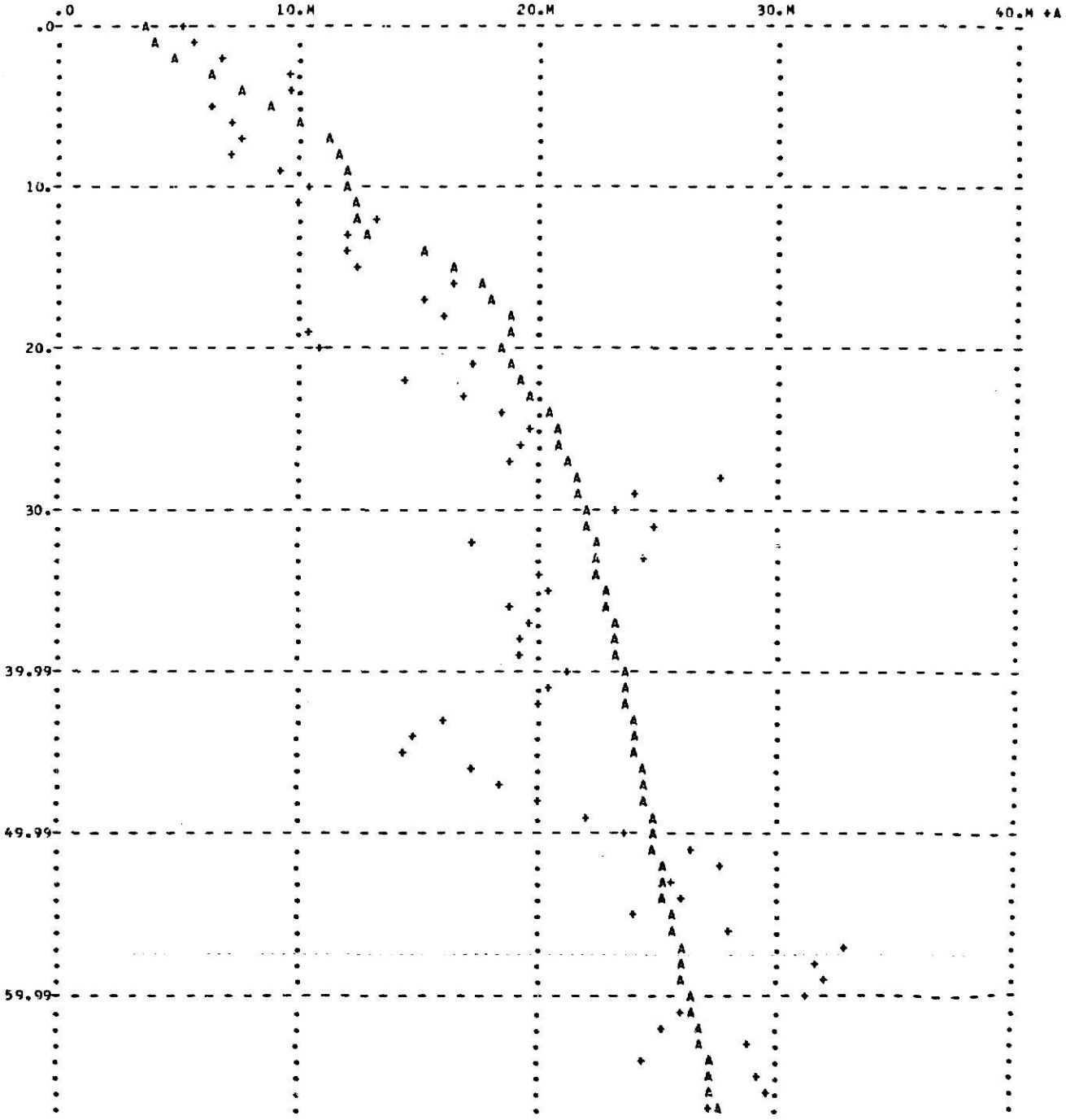
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SALE=*,SARA=S



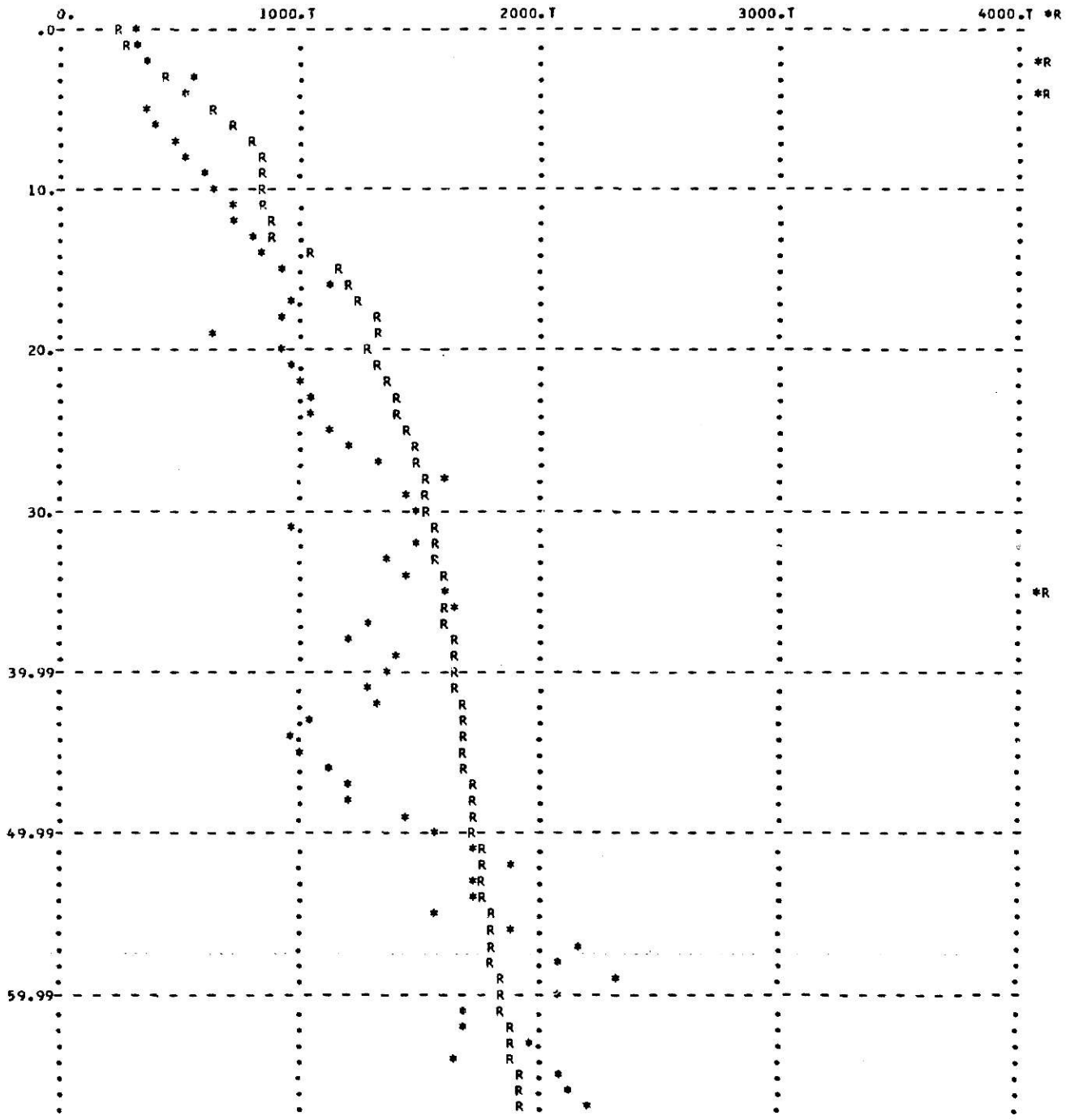
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MANF=+,AVMR=A



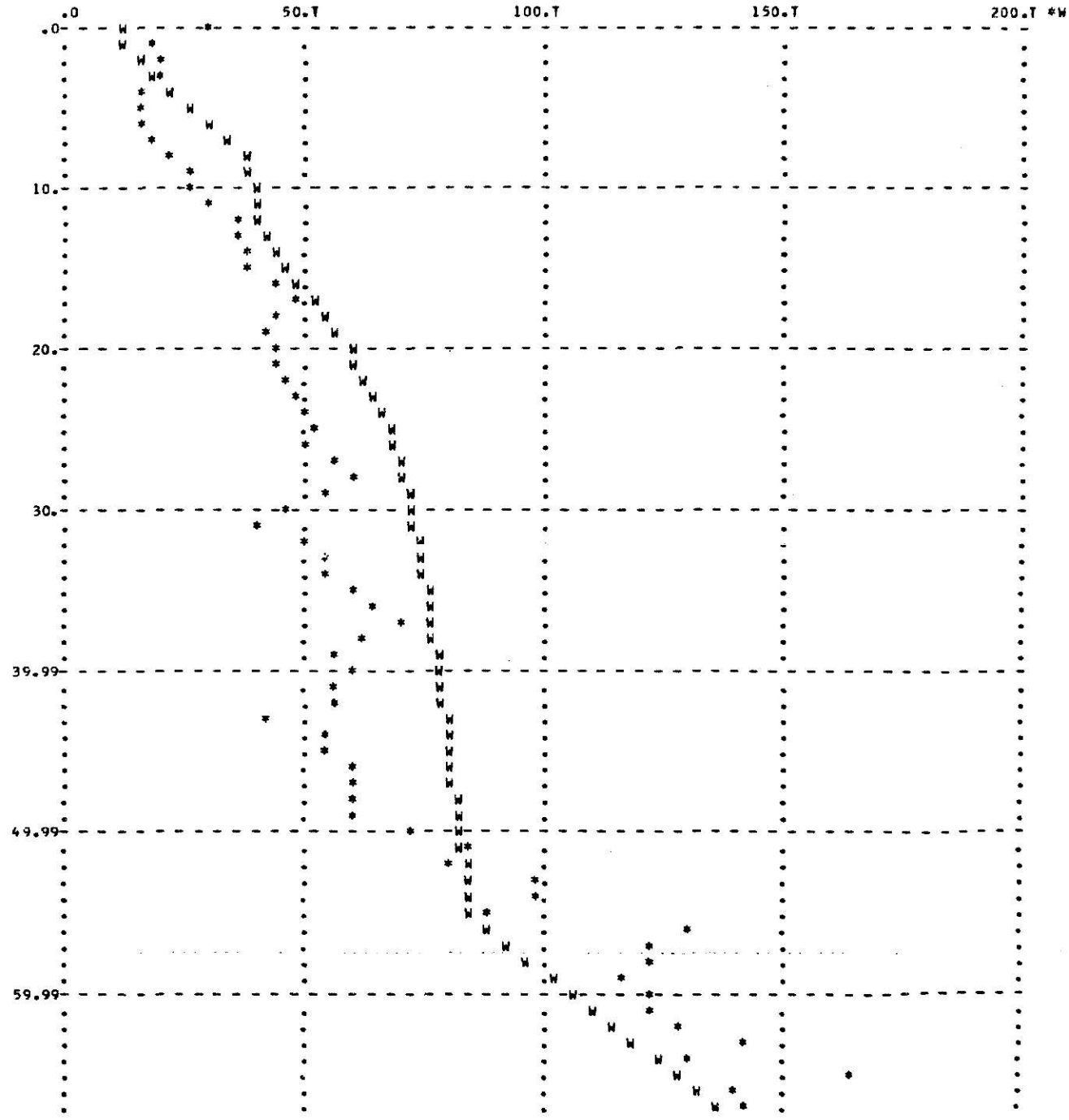
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CORM=*,RMCO=R



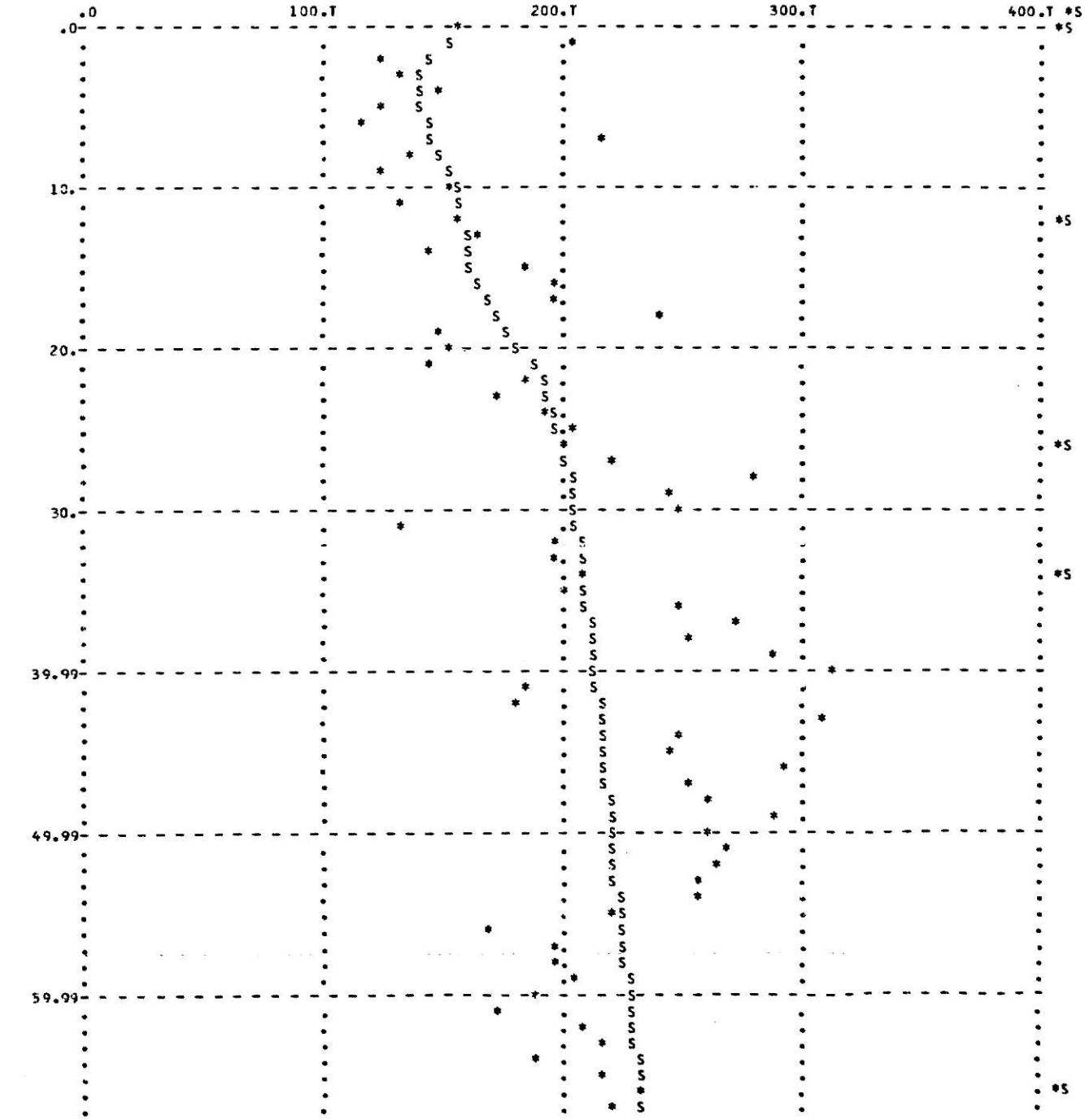
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WAGS=*,WAGE=W



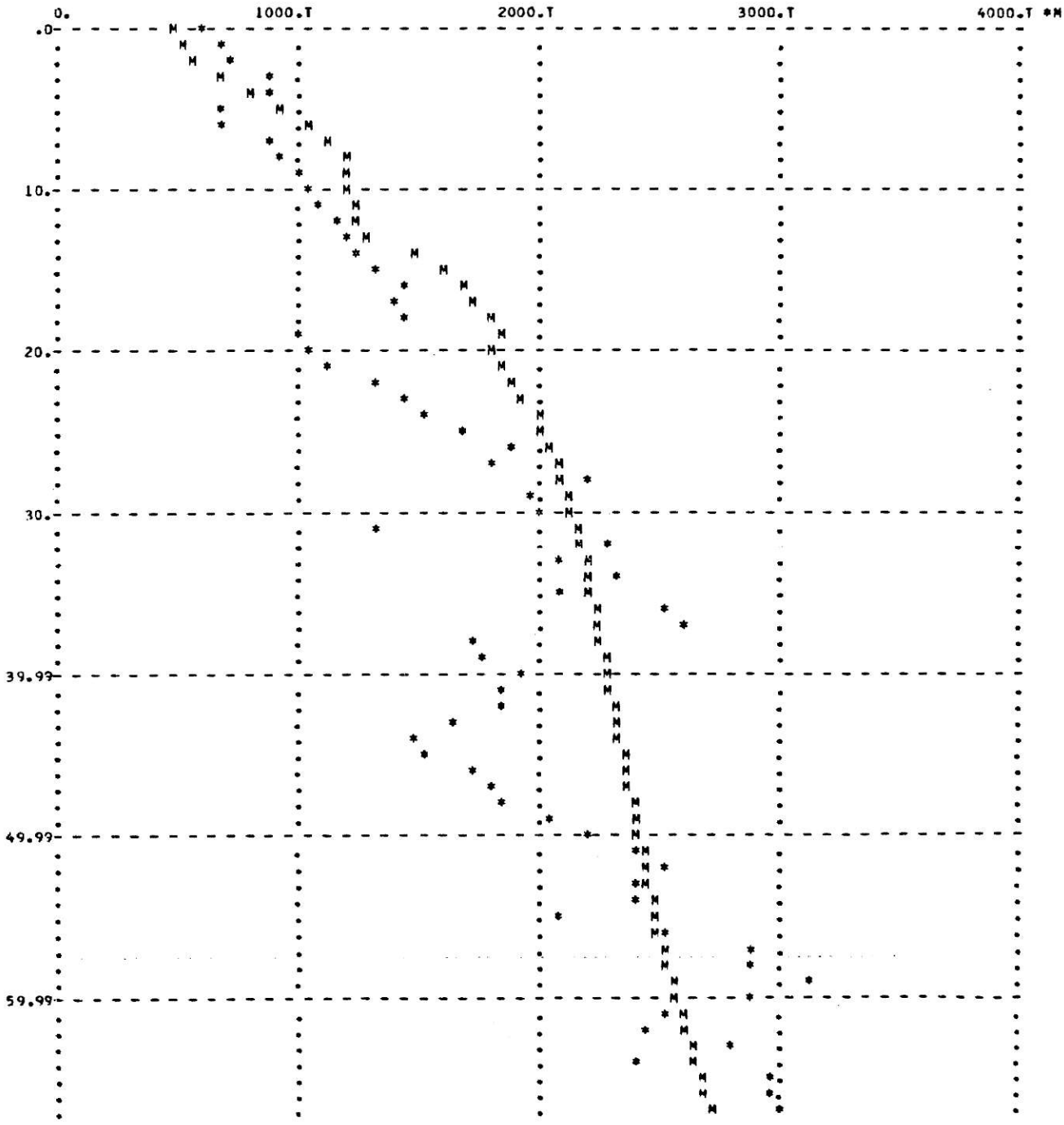
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SALS=*,SALA=S



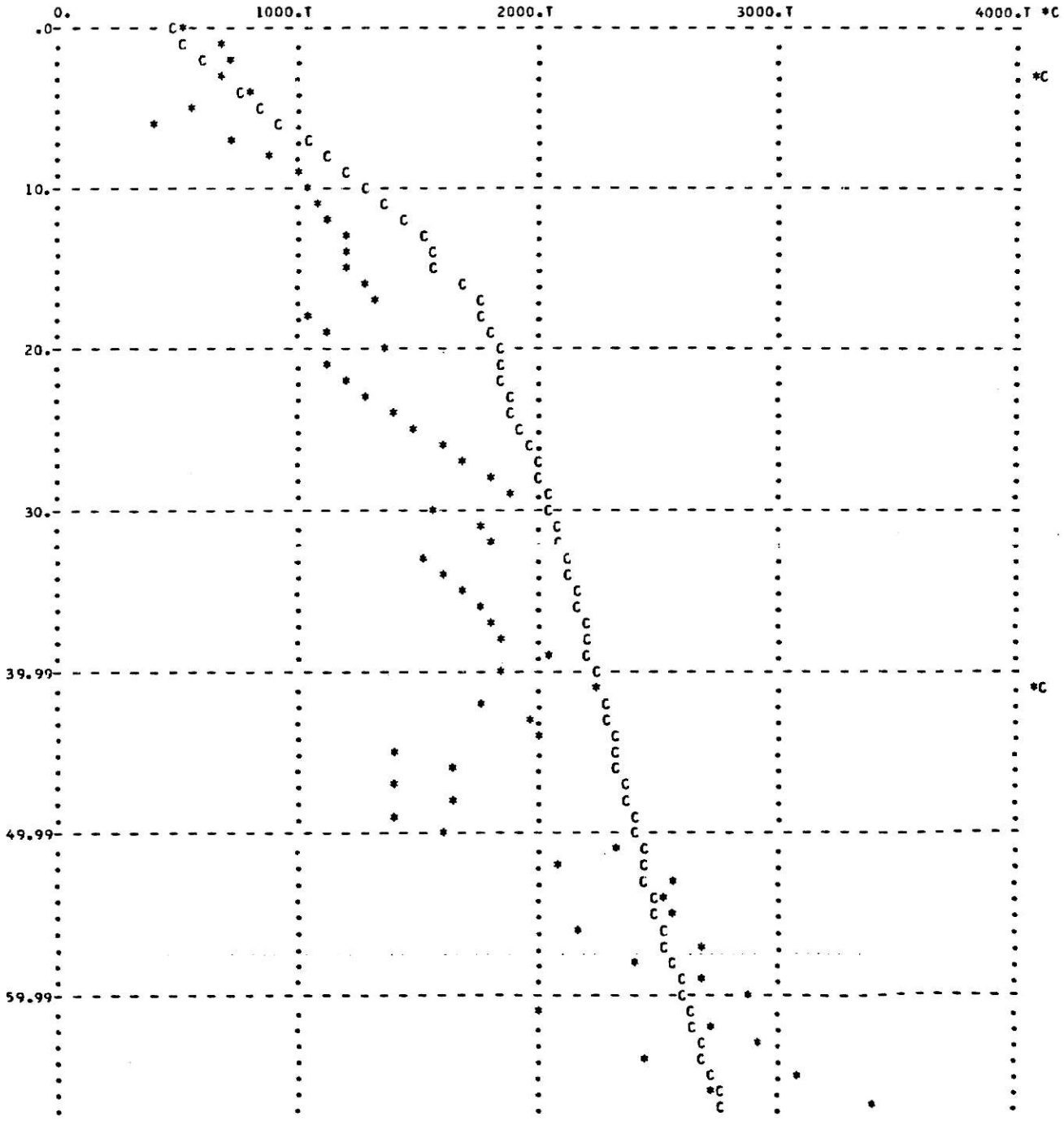
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MACO=,MANC=M



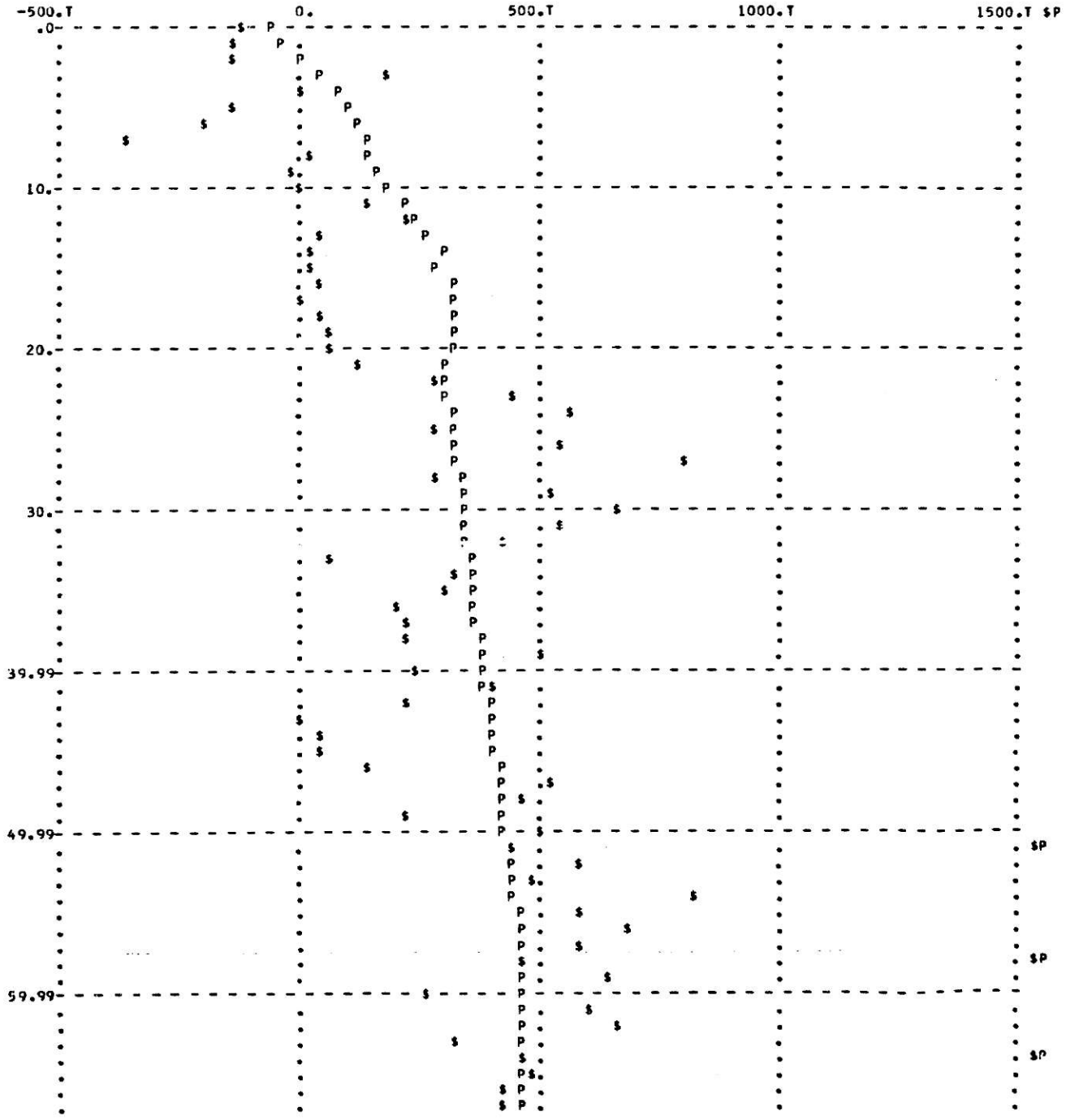
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SACO=*,COSA=C



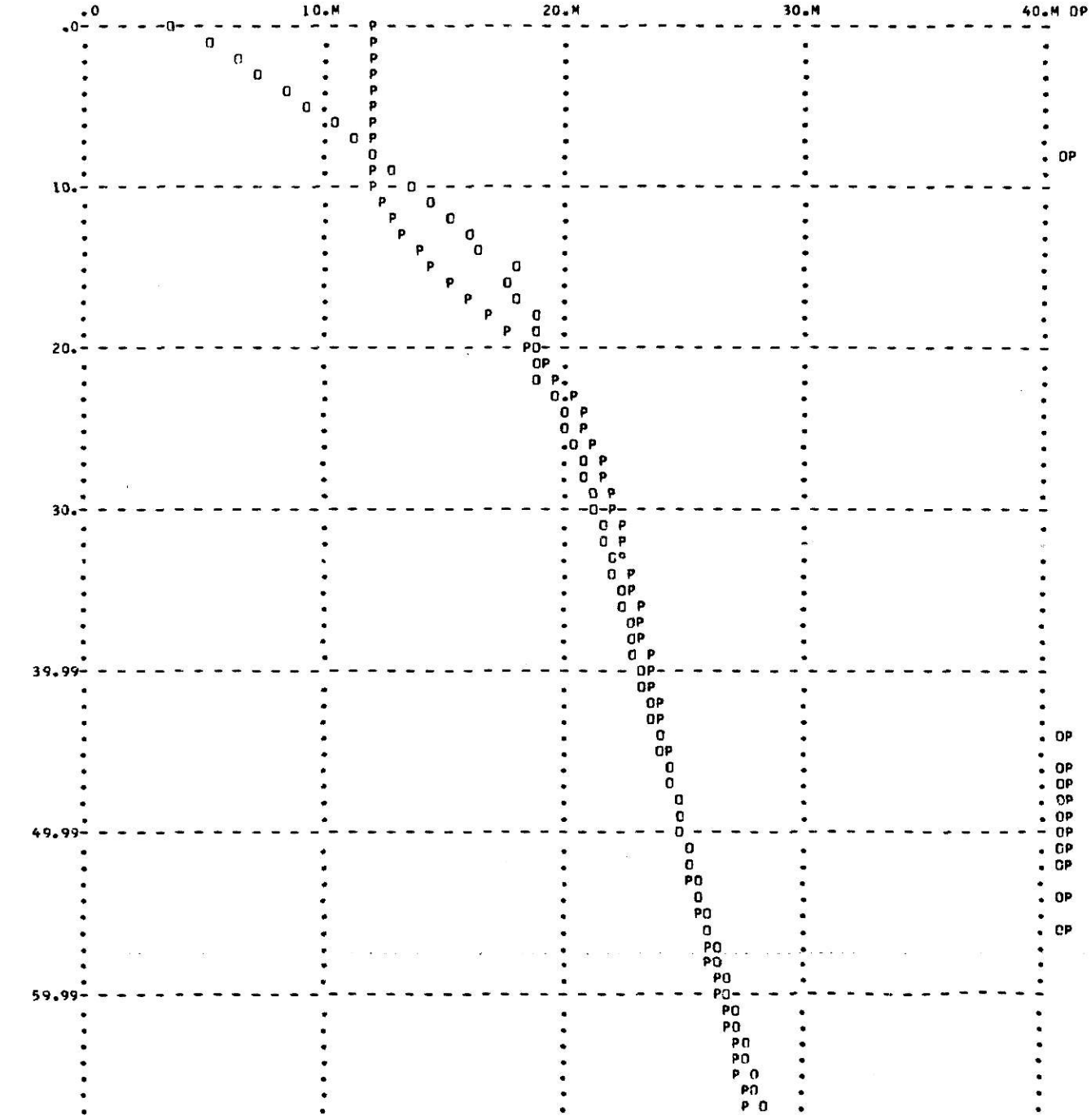
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TRPR=$,TPRD=P



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ORRF=O,PRCA=P



APPENDIX B

Computer Program for Company Sector Performance Test

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NOTE----------------------------------------------------------------------
NOTE
NOTE        MODEL OF CIGARETTE MANUFACTURING COMPANY IN MOZAMBIQUE
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE                              THE COMPANY
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE     ORDER FILLING SECTOR
NOTE
R      ORRF.KL=ORDE.K                                  ORDER RATE USED AS AN INPUT
A      ORDE.K=TABLE(OTAB,TIME.K,0,67,1)               ORDERS - MAY 1968 TO DEC 1973
L      UNOF.K=UNOF.J+(DT)(ORRF.JK-SSFI.JK)             UNFILLED ORDERS AT FACTORY
N      UNOF=UODF
L      INVF.K=INVF.J+(DT)(PRFI.JK-SSFI.JK)             INVENTORY AT THE FACTORY
N      INVF=INDF
R      SSFI.KL=CLIP(NSRF.K,RSRF.K,INVF.K,UNOF.K) SHIPMENTS SENT FROM FACTORY
A      NSRF.K=UNOF.K/DFOF                NORMAL SHIPPING RATE FROM FACTORY
A      RSRF.K=INVF.K/DFOF                RESTRICTED SHIPPING RATE FROM FACTORY
C      DFOF=0.1                          DELAY IN FILLING ORDERS AT FACTORY
NOTE
NOTE     MANUFACTURING SECTOR
NOTE
A      MRDF.K=SORF.K+(UNOF.K-UODF.K+INDF.K-INVF.K-WIPF.K)/TAIB MANUFACTURING
NOTE                                                   RATE DESIRED AT FACTORY
C      TAIB=3                            TIME TO ADJUST INVENTORY AND BACKLOG
L      SORF.K=SORF.J+(DT)(ORRF.JK-SORF.J)/DSOR SMOOTHED ORDER RATE AT FACTORY
N      SORF=ORRF
C      DSOR=1                            DELAY IN SMOOTHING ORDER RATE
A      INDF.K=MIDF+(PIDF)(SORF.K)                     INVENTORY DESIRED AT FACTORY
C      MIDF=1000000                      MINIMUM INVENTORY DESIRED AT FACTORY
C      PIDF=1.5                          PERIOD OF INVENTORY DESIRED AT FACTORY
A      UODF.K=(DFOF)(SORF.K)             UNFILLED ORDERS DESIRED AT FACTORY
A      SSPC.K=PRCA.K+PCCO.K              SINGLE SHIFT PRODUCTION CAPABILITY
A      DSPC.K=2*PRCA.K                   DOUBLE SHIFT PRODUCTION CAPABILITY
A      PCCO.K=CLIP(0.0,OPAF.K,INVF.K,UNOF.K)  PRODUCTION CAPACITY CONTRIBUTED
NOTE                                                   BY OVERTIME
A      PRCF.K=CLIP(DSPC.K,SSPC.K,PRCA.K,PRCL)          PRODUCTION CAPABILITY
C      PRCL=40000000                                   PRODUCTION CAPCITY LIMIT
A      OPAF.K=(FCCO)(PRCA.K)             OVERTIME PRODUCTION ALLOWED AT FACTORY
C      FCCO=0.4              FRACTION OF CAPACITY CONTRIBUTED BY OVERTIME
R      MARA.KL=CLIP(MRDF.K,PRCF.K,PRCF.K,MRDF.K) MANUFACTURING RATE
N      MARA=ORRF
R      PRFI.KL=DELAY3(MARA.JK,DPLT)      PRODUCTS RECEIVED AT FACTORY INVENTORY
C      DPLT=0.1                          DELAY DUE TO PRODUCTION LEAD TIME
L      WIPF.K=WIPF.J+(DT)(MARA.JK-PRFI.JK)             WORK-IN-PROGRESS AT FACTORY
N      WIPF=0
L      AVMR.K=AVMR.J+(DT)(MARA.JK-AVMR.J)/DAMR    AVERAGE MANUFACTURING RATE
N      AVMR=MARA
C      DAMR=1                            DELAY IN AVERAGING MANUFACTURING RATE
NOTE
NOTE     PRODUCTION CAPACITY ACQUISITION SECTOR
NOTE
A      PCDF.K=SORF.K+ECOR.K              PRODUCTION CAPACITY DESIRED AT FACTORY
L      PORA.K=PORA.J+(DT)(SORF.J-PORA.J)/DAPO     PAST ORDER RATE
N      PORA=SORF
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C     DAPO=12                                  DELAY IN AVERAGING PAST ORDERS
A     CORP.K=SORF.K-PORA.K                     CHANGE IN ORDER RATE IN THE PAST
A     ECOR.K=(CORP.K)(DRIC)/DAPO               EXPECTED CHANGE IN ORDER RATE
C     DRIC=6                    DELAY IN RECEIVING AND INSTALLING CAPACITY
R     PRCO.KL=CLIP(PCOF.K,0.0,PCOF.K,0.0)      PRODUCTION CAPACITY ORDER RATE
A     PCOF.K=(PCOF.K-PRCA.K-PCOO.K)/TAPC         PRODUCTION CAPACITY ORDERS
C     TAPC=1                                   TIME TO ADJUST PRODUCTION CAPACITY
R     PCAR.KL=DELAY3(PRCO.JK,DRIC)             PRODUCTION CAPACITY ADDITION RATE
L     PCOO.K=PCOO.J+(DT)(PRCO.JK-PCAR.JK)        PRODUCTION CAPACITY ON ORDER
N     PCOO=0
R     PCOR.KL=DELAY3(PCAR.JK,ALCF)             PRODUCTION CAPACITY OBSOLESCENCE RATE
C     ALCF=180                  AVERAGE LIFETIME OF CAPACITY AT FACTORY
L     PRCA.K=PRCA.J+(DT)(PCAR.JK-PCOR.JK)        PRODUCTION CAPACITY
N     PRCA=12000000
NOTE
NOTE     PERSONNEL REQUIREMENT SECTOR
NOTE
A     TPDF.K=CLIP(TPDU.K,TPDO.K,PRCA.K,AVMR.K)  TECHNICAL PERSONNEL DESIRED
A     TPDU.K=AVMR.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING UNDERCAPACITY
A     TPDO.K=PRCA.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING OVERCAPACITY
C     PTPF=300000            PRODUCTIVITY OF TECHNICAL PERSONNEL AT FACTORY
A     PPDF.K=MPPD+(PRCA.K/PPPF)        PROFESIONAL PERSONNEL DESIRED
C     MPPD=8                 MINIMUM NUMBER OF PROFESSIONAL PERSONNEL DESIRED
C     PPPF=2400000          PRODUCTIVITY OF PROFESSIONAL PERSONNEL AT FACTORY
A     RTPF.K=TPDF.K/(TPDF.K+PPDF.K)   RATIO OF TECHNICAL TO PROFESSIONAL
NOTE                                  PERSONNEL AT FACTORY
A     PCIF.K=(TPDF.K+PPDF.K-PITF.K-PPLF.K)/TPAF PERSONNEL CHANGE INDICATED
C     TPAF=1                 TIME FOR PERSONNEL ADJUSTMENT AT FACTORY
R     PHRF.KL=CLIP(PCIF.K,0,PCIF.K,0) PERSONNEL HIRING RATE AT FACTORY
R     PDRF.KL=CLIP(0,-PCIF.K,PCIF.K,0)  PERSONNEL DISMISSAL RATE AT FACTORY
L     PITF.K=PITF.J+(DT)(PHRF.JK-PBPF.JK)        PERSONNEL IN TRAINING
N     PITF=0
R     PBPF.KL=DELAY3(PHRF.JK,DPTF)     PERSONNEL BECOMING PRODUCTIVE
C     DPTF=0.5               DELAY DUE TO PERSONNEL TRAINING AT FACTORY
L     PPLF.K=PPLF.J+(DT)(PBPF.JK-PDRF.JK)        PRODUCTIVE PERSONNEL LEVEL
N     PPLF=TPDF+PPDF
A     PERC.K=PITF.K+PPLF.K                       PERSONNEL IN THE COMPANY
NOTE
NOTE     MANUFACTURING COST SECTOR
NOTE
A     MANC.K=RMCO.K+WAGE.K+SALA.K+PROE.K                  MANUFACTURING COST
A     RMCO.K=(PKRM)(AVMR.K)/CKRM                          RAW MATERIAL COST
C     CKRM=1000                        CIGARETTES PER KG. OF RAW MATERIAL
C     PKRM=70                          PRICE PER KG. OF RAW MATERIAL
A     WAGE.K=(WARA.K)(RTPF.K)(PERC.K)            WAGES
A     WARA.K=TABHL(WRTA,TIME.K,55,67,12)         WAGE RATE
A     SALA.K=(SALR)(1-RTPF.K)(PERC.K)            SALARIES
C     SALR=12000                                 SALARY RATE
A     PROE.K=(UCPR)(AVMR.K)                      PRODUCTION EXPENSES
C     UCPR=.015                                  UNIT COST OF PRODUCTION
NOTE
NOTE     TABLES AND SUPPLEMENTARY EQUATIONS
NOTE
T     OTAB=5743960,6884420,7470580,8352800,5383000,3798000,6677000,
X     7891000,8415230,7631540,8692900,11151520,9691160,13204800,
X     13011200,14236350,11379190,12709210,14790290,13915990,13806920,
X     13541090,14913780,15017140,17111640,17400920,16491540,22604960,
X     19007000,21377100,21368200,23371000,21720000,17682000,19576000,
```

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X       20280000,19974000,21329050,20086125,24741950,19553700,21517650,
X       20721500,14326000,16119000,13902000,16136000,21024000,20328000,
X       21136000,25337000,22651000,28104000,27640000,28737000,23891000,
X       29910000,26364000,28127000,30686000,20939000,28541000,30561000,
X       24710000,31084000,26790000,32701000,28360000
T       WRTA=1000,1500
S       MANF.K=TABLE(MTAB,TIME.K,0,67,1)
T       MTAB=5234080,5774320,6896300,9755300,9527100,6313220,7084540,
X       7761760,7398910,9008700,10355400,9915150,13398710,12155730,
X       12093630,12235000,16595320,15061790,16151800,10325290,10915150,
X       17067100,14418120,16861400,18268800,19403400,19124400,18769430,
X       27506300,23888200,23336350,24658000,16989400,24377550,20174800,
X       20358400,18972550,19444600,19188250,19301500,21280000,20518500,
X       20096200,15944800,14697000,14442000,17110000,18502000,20133000,
X       22146000,23814000,26441000,27739000,25698000,26098000,24014000,
X       27916000,32670000,31401000,31837000,31025000,26023000,25109000,
X       28970000,24272000,29325000,29616000,27181000
S       CORM.K=TABLE(RTAB,TIME.K,0,67,1)
T       RTAB=323000,320000,350000,572000,513000,345000,388000,462000,
X       523000,608000,621000,702000,731000,798000,832000,916000,1102000,
X       941000,934000,622000,918000,962000,1006000,1050000,1038000,
X       1112000,1190000,1323000,1616000,1447000,1470000,960000,1492000,
X       1354000,1432000,1583000,1621000,1267000,1186000,1390000,1353000,
X       1292000,1311000,1050000,963000,1009000,1140000,1214000,1213000,
X       1436000,1556000,1731000,1866000,1726000,1734000,1565000,1877000,
X       2149000,2083000,2315000,2068000,1657000,1687000,1974000,1651000,
X       2081000,2136000,2181000
S       WAGS.K=TABLE(WTAB,TIME.K,0,67,1)
T       WTAB=29100,17800,19150,20820,16929,15219,16595,18513,21730,25910,
X       26230,29120,35180,36030,37180,38250,43500,47800,43100,42700,43800,
X       44900,46300,48200,50100,51400,50600,55100,59200,53800,46000,40900,
X       50000,55000,55000,60000,65000,69400,62400,55500,60000,55200,56900,
X       41900,54000,55000,60000,60000,59000,61000,73000,85000,80000,98000,
X       97000,87000,130000,122000,122000,116000,122000,123000,129000,
X       143000,129000,164000,139000,142000
S       SALS.K=TABLE(SALT,TIME.K,0,67,1)
T       SALT=155000,206000,124000,133000,148000,122000,115000,216000,
X       135000,124000,152000,131000,157000,163000,145000,185000,198000,
X       194000,239000,147000,153000,142000,186000,172000,191000,203000,
X       200000,220000,282000,244000,247000,133000,196000,198000,209000,
X       200000,250000,271000,250000,288000,311000,184000,181000,310000,
X       248000,244000,292000,253000,262000,289000,261000,269000,263000,
X       254000,257000,221000,168000,195000,197000,205000,188000,171000,
X       207000,215000,187000,216000,232000,220000
S       MACO.K=TABLE(MANT,TIME.K,0,67,1)
T       MANT=607000,669000,709000,870000,899000,663000,671000,887000,
X       902000,1003000,1032000,1090000,1143000,1190000,1240000,1311000,
X       1447000,1409000,1427000,984000,1030000,1102000,1309000,1451000,
X       1505000,1662000,1895000,1807000,2185000,1958000,1990000,1327000,
X       2265000,2095000,2318000,2065000,2531000,2611000,1698000,1761000,
X       1907000,1827000,1842000,1623000,1470000,1509000,1722000,1792000,
X       1857000,2039000,2183000,2399000,2524000,2389000,2389000,2095000,
X       2537000,2881000,2892000,3128000,2882000,2503000,2445000,2789000,
X       2402000,2981000,2971000,2983000
NOTE
NOTE      CONTROL CARDS
NOTE
PRINT 1)ORRF/2)MANF/3)CORM/4)WAGS/5)SALS/6)MACO
```

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```
PRINT 1)SSFI/2)AVMR/3)RMCO/4)WAGE/5)SALA/6)MANC
PLOT ORRF=*,MANF=+,AVMR=A
PLOT CORM=*,RMCO=R
PLOT WAGS=*,WAGE=W
PLOT SALS=*,SALA=S
PLOT MACO=*,MANC=M
PLOT ORRF=0,PRCA=P
SPEC DT=0.05/LENGTH=67/PRTPER=1/PLTPER=1
RUN STD
```

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TIME	ORRF SSFI	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC
E+00	E+06 E+06	E+06 E+06	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03
.0	5.744 5.744	5.234 5.744	323.0 402.1	29.10 19.15	155.00 156.00	607.0 663.4
1.	6.884 6.770	5.774 5.931	320.0 415.2	17.80 19.47	206.00 153.63	669.0 677.2
2.	7.471 7.412	6.896 6.658	350.0 466.0	19.15 21.06	124.00 148.07	709.0 735.0
3.	8.353 8.265	9.755 7.563	572.0 529.4	20.82 23.49	133.00 145.38	870.0 811.7
4.	5.383 5.680	9.527 7.956	513.0 556.9	16.93 25.54	148.00 150.25	899.0 852.0
5.	3.798 3.957	6.313 6.499	345.0 454.9	15.22 23.43	122.00 168.73	663.0 744.6
6.	6.677 6.389	7.084 5.058	388.0 354.1	16.59 18.98	115.00 175.61	671.0 624.6
7.	7.001 7.769	7.762 5.742	462.0 401.9	18.51 18.90	219.99 154.07	887.0 661.0
8.	8.415 8.363	7.399 7.207	523.0 504.5	21.73 21.89	135.01 142.18	902.0 776.6
9.	7.632 7.710	9.009 8.227	608.0 575.9	25.91 25.27	124.00 143.73	1003.0 868.3
10.	8.693 8.587	10.355 8.504	621.0 595.3	26.23 27.17	152.00 149.50	1032.0 899.5
11.	11.151 10.905	9.915 9.326	702.0 652.8	29.12 29.27	131.00 146.86	1090.0 968.9
12.	9.691 9.837	13.398 10.688	731.0 748.1	35.18 32.93	157.00 144.18	1143.0 1085.6
13.	13.204 12.853	12.156 11.345	798.0 794.1	36.03 35.75	163.00 147.47	1190.0 1147.5
14.	13.011 13.031	12.094 11.766	832.0 823.6	37.18 37.85	145.00 150.58	1240.0 1188.5
15.	14.236 14.114	12.235 11.937	916.0 835.6	38.25 39.02	184.99 153.32	1311.0 1207.0
16.	11.380 11.666	16.594 12.078	1102.0 845.5	43.50 39.71	198.00 155.11	1447.0 1221.4

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TIME	ORRF SSFI	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC
17.	12.709	15.063	941.1	47.80	194.00	1409.0
	12.576	12.297	860.8	40.36	156.41	1242.0
17.999	14.789	16.151	934.0	43.10	238.97	1427.0
	14.581	12.622	883.5	41.22	157.70	1271.8
18.999	13.917	10.331	622.3	42.70	147.09	984.4
	14.004	13.020	911.4	42.35	159.24	1308.2
19.999	13.807	10.914	917.6	43.80	152.99	1029.9
	13.818	13.444	941.1	43.65	161.07	1347.5
20.999	13.541	17.058	961.9	44.90	142.02	1101.9
	13.568	13.868	970.7	45.03	163.08	1386.8
21.998	14.911	14.423	1005.9	46.30	185.93	1308.6
	14.774	14.269	998.9	46.40	165.12	1424.4
22.998	15.017	16.857	1049.9	48.20	172.03	1450.7
	15.007	14.633	1024.3	47.70	167.08	1458.6
23.998	17.107	18.266	1038.0	50.10	190.96	1504.9
	16.898	14.950	1046.5	48.87	168.89	1488.5
24.998	17.400	19.401	1111.8	51.40	202.97	1661.6
	17.371	15.228	1065.9	49.90	170.54	1514.8
25.997	16.494	19.125	1189.8	50.60	200.01	1894.4
	16.585	15.498	1084.9	50.84	172.13	1540.3
26.997	22.587	18.770	1322.6	55.09	219.94	1807.3
	29.517	17.633	1234.3	52.33	171.78	1722.9
27.997	19.018	27.479	1615.1	59.19	281.80	2183.8
	20.034	20.152	1410.6	53.96	174.43	1941.3
28.997	21.369	23.900	1447.6	53.82	244.13	1958.8
	27.591	20.135	1409.4	55.72	176.74	1943.9
29.996	21.368	23.338	1469.9	46.03	246.99	1989.9
	24.777	20.986	1469.0	57.86	179.46	2021.1
30.996	23.363	24.653	962.0	40.92	133.44	1329.6
	4.916	21.741	1521.9	60.39	182.90	2091.3
31.996	21.727	17.021	1489.8	49.96	195.74	2261.1
	21.488	22.866	1600.6	63.21	186.98	2193.8
32.996	17.700	24.345	1354.6	54.98	197.99	2095.7
	18.106	21.946	1536.2	66.20	191.46	2123.1
33.995	19.567	20.194	1431.6	55.00	208.95	2317.0
	19.378	21.470	1502.9	69.14	197.10	2091.2

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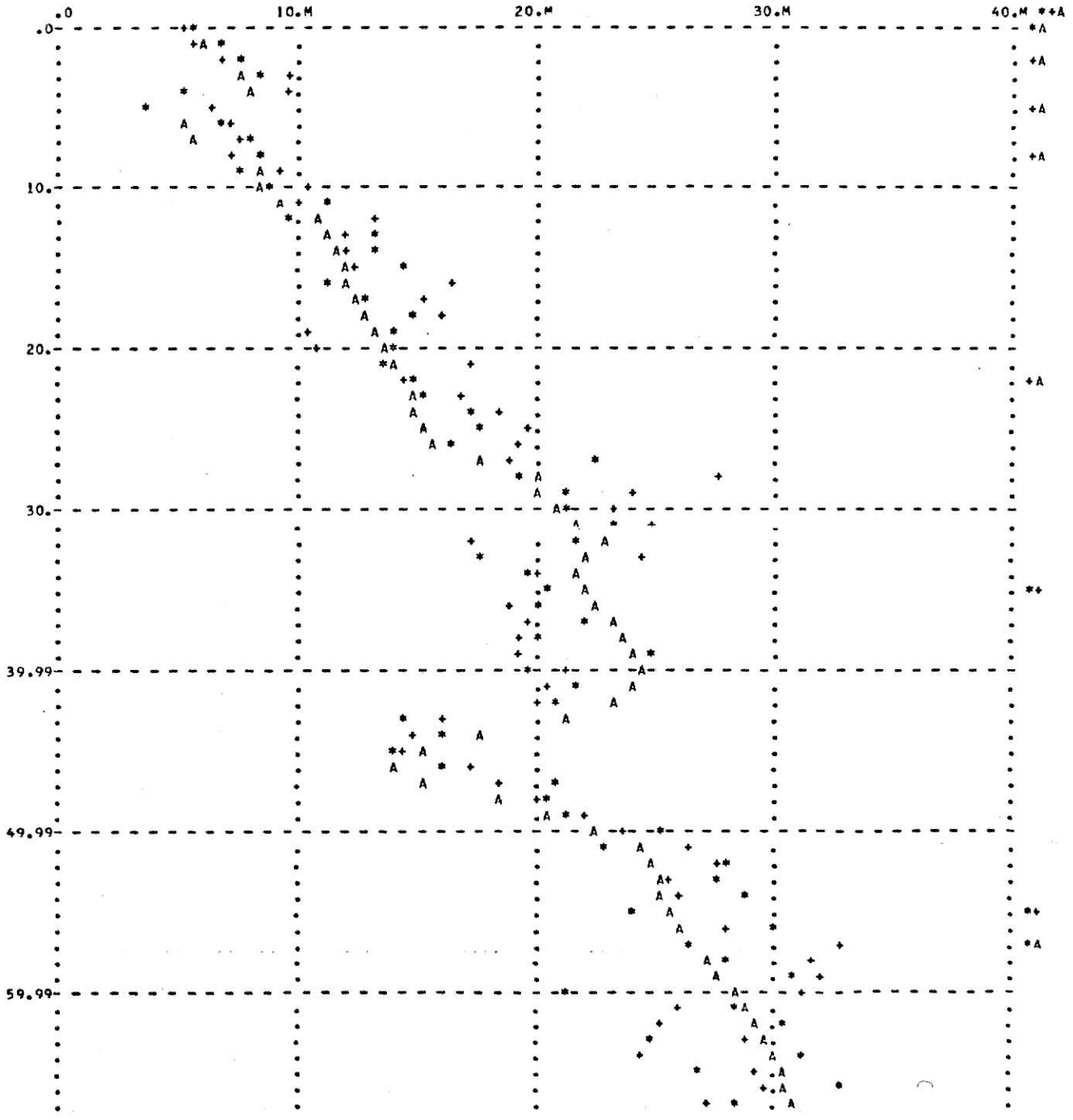
TIME	ORRF SSFI	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC
34.995	20.277	20.358	1582.3	59.98	200.04	2066.2
	20.206	21.857	1530.0	71.08	203.07	2132.0
35.995	19.976	18.980	1620.8	64.97	249.74	2528.6
	20.006	22.487	1574.1	73.06	206.37	2190.8
36.995	21.819	19.442	1268.9	69.38	270.89	2610.6
	21.634	23.123	1618.6	75.18	209.33	2250.0
37.994	20.096	19.190	1186.5	62.44	250.12	1703.1
	20.270	23.680	1657.6	77.20	212.15	2302.2
38.994	24.715	19.301	1388.8	55.54	287.78	1760.6
	24.249	24.134	1689.4	78.97	214.66	2345.1
39.994	19.585	21.268	1353.2	59.97	310.86	1906.1
	20.104	24.489	1714.2	80.44	216.77	2378.7
40.994	21.505	20.523	1292.4	55.23	184.80	1827.5
	21.309	23.922	1674.6	80.46	222.92	2336.8
41.993	20.727	20.099	1310.9	56.89	181.02	1841.9
	20.806	23.224	1625.7	78.84	225.67	2278.6
42.993	14.370	15.972	1051.8	42.00	309.12	1624.3
	15.009	21.395	1497.7	75.33	234.57	2128.5
43.993	16.106	14.706	963.6	53.91	248.44	1471.1
	15.927	17.532	1227.2	65.96	251.01	1807.2
44.993	13.918	14.444	1008.7	54.99	244.03	1508.7
	14.140	15.306	1071.5	56.98	248.60	1606.6
45.992	16.119	17.090	1139.0	59.96	291.64	1720.4
	15.896	13.939	975.7	50.40	241.62	1476.8
46.992	20.986	18.491	1213.4	60.00	253.30	1791.5
	20.497	15.112	1057.9	49.55	219.16	1553.3
47.992	20.334	20.120	1213.0	59.01	261.93	1856.5
	20.403	18.388	1287.2	55.64	202.29	1820.9
48.992	21.129	22.129	1434.2	60.98	288.78	2037.5
	21.049	20.492	1434.5	62.87	205.09	2009.8
49.991	25.301	23.800	1555.0	72.90	261.24	2181.8
	24.881	22.348	1564.3	69.16	206.89	2175.6
50.991	22.675	26.418	1729.5	84.89	268.93	2397.1
	22.943	24.272	1699.0	75.88	208.97	2347.9
51.991	28.055	27.727	1864.8	80.05	263.05	2522.9
	27.510	24.969	1747.8	80.30	214.95	2417.6

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TIME	ORRF SSFI	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC
52.991	27.644	25.717	1727.3	97.83	254.08	2390.3
	27.691	25.222	1765.5	82.61	219.00	2445.5
53.99	28.727	26.094	1733.9	97.01	256.97	2389.0
	28.617	25.357	1775.0	83.73	221.42	2460.5
54.99	23.938	24.034	1566.6	87.10	221.35	2097.9
	24.423	25.557	1789.0	84.46	223.24	2480.1
55.99	29.850	27.877	1873.9	129.57	168.53	2532.6
	29.248	25.918	1814.3	88.87	225.11	2517.1
56.99	26.400	32.621	2146.2	122.08	194.72	2877.5
	26.755	26.442	1850.9	93.87	227.32	2568.7
57.99	28.108	31.414	2083.7	122.00	196.98	2891.9
	27.932	27.062	1894.3	99.45	229.93	2629.7
58.989	30.659	31.832	2312.5	116.06	204.91	3125.5
	30.403	27.704	1939.3	105.48	232.78	2693.1
59.989	21.046	31.034	2070.7	121.93	188.19	2884.7
	22.020	28.308	1981.6	111.73	235.67	2753.6
60.989	28.458	26.079	1661.6	122.99	171.19	2507.3
	27.696	28.850	2019.5	118.02	238.45	2808.7
61.989	30.538	25.119	1686.7	128.93	206.59	2445.7
	30.336	29.327	2052.9	124.23	240.98	2858.0
62.988	24.778	28.925	1970.6	142.84	214.91	2785.0
	25.363	29.735	2081.5	130.32	243.20	2901.0
63.988	31.008	24.328	1654.9	129.17	187.33	2406.6
	30.371	30.074	2105.2	136.24	245.09	2937.6
64.988	26.842	29.263	2075.8	163.57	215.65	2973.9
	27.272	30.346	2124.2	141.94	246.65	2968.0
65.988	32.627	29.612	2135.3	139.31	231.80	2971.1
	32.036	30.556	2138.9	147.42	247.90	2992.6
66.987	28.415	27.212	2180.4	141.96	220.15	2982.8
	28.849	30.712	2149.9	152.67	248.87	3012.1

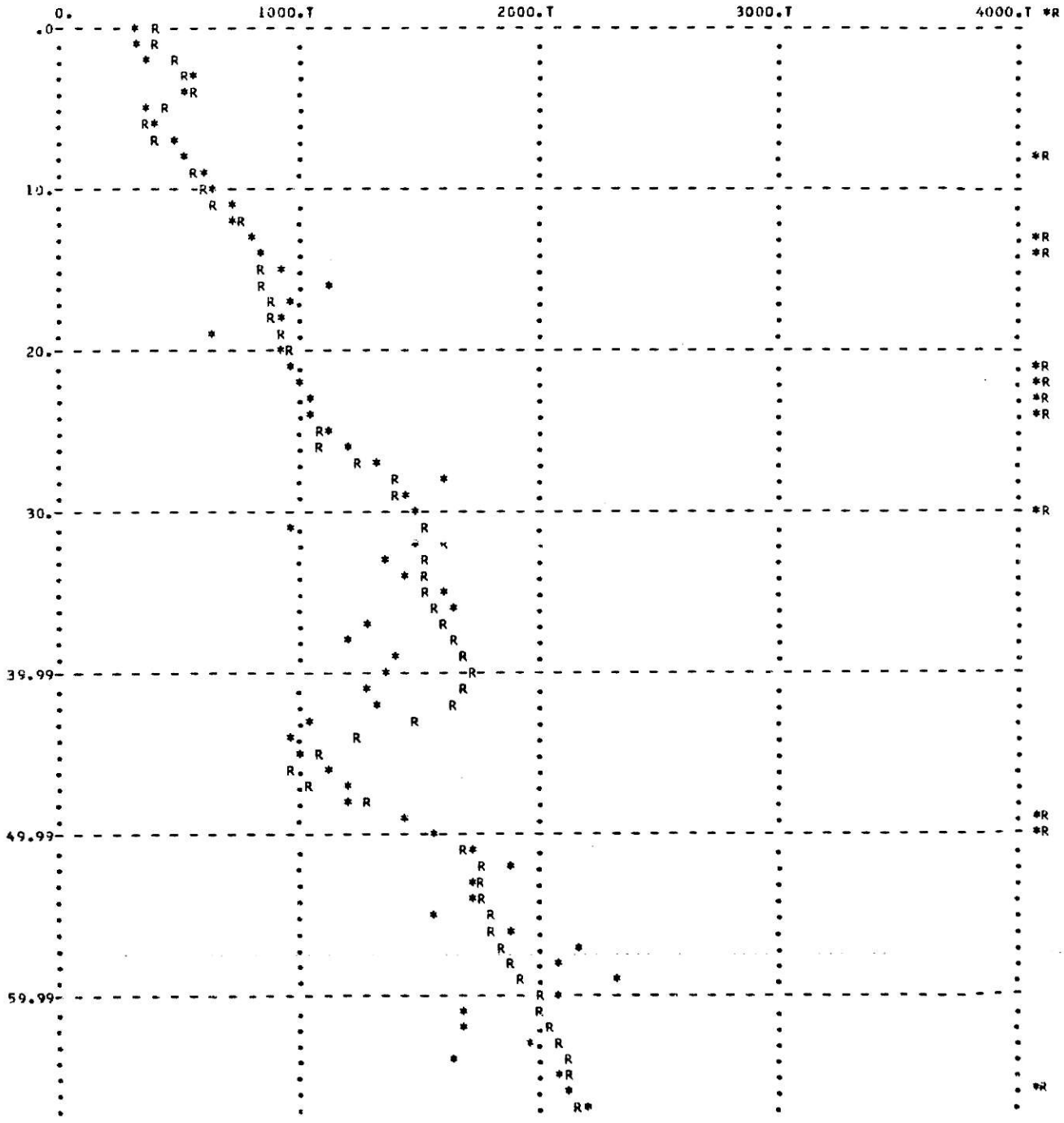
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ORRF=*,MANF=+,AVMR=A



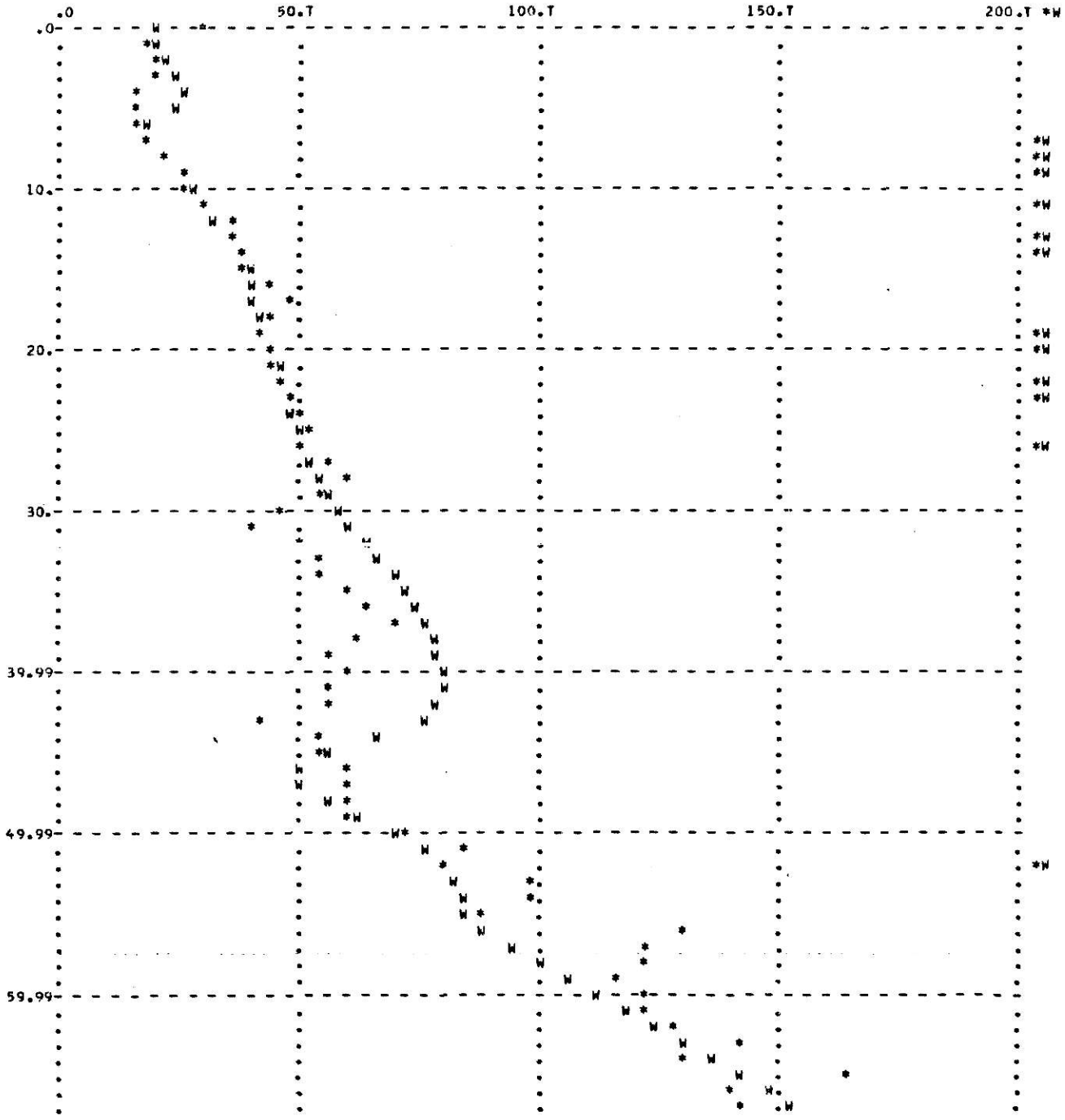
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CORM=*,RMCD=R



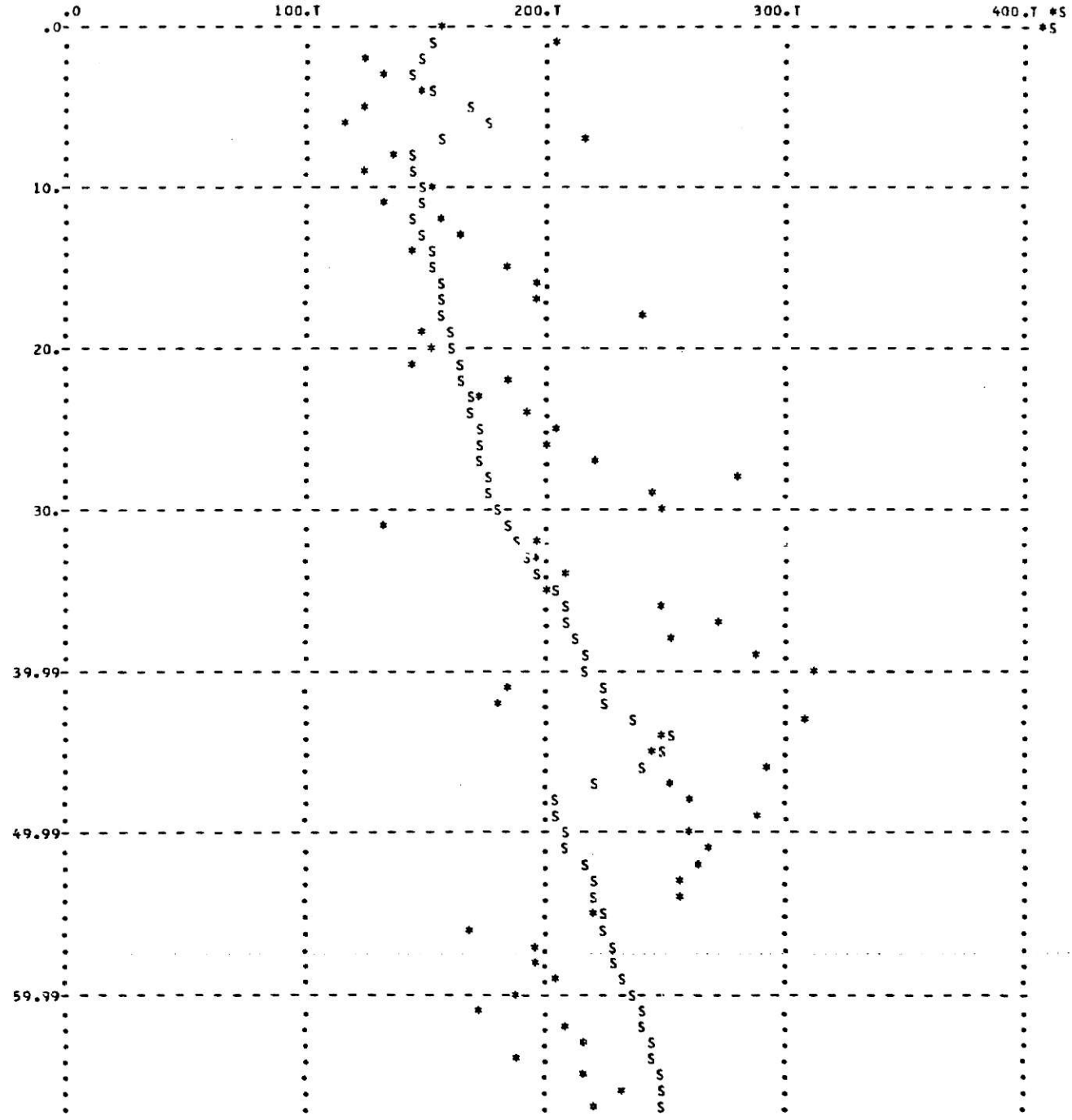
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WAGS=*,WAGE=W



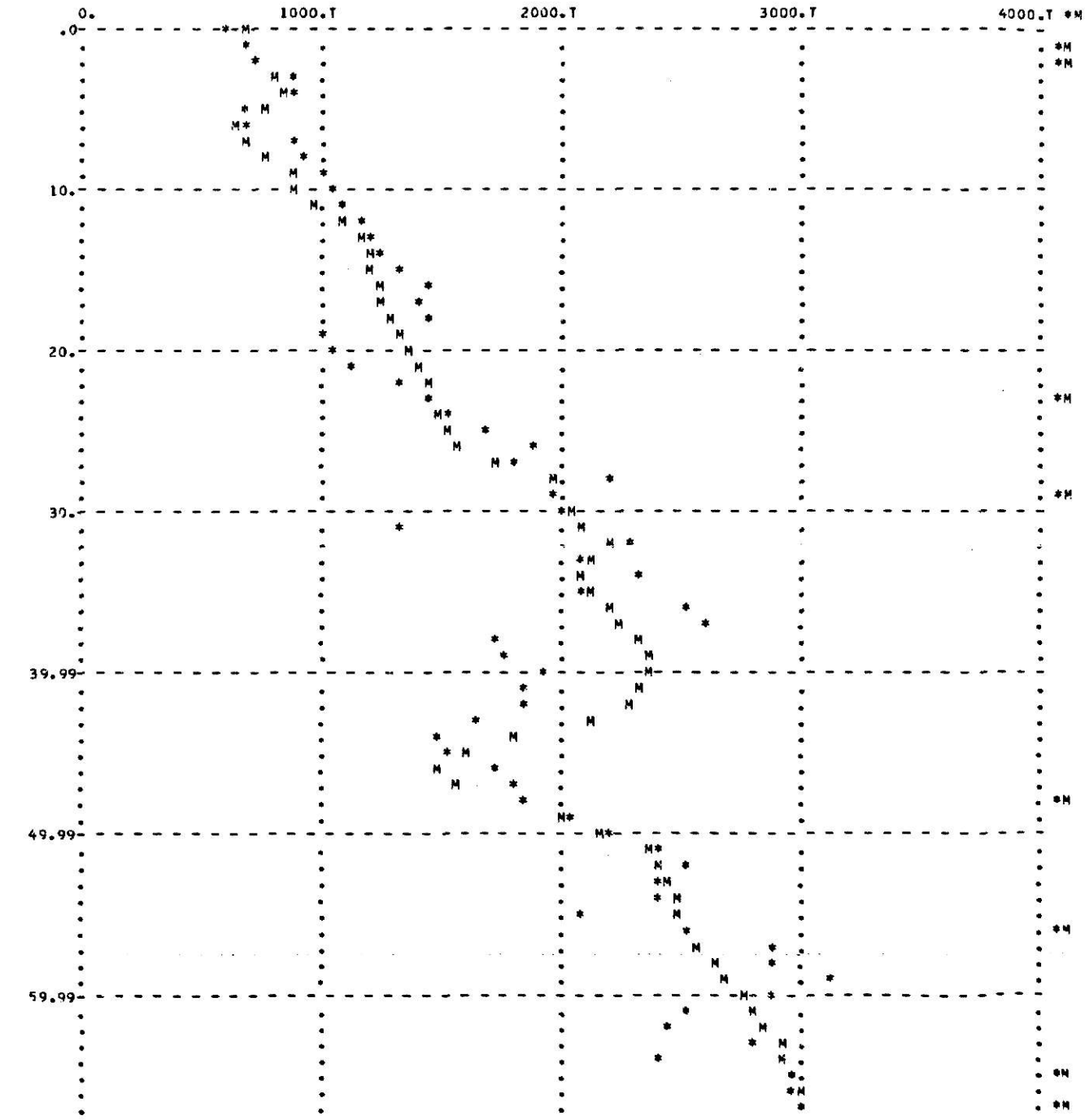
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SALS=*,SALA=S



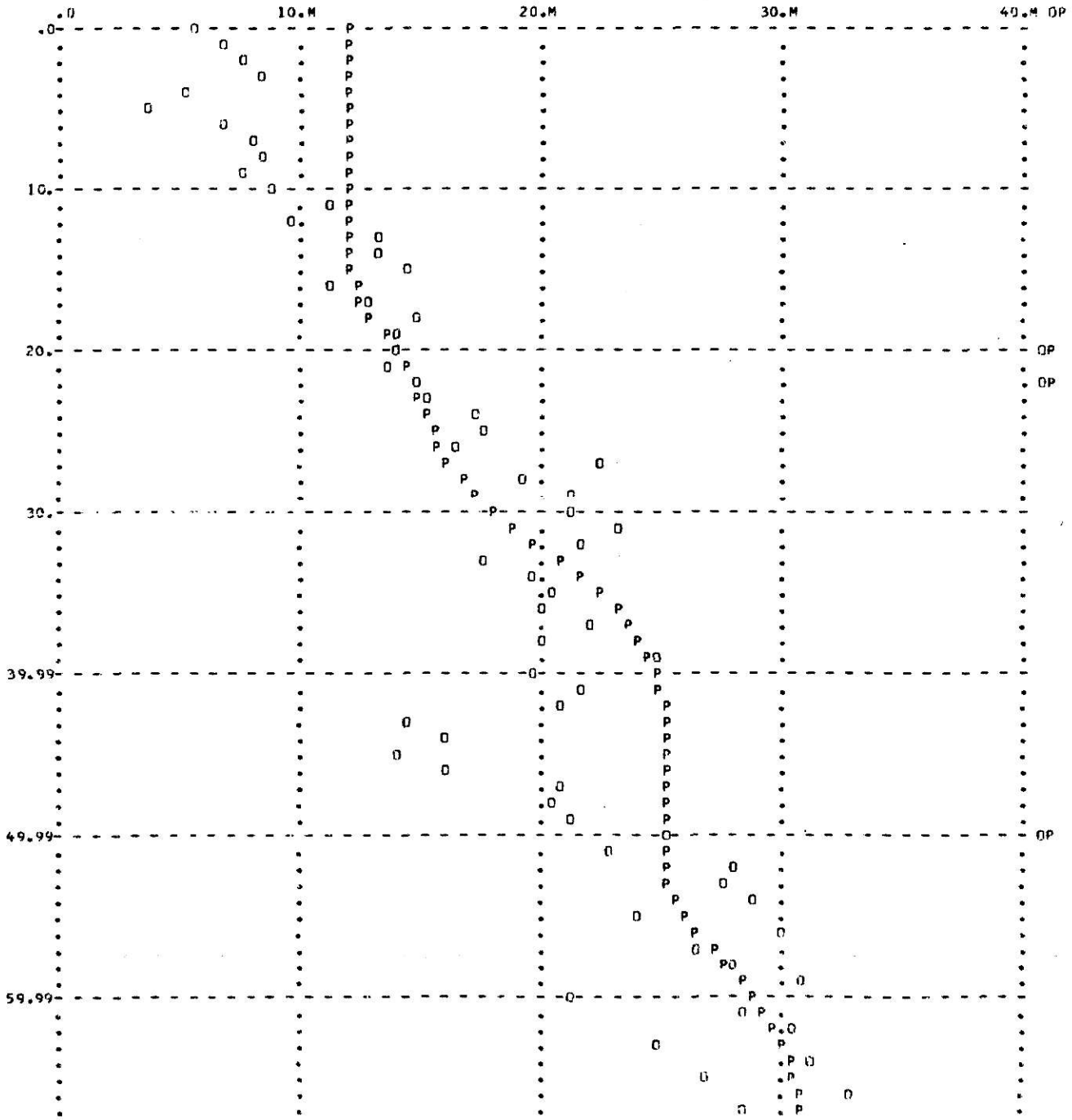
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MACO=*,MANC=M



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ORRF=O,PRCA=P



APPENDIX C

Computer Program for Market Sector Performance Test

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NOTE----------------------------------------------------------------------
NOTE
NOTE          MODEL OF CIGARETTE MANUFACTURING COMPANY IN MOZAMBIQUE
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE                                THE MARKET
NOTE
NOTE----------------------------------------------------------------------
NOTE
NOTE      POTENTIAL DEMAND GENERATION SECTOR
NOTE
R       ADDE.KL=TABLE(ATAB,TIME.K,0,67,1)          ADVERTIZING DECISION
L       AVMR.K=AVMR.J+(DT)(MARA.JK-AVMR.J)/DAMR    AVERAGE MANUFACTURING RATE
N       AVMR=MARA
C       DAMR=1                                  DELAY IN AVERAGING MANUFACTURING RATE
R       APMC.KL=DELAY3(ADDE.JK,DAAM)               ADVERTIZING PRESENTED BY
                                                   MEDIA TO CONSUMER
NOTE
C       DAAM=0.25                 DELAY AT ADVERTIZING AGENCIES AND MEDIA
L       ADAC.K=ADAC.J+(DT)(APMC.JK-ADAC.J)/DAAC    ADVERTIZING AWARENESS
                                                   OF CONSUMER
N       ADAC=ADDE
C       DAAC=0.5                  DELAY IN ADVERTIZING AWARENESS OF CONSUMER
A       CACB.K=ADAC.K/AAOC.K          CONSUMER AWARENESS OF COMPANY'S BRANDS
L       AAOC.K=AAOC.J+(DT)(GRAC)     AVERAGE ADVERTIZING OUTLAY OF COMPETITORS
N       AAOC=1100000
C       GRAC=4900                 GROWTH RATE IN ADVERTIZING OF COMPETITORS
A       RPPR.K=0.39+(0.36)(CACB.K)       REPEAT PURCHASE PROBABILITY
A       TPPR.K=0.11+(0.16)(CACB.K)       TRANSFER PURCHASE PROBABILITY
A       PMSC.K=(RPPR.K)(MASH.K)+(TPPR.K)(1-MASH.K)      POTENTIAL MARKET SHARE
N       PMSC=.03
A       MASH.K=SARA.JK/ACSI.K                      MARKET SHARE
A       PODE.K=(PMSC.K)(ACSI.K)                    POTENTIAL DEMAND
L       ACSI.K=ACSI.J+(DT)(GRCI)         AVERAGE CIGARETTE SALES OF INDUSTRY
N       ACSI=61500000
C       GRCI=583000                      GROWTH RATE OF CIGARETTE INDUSTRY
NOTE
NOTE      RETAIL SECTOR
NOTE
R       SARA.KL=(PODE.K)(PRAM.K)                   SALES RATE
A       PRAM.K=TABHL(PRAT,INRA.K,0,1,0.2)       PRODUCT AVAILABILITY MULTIPLIER
A       INRA.K=INVR.K/INNR.K                       INVENTORY RATIO
L       INVR.K=INVR.J+(DT)(SRRI.JK-SARA.JK)        INVENTORY AT RETAIL
N       INVR=INNR
A       INNR.K=(PINR)(PODE.K)                INVENTORY NECESSARY AT RETAIL
C       PINR=0.5                  PERIOD OF  INVENTORY NECESSARY AT RETAIL
R       SRRI.KL=DELAY3(SSFI.JK,DIST)         SHIPMENTS RECEIVED AT RETAIL INVENTORY
C       DIST=0.5                             DELAY IN SHIPMENT TRANSPORTATION
L       SITR.K=SITR.J+(DT)(SSFI.JK-SRRI.JK)     SHIPMENTS IN TRANSIT TO RETAIL
N       SITR=0
R       ORRF.KL=SRSA.K+(INDR.K-INVR.K-SITR.K)/TAIR       ORDER RATE AT FACTORY
C       TAIR=0.5                             TIME TO ADJUST INVENTORY AT RETAIL
L       SRSA.K=SRSA.J+(DT)(SARA.JK-SRSA.J)/DSRS    SMOOTHED RETAIL SALES
N       SRSA=PODE
C       DSRS=1                               DELAY IN SMOOTHING RETAIL SALES
A       INDR.K=(PIDR)(SRSA.K)                      INVENTORY DESIRED AT RETAIL
C       PIDR=1                               PERIOD OF INVENTORY DESIRED AT RETAIL
NOTE
NOTE----------------------------------------------------------------------
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THIS BOOK CONTAINS NUMEROUS PAGES THAT ARE CUT OFF

THIS IS AS RECEIVED FROM THE CUSTOMER

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NOTE
NOTE                                THE COMPANY
NOTE
NOTE*****************************************************************
NOTE
NOTE     ORDER FILLING SECTOR
NOTE
L     UNOF.K=UNOF.J+(DT)(ORRF.JK-SSFI.JK)        UNFILLED ORDERS AT FACTORY
N     UNOF=UODF
L     INVF.K=INVF.J+(DT)(PRFI.JK-SSFI.JK)        INVENTORY AT THE FACTORY
N     INVF=INDF
R     SSFI.KL=CLIP(NSRF.K,RSRF.K,INVF.K,UNOF.K) SHIPMENTS SENT FROM FACTORY
A     NSRF.K=UNOF.K/DFOF                  NORMAL SHIPPING RATE FROM FACTORY
A     RSRF.K=INVF.K/DFOF                  RESTRICTED SHIPPING RATE FROM FACTORY
C     DFOF=0.1                            DELAY IN FILLING ORDERS AT FACTORY
NOTE
NOTE     MANUFACTURING SECTOR
NOTE
A     MRDF.K=SORF.K+(UNOF.K-UODF.K+INDF.K-INVF.K-WIPF.K)/TAIB MANUFACTURING
NOTE                                              RATE DESIRED AT FACTORY
C     TAIB=3                              TIME TO ADJUST INVENTORY AND BACKLOG
L     SORF.K=SORF.J+(DT)(ORRF.JK-SORF.J)/DSOR SMOOTHED ORDER RATE AT FACTORY
N     SORF=ORRF
C     DSOR=1                              DELAY IN SMOOTHING ORDER RATE
A     INDF.K=MIDF+(PIDF)(SORF.K)                INVENTORY DESIRED AT FACTORY
C     MIDF=1000000                        MINIMUM INVENTORY DESIRED AT FACTORY
C     PIDF=1.5                            PERIOD OF INVENTORY DESIRED AT FACTORY
A     UODF.K=(DFOF)(SORF.K)               UNFILLED ORDERS DESIRED AT FACTORY
A     PRCF.K=CLIP(DSPC.K,SSPC.K,PRCA.K,PRCL)     PRODUCTION CAPABILITY
A     DSPC.K=2*PRCA.K                     DOUBLE SHIFT PRODUCTION CAPABILITY
A     SSPC.K=PRCA.K+PCCO.K                SINGLE SHIFT PRODUCTION CAPABILITY
C     PRCL=40000000                             PRODUCTION CAPCITY LIMIT
A     PCCO.K=CLIP(0.0,OPAF.K,INVF.K,UNOF.K)  PRODUCTION CAPACITY CONTRIBUTED
NOTE                                              BY OVERTIME
A     OPAF.K=(FCCO)(PRCA.K)               OVERTIME PRODUCTION ALLOWED AT FACTORY
C     FCCO=0.4                  FRACTION OF CAPACITY CONTRIBUTED BY OVERTIME
R     MARA.KL=CLIP(MRDF.K,PRCF.K,PRCF.K,MRDF.K) MANUFACTURING RATE
N     MARA=ORRF
R     PRFI.KL=DELAY3(MARA.JK,DPLT)     PRODUCTS RECEIVED AT FACTORY INVENTORY
C     DPLT=0.1                            DELAY DUE TO PRODUCTION LEAD TIME
L     WIPF.K=WIPF.J+(DT)(MARA.JK-PRFI.JK)        WORK-IN-PROGRESS AT FACTORY
N     WIPF=0
NOTE
NOTE     PRODUCTION CAPACITY ACQUISITION SECTOR
NOTE
A     PCDF.K=SORF.K+ECOR.K                PRODUCTION CAPACITY DESIRED AT FACTORY
L     PORA.K=PORA.J+(DT)(SORF.J-PORA.J)/DAPO     PAST ORDER RATE
N     PORA=SORF
C     DAPO=12                             DELAY IN AVERAGING PAST ORDERS
A     CORP.K=SORF.K-PORA.K                CHANGE IN ORDER RATE IN THE PAST
A     ECOR.K=(CORP.K)(DRIC)/DAPO          EXPECTED CHANGE IN ORDER RATE
C     DRIC=6                    DELAY IN RECEIVING AND INSTALLING CAPACITY
R     PRCO.KL=CLIP(PCDF.K,0.0,PCDF.K,0.0)      PRODUCTION CAPACITY ORDER RATE
A     PCDF.K=(PCDF.K-PRCA.K-PCOO.K)/TAPC          PRODUCTION CAPACITY ORDERS
C     TAPC=1                              TIME TO ADJUST PRODUCTION CAPACITY
R     PCAR.KL=DELAY3(PRCO.JK,DRIC)        PRODUCTION CAPACITY ADDITION RATE
L     PCOO.K=PCOO.J+(DT)(PRCO.JK-PCAR.JK)        PRODUCTION CAPACITY ON ORDER
N     PCOO=0
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R     PCOR.KL=DELAY3(PCAR.JK,ALCF)     PRODUCTION CAPACITY OBSOLESCENCE RATE
C     ALCF=180                 AVERAGE LIFETIME OF CAPACITY AT FACTORY
L     PRCA.K=PRCA.J+(DT)(PCAR.JK-PCOR.JK)       PRODUCTION CAPACITY
N     PRCA=12000000
NOTE
NOTE     PERSONNEL REQUIREMENT SECTOR
NOTE
A     TPDF.K=CLIP(TPDU.K,TPDO.K,PRCA.K,AVMR.K)  TECHNICAL PERSONNEL DESIRED
A     TPDU.K=AVMR.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING UNDERCAPACITY
A     TPDO.K=PRCA.K/PTPF     TECHNICAL PERSONNEL DESIRED DURING OVERCAPACITY
C     PTPF=300000            PRODUCTIVITY OF TECHNICAL PERSONNEL AT FACTORY
A     PPDF.K=MPPD+(PRCA.K/PPPF)       PROFESIONAL PERSONNEL DESIRED
C     MPPD=8                 MINIMUM NUMBER OF PROFESSIONAL PERSONNEL DESIRED
C     PPPF=2400000          PRODUCTIVITY OF PROFESSIONAL PERSONNEL AT FACTORY
A     RTPF.K=TPDF.K/(TPDF.K+PPDF.K)   RATIO OF TECHNICAL TO PROFESSIONAL
NOTE                                  PERSONNEL AT FACTORY
A     PCIF.K=(TPDF.K+PPDF.K-PITF.K-PPLF.K)/TPAF PERSONNEL CHANGE INDICATED
C     TPAF=1                 TIME FOR PERSONNEL ADJUSTMENT AT FACTORY
R     PHRF.KL=CLIP(PCIF.K,0,PCIF.K,0) PERSONNEL HIRING RATE AT FACTORY
R     PDRF.KL=CLIP(0,-PCIF.K,PCIF.K,0)  PERSONNEL DISMISSAL RATE AT FACTORY
L     PITF.K=PITF.J+(DT)(PHRF.JK-PBPF.JK)       PERSONNEL IN TRAINING
N     PITF=0
R     PBPF.KL=DELAY3(PHRF.JK,DPTF)     PERSONNEL BECOMING PRODUCTIVE
C     DPTF=0.5               DELAY DUE TO PERSONNEL TRAINING AT FACTORY
L     PPLF.K=PPLF.J+(DT)(PBPF.JK-PDRF.JK)       PRODUCTIVE PERSONNEL LEVEL
N     PPLF=TPDF+PPDF
A     PERC.K=PITF.K+PPLF.K                      PERSONNEL IN THE COMPANY
NOTE
NOTE
NOTE     PROFIT SECTOR
NOTE
A     REVS.K=(USPC)(AVSR.K)                     REVENUE FROM SALES
C     USPC=0.22                        UNIT SELLING PRICE OF CIGARETTES
L     AVSR.K=AVSR.J+(DT)(SSFI.JK-AVSR.J)/DSSR   AVERAGE SHIPPING RATE
N     AVSR=SSFI
C     DSSR=1
A     MANC.K=RMCO.K+WAGE.K+SALA.K+PROE.K                  MANUFACTURING COST
A     RMCO.K=(PKRM)(AVMR.K)/CKRM                          RAW MATERIAL COST
C     CKRM=1000                      CIGARETTES PER KG. OF RAW MATERIAL
C     PKRM=70                        PRICE PER KG. OF RAW MATERIAL
A     WAGE.K=(WARA.K)(RTPF.K)(PERC.K)           WAGES
A     WARA.K=TABHL(WRTA,TIME.K,55,67,12)        WAGE RATE
A     SALA.K=(SALR)(1-RTPF.K)(PERC.K)           SALARIES
C     SALR=12000                                SALARY RATE
A     PROE.K=(UCPR)(AVMR.K)                     PRODUCTION EXPENSES
C     UCPR=.015                                 UNIT COST OF PRODUCTION
A     COSA.K=(UMCO.K)(AVSR.K)                   COST OS SALES
A     UMCO.K=MANC.K/AVMR.K                      UNIT MANUFACTURING COST
A     EXDU.K=(DUTY)(USPC)(AVSR.K)               EXCISE DUTY
C     DUTY=.28                                  DUTY RATE
A     SELE.K=(FRSE)(USPC)(AVSR.K)               SELLING EXPENDITURES
C     FRSE=0.1               FRACTION OF REVENUE FOR SELLING EXPENDITURES
L     ADEX.K=ADEX.J+(DT)(ADDE.JK-ADEX.J)/DSAE   ADVERTIZING EXPENDITURES
N     ADEX=ADDE
C     DSAE=1                 DELAY IN SMOOTHING ADVERTIZING EXPENDITURES
A     TPRO.K=REVS.K-COSA.K-EXDU.K-SELE.K-ADEX.K TRADE PROFIT
NOTE
NOTE
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NOTE     TABLES AND SUPPLEMENTARY EQUATIONS
NOTE
T       ATAB=133000,124000,131000,100000,114000,119000,159000,174000,
X       163000,165000,172000,169000,173500,182000,189000,195000,205000,
X       218000,177000,178000,171000,182000,208000,256000,309000,342000,
X       412000,403000,382000,625000,514000,301000,619000,538000,512000,
X       594000,483000,381000,388000,392000,342000,303000,251000,239000,
X       255000,262000,257000,229000,233000,252000,520000,533000,516000,
X       544000,487000,474000,438000,571000,560000,528000,576000,518000,
X       575000,588000,548000,638000,538000,661000
T       PRAT=0.0,.32,.55,.72,.85,1.0
T       WRTA=1000,1500
S       SALE.K=TABLE(STAB,TIME.K,0,67,1)
T       STAB=5301120,5743960,6884420,7470580,8352800,5383000,3798000,
X       6677000,7891000,8415230,7631540,8692900,11151520,9691160,13204800,
X       13011200,14236350,11379190,12709210,14790290,13915990,13806920,
X       13541090,14913780,15017140,17111640,17400920,16491540,22604960,
X       19007000,21377100,21368200,23371000,21720000,17682000,19576000,
X       20280000,19974000,21829050,20086125,24741950,19553700,21517650,
X       20721500,14326000,16119000,13902000,16136000,21024000,20328000,
X       21136000,25337000,22651000,28104000,27640000,28737000,23891000,
X       29910000,26364000,28127000,30686000,20939000,28541000,30561000,
X       24710000,31084000,26790000,32701000
S       MANF.K=TABLE(MTAB,TIME.K,0,67,1)
T       MTAB=5234080,5774320,6896300,9755300,9527100,6313220,7084540,
X       7761760,7398910,9008700,10355400,9915150,13398710,12155730,
X       12093630,12235000,16595320,15061790,16151800,10325290,10915150,
X       17067100,14410120,16861400,18268800,19403400,19124400,18769430,
X       27506300,23885200,23336350,24658000,16989400,24377550,20174800,
X       20358400,18972550,19444600,19188250,19301500,21280000,20518500,
X       20096200,15944800,14697000,14442000,17110000,18502000,20133000,
X       22146000,23614000,26441000,27739000,25698000,26098000,24014000,
X       27916000,32670000,31401000,31837000,31025000,26023000,25109000,
X       28970000,24272000,29325000,29616000,27181000
S       CORM.K=TABLE(RTAB,TIME.K,0,67,1)
T       RTAB=323000,320000,350000,572000,513000,345000,388000,462000,
X       523000,608000,621000,702000,731000,798000,832000,916000,1102000,
X       941000,934000,622000,918000,962000,1006000,1050000,1038000,
X       1112000,1190000,1323000,1616000,1447000,1470000,960000,1492000,
X       1354000,1432000,1583000,1621000,1267000,1186000,1390000,1353000,
X       1292000,1311000,1050000,963000,1009000,1140000,1214000,1213000,
X       1436000,1556000,1731000,1866000,1726000,1734000,1565000,1877000,
X       2149000,2083000,2315000,2068000,1657000,1687000,1974000,1651000,
X       2081000,2136000,2181000
S       WAGS.K=TABLE(WTAB,TIME.K,0,67,1)
T       WTAB=29100,17800,19150,20820,16929,15219,16595,18513,21730,25910,
X       26230,29120,35180,36030,37180,38250,43500,47800,43100,42700,43800,
X       44900,46300,48200,50100,51400,50600,55100,59200,53800,46000,40900,
X       50000,55000,55000,60000,65000,69400,62400,55500,60000,55200,56900,
X       41900,54000,55000,60000,60000,59000,61000,73000,85000,80000,98000,
X       97000,87000,130000,122000,122000,116000,122000,123000,129000,
X       143000,129000,164000,139000,142000
S       SALS.K=TABLE(SALT,TIME.K,0,67,1)
T       SALT=155000,206000,124000,133000,148000,122000,115000,216000,
X       135000,124000,152000,131000,157000,163000,145000,185000,198000,
X       194000,239000,147000,153000,142000,186000,172000,191000,203000,
X       200000,220000,282000,244000,247000,133000,196000,198000,209000,
X       200000,250000,271000,250000,288000,311000,184000,181000,310000,
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PAGE 5          6/03/74

               X     248000,244000,292000,253000,262000,289000,261000,269000,263000,
               X     254000,257000,221000,168000,195000,197000,205000,188000,171000,
               X     207000,215000,187000,216000,232000,220000
               S     MACO.K=TABLE(MANT,TIME.K,0,67,1)
               T     MANT=607000,669000,709000,870000,899000,663000,671000,887000,
               X     902000,1003000,1032000,1090000,1143000,1190000,1240000,1311000,
               X     1447000,1409000,1427000,984000,1030000,1102000,1309000,1451000,
               X     1505000,1662000,1895000,1807000,2185000,1958000,1990000,1327000,
               X     2265000,2095000,2318000,2065000,2531000,2611000,1698000,1761000,
               X     1907000,1827000,1842000,1623000,1470000,1509000,1722000,1792000,
               X     1857000,2039000,2183000,2399000,2524000,2389000,2389000,2095000,
               X     2537000,2881000,2892000,3128000,2882000,2503000,2445000,2789000,
               X     2402000,2981000,2971000,2983000
               S     SACO.K=TABLE(COST,TIME.K,0,67,1)
               T     COST=518000,671000,713000,685000,784000,566000,398000,720000,
               X     900000,1000000,1050000,1100000,1140000,1200000,1200000,1200000,
               X     1300000,1329000,1053000,1139000,1377000,1100000,1200000,1300000,
               X     1400000,1500000,1600000,1700000,1800000,1865000,1559000,1775000,
               X     1816000,1500000,1600000,1700000,1750000,1800000,1854000,2031000,
               X     1852000,2249000,1760000,1953000,1983000,1406000,1637000,1406000,
               X     1637000,1405000,1592000,2313000,2059000,2582000,2534000,2569000,
               X     2164000,2668000,2385000,2691000,2879000,2005000,2726000,2934000,
               X     2416000,3078000,2712000,3408000
               S     TRPR.K=TABLE(PROT,TIME.K,0,67,1)
               T     PROT=-114000,-139726,-141550,183560,-1686,-134602,-195000,
               X     -361900,15600,-16300,-2630,145200,225300,35000,25600,23400,38267
               X     33400,2280,33530,52300,59400,128000,286000,432000,568000,283000,
               X     543000,795200,292700,527000,560500,532000,415000,65200,315000,
               X     295000,202000,227000,230000,501000,231000,411000,211000,-134,
               X     50000,30300,137000,514000,462000,220000,499000,431000,589000,
               X     481000,832000,579000,680000,589000,456000,633000,262000,606000,
               X     669000,319000,459000,483000,428000
               NOTE
               NOTE      CONTROL CARDS
               NOTE
               PRINT 1)SALE/2)MANF/3)CORM/4)WAGS/5)SALS/6)MACO/7)SACO/8)TRPR
               PRINT 1)SARA/2)AVMR/3)RMCO/4)WAGE/5)SALA/6)MANC/7)COSA/8)TPRO
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               PLOT ORRF=O,PRCA=P
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               RUN STD

WRONG NUMBER OF VALUES IN TABLE PROT
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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
E+00	E+06 E+06	E+06 E+06	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03
.0	5.301 2.888	5.234 3.690	323.0 258.3	29.10 12.30	155.00 156.00	607.0 481.9	518.0 481.9	-114.00 -111.63
1.	5.744 3.942	5.774 3.984	320.0 278.9	17.80 12.89	206.00 151.40	669.0 503.0	671.0 530.1	-139.73 -87.08
2.	6.884 5.078	6.896 4.948	350.0 346.4	19.15 15.14	124.00 143.16	709.0 578.9	713.0 597.5	-141.55 -29.43
3.	7.471 6.097	9.755 6.269	572.0 438.9	20.82 18.60	133.00 138.85	870.0 690.4	685.0 677.8	183.55 42.77
4.	8.353 7.117	9.527 7.622	513.0 533.6	16.93 22.62	148.00 138.87	899.0 809.4	784.0 760.2	-1.68 104.47
5.	5.383 8.037	6.313 8.894	345.0 622.6	15.22 26.72	122.00 140.60	663.0 923.3	566.0 844.8	-134.59 150.19
6.	3.798 8.951	7.084 10.012	388.0 700.8	16.59 30.59	115.00 142.98	671.0 1024.5	398.0 923.8	-195.00 175.60
7.	6.677 9.826	7.762 11.011	468.0 770.7	18.51 34.11	215.99 144.98	887.0 1115.0	720.0 1002.7	-361.88 193.22
8.	7.891 10.669	7.399 11.645	523.0 815.2	21.73 36.94	135.01 148.47	902.0 1175.2	900.0 1084.1	15.56 217.97
9.	8.415 11.473	9.009 11.881	608.0 831.7	25.91 38.57	124.00 152.07	1003.0 1200.5	1000.0 1166.6	-16.30 244.41
10.	7.632 12.254	10.355 12.003	621.0 840.2	26.23 39.43	152.00 154.31	1032.0 1214.0	1050.0 1245.7	-2.63 267.22
11.	8.693 13.003	9.915 12.141	702.0 849.8	29.12 39.99	131.00 155.69	1090.0 1227.6	1100.0 1321.2	145.18 291.85
12.	11.151 13.247	13.398 12.355	731.0 864.9	35.18 40.59	157.00 156.80	1143.0 1247.6	1140.0 1382.1	225.29 314.18
13.	9.691 13.437	12.156 12.674	798.0 887.2	36.03 41.41	163.00 158.06	1190.0 1276.8	1200.0 1391.0	35.04 316.90
14.	13.204 13.667	12.094 13.095	832.0 916.6	37.18 42.55	145.00 159.66	1240.0 1315.2	1200.0 1391.2	25.60 315.86
15.	13.011 13.886	12.235 13.587	916.0 951.1	38.25 43.97	184.99 161.65	1311.0 1360.6	1200.0 1399.5	23.40 318.19
16.	14.236 14.117	16.594 14.104	1102.0 987.3	43.50 45.58	198.00 163.93	1447.0 1408.4	1300.0 1412.5	38.26 320.63

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
17.	11.381	15.063	941.1	47.80	194.00	1409.0	1329.0	2.30
	14.406	14.600	1022.0	47.24	166.35	1454.6	1431.6	321.81
17.999	12.708	16.151	934.0	43.10	238.97	1427.0	1053.2	33.51
	14.410	15.042	1052.9	48.82	168.71	1496.1	1456.4	341.67
18.999	14.788	10.331	622.3	42.70	147.09	984.4	1138.9	52.28
	14.131	15.418	1079.2	50.24	170.87	1531.6	1438.2	351.20
19.999	13.917	10.914	917.6	43.80	152.99	1029.9	1376.7	59.39
	14.141	15.730	1101.1	51.45	172.76	1561.2	1407.2	348.51
20.999	13.807	17.058	961.9	44.90	142.02	1101.9	1100.4	127.90
	14.231	15.984	1118.9	52.47	174.36	1585.5	1400.3	347.82
21.998	13.542	14.423	1005.9	46.30	185.93	1308.6	1199.8	285.73
	14.585	16.189	1133.2	53.30	175.67	1605.1	1416.3	342.55
22.998	14.911	16.857	1049.9	48.20	172.03	1450.7	1299.8	431.72
	15.257	16.350	1144.5	53.97	176.73	1620.5	1465.3	332.75
23.998	15.017	18.266	1038.0	50.10	190.96	1504.9	1399.8	567.70
	16.230	16.475	1153.2	54.50	177.57	1632.4	1554.1	323.74
24.998	17.107	19.401	1111.8	51.40	202.97	1661.6	1499.8	283.69
	16.968	16.570	1159.9	54.91	178.24	1641.6	1665.9	323.94
25.997	17.400	19.125	1189.8	50.60	200.01	1894.4	1599.7	542.31
	17.805	16.660	1166.2	55.24	178.86	1650.2	1754.2	308.18
26.997	16.494	18.770	1322.6	55.09	219.94	1807.3	1699.7	794.46
	18.586	16.789	1175.2	55.59	179.58	1662.2	1839.0	306.82
27.997	22.586	27.479	1615.1	59.19	281.80	2183.8	1799.7	284.32
	19.124	17.007	1190.5	56.10	180.53	1682.2	1914.8	335.64
28.997	19.019	23.900	1447.6	53.82	244.13	1958.8	1864.8	526.17
	20.454	17.348	1214.3	56.92	181.89	1713.4	1953.0	272.67
29.996	21.368	23.338	1469.9	46.03	246.99	1989.9	1560.1	660.01
	20.907	19.173	1342.1	58.66	180.05	1868.4	1988.9	264.56
30.996	21.368	24.653	962.0	40.92	133.44	1329.6	1774.2	532.50
	20.594	21.283	1489.8	61.21	184.45	2054.7	2093.0	420.07
31.996	23.363	17.021	1489.8	49.96	195.74	2261.1	1815.8	415.48
	20.237	20.852	1459.6	63.70	188.23	2024.3	1987.9	339.64
32.996	21.727	24.345	1354.6	54.98	197.99	2095.7	1501.4	66.73
	21.650	20.460	1432.2	66.16	193.04	1998.3	2074.1	287.36
33.995	17.701	20.194	1431.6	55.00	208.95	2317.0	1599.5	313.85
	22.688	22.050	1543.5	68.85	196.01	2139.1	2175.7	355.64

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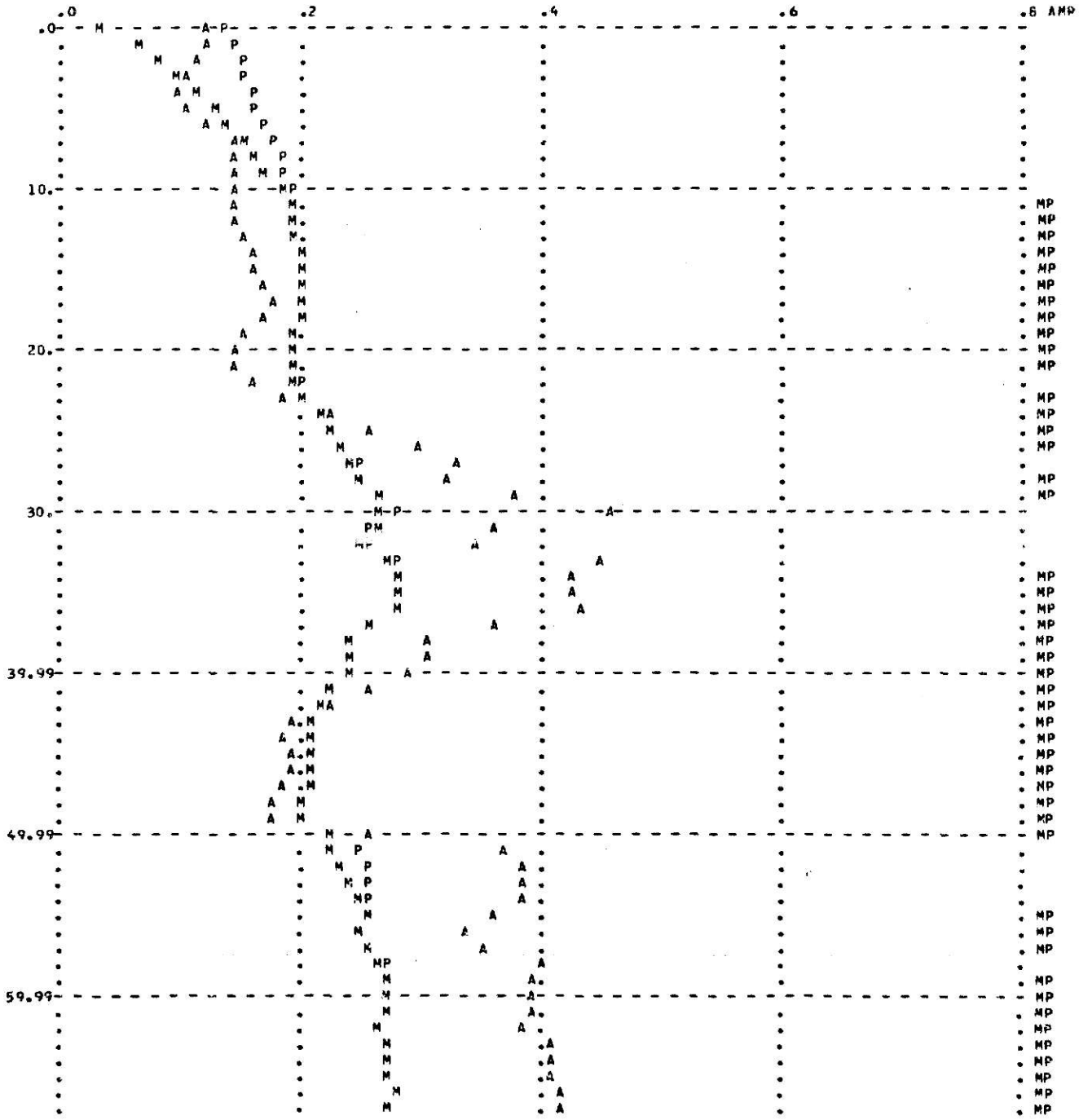
TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
34.995	19.567	20.358	1582.3	59.98	200.04	2066.2	1699.5	295.10
	22.999	23.648	1655.3	71.40	200.16	2281.6	2217.0	370.40
35.995	20.276	18.980	1620.8	64.97	249.74	2528.6	1749.7	202.48
	23.281	23.939	1675.7	73.74	203.99	2312.6	2285.6	404.02
36.995	19.976	19.442	1268.9	69.38	270.89	2610.6	1799.7	226.87
	21.445	23.745	1662.2	75.91	207.49	2301.7	2257.5	452.75
37.994	21.819	19.190	1186.5	62.44	250.12	1703.1	1853.7	229.98
	20.206	23.702	1659.1	77.67	212.01	2304.4	2043.2	409.27
38.994	20.096	19.301	1388.8	55.54	287.78	1760.6	2030.0	499.42
	20.220	24.042	1682.9	78.93	215.01	2337.5	1908.8	370.32
39.994	24.714	21.268	1353.2	59.97	310.86	1906.1	1853.1	232.64
	20.024	23.965	1677.6	79.64	219.96	2336.6	1915.1	387.37
40.994	19.587	20.523	1292.4	55.23	184.80	1827.5	2246.5	409.86
	19.295	23.150	1620.5	78.50	226.42	2272.7	1912.0	403.95
41.993	21.505	20.099	1310.9	56.89	181.02	1841.9	1763.2	212.32
	18.525	21.687	1518.1	75.25	233.30	2152.0	1863.8	400.16
42.993	20.727	15.973	1051.8	42.00	309.12	1624.5	1951.7	1.51
	17.891	19.932	1395.2	70.38	238.65	2003.2	1799.9	379.21
43.993	14.371	14.706	963.6	53.91	248.44	1471.1	1982.8	49.65
	17.866	18.402	1288.2	65.10	240.07	1869.4	1763.7	351.02
44.993	16.106	14.444	1008.7	54.99	244.03	1508.7	1410.2	30.44
	18.160	17.780	1244.6	61.44	235.16	1807.9	1783.4	352.00
45.992	13.919	17.090	1139.0	59.96	291.64	1720.4	1635.3	136.19
	18.331	18.029	1262.1	60.38	228.36	1821.2	1821.6	379.67
46.992	16.119	18.491	1213.4	60.00	253.30	1791.5	1407.8	511.06
	18.208	18.476	1293.3	60.97	225.31	1856.7	1841.2	410.25
47.992	20.985	20.120	1213.0	59.01	261.93	1856.5	1635.1	462.42
	18.016	18.542	1297.9	61.55	226.84	1864.5	1826.5	414.06
48.992	20.334	22.129	1434.2	60.98	288.78	2037.5	1406.9	222.01
	18.236	18.280	1279.6	61.26	229.15	1844.2	1817.6	398.63
49.991	21.129	23.800	1555.0	72.90	261.24	2181.8	1590.4	496.62
	20.343	18.377	1286.4	61.11	227.44	1850.6	1858.9	316.20
50.991	25.300	26.418	1729.5	84.89	268.93	2397.1	2306.7	431.60
	20.599	19.961	1397.3	63.68	218.21	1978.6	2004.7	292.91
51.991	22.675	27.727	1864.8	80.05	263.05	2522.9	2061.3	587.58
	21.478	21.732	1521.2	68.43	215.40	2131.0	2097.1	318.73

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
52.991	28.053	25.717	1727.3	97.83	254.08	2390.3	2577.2	482.00
	22.353	23.158	1621.1	73.35	216.63	2258.4	2178.3	347.83
53.99	27.644	26.094	1733.9	97.01	256.97	2389.0	2534.5	828.66
	23.135	24.282	1699.7	77.64	218.64	2360.2	2256.1	394.31
54.99	28.726	24.034	1566.6	87.10	221.35	2097.9	2568.7	581.47
	23.868	25.179	1762.5	81.21	220.49	2441.9	2323.9	451.88
55.99	23.939	27.877	1873.9	129.57	168.53	2532.6	2168.0	678.99
	23.671	25.840	1808.8	87.52	222.32	2506.2	2375.7	497.27
56.99	29.848	32.621	2146.2	122.08	194.72	2877.5	2662.8	589.93
	24.253	25.614	1793.0	92.26	227.27	2496.7	2348.1	442.07
57.99	26.401	31.414	2083.7	122.00	196.98	2891.9	2388.0	457.39
	25.261	25.625	1793.8	95.67	226.84	2500.7	2443.0	431.62
58.989	28.108	31.832	2312.5	116.06	204.91	3125.5	2687.7	631.10
	25.924	26.096	1826.7	100.41	225.51	2544.1	2537.3	471.12
59.989	30.658	31.034	2070.7	121.93	188.19	2884.7	2876.9	266.07
	25.984	26.287	1840.1	105.06	226.44	2565.9	2572.3	472.47
60.989	21.040	26.079	1661.6	122.99	171.19	2507.3	2014.8	602.14
	26.232	26.422	1849.5	109.42	227.53	2582.8	2595.0	479.76
61.989	28.454	25.119	1686.7	128.93	206.59	2445.7	2717.7	668.28
	26.095	26.593	1861.5	113.76	228.57	2602.7	2581.6	468.09
62.988	30.537	28.925	1970.6	142.84	214.91	2785.0	2931.6	323.10
	26.959	26.820	1877.4	118.27	229.65	2627.6	2594.6	447.74
63.988	24.780	24.328	1654.9	129.17	187.33	2406.6	2422.2	457.33
	27.047	27.095	1896.0	123.04	230.81	2656.1	2672.0	477.08
64.988	31.006	29.263	2075.8	163.57	215.65	2973.9	3069.9	482.71
	27.348	27.361	1915.2	127.99	232.06	2685.7	2675.3	455.67
65.988	26.843	29.612	2135.3	139.31	231.80	2971.1	2716.6	428.68
	27.839	27.630	1934.1	133.06	233.36	2715.0	2739.3	478.73
66.987	32.626	27.212	2180.4	141.96	220.15	2982.8	3399.2	428.00
	27.715	27.889	1952.2	138.19	234.66	2743.4	2740.4	461.67

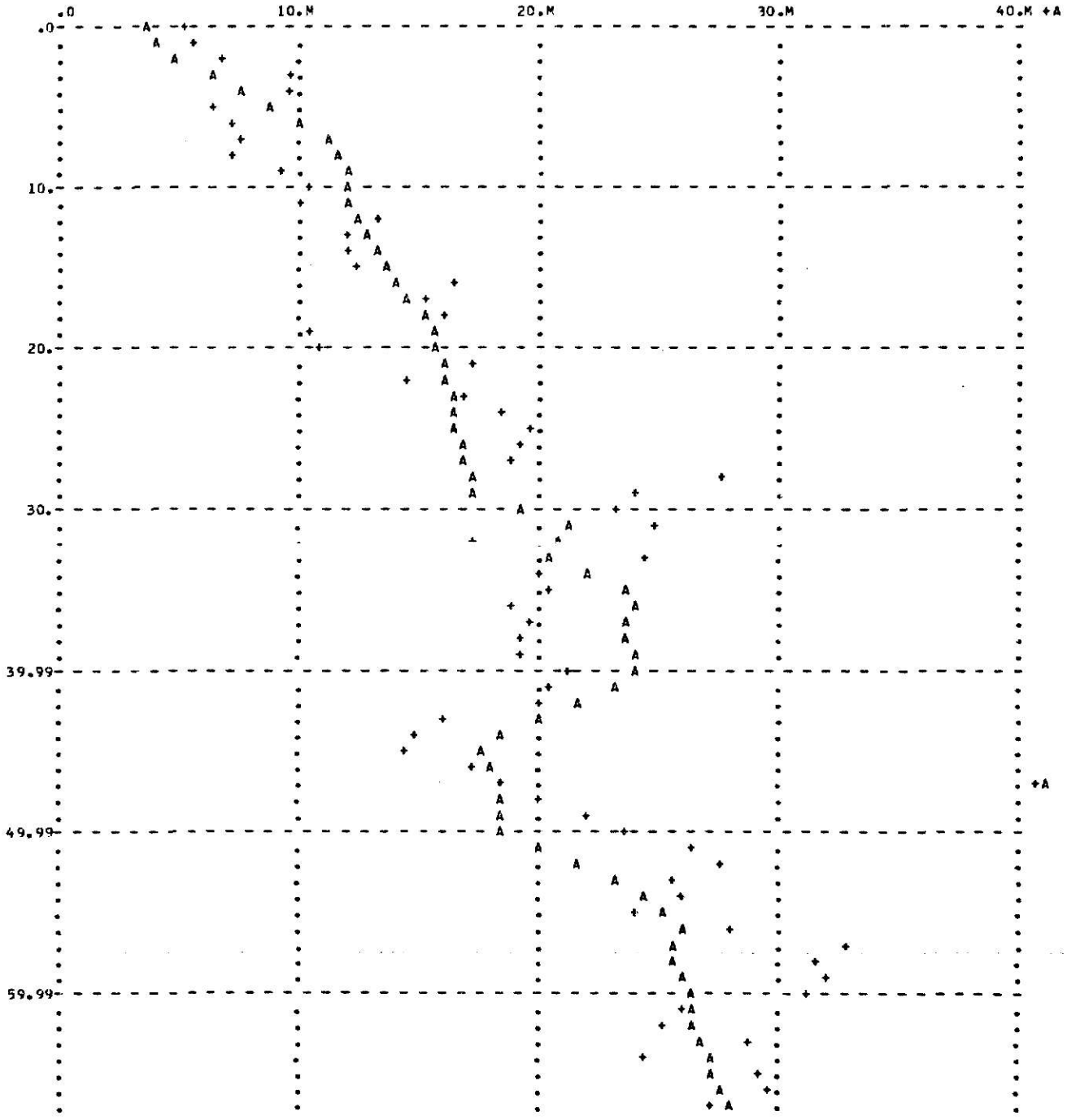
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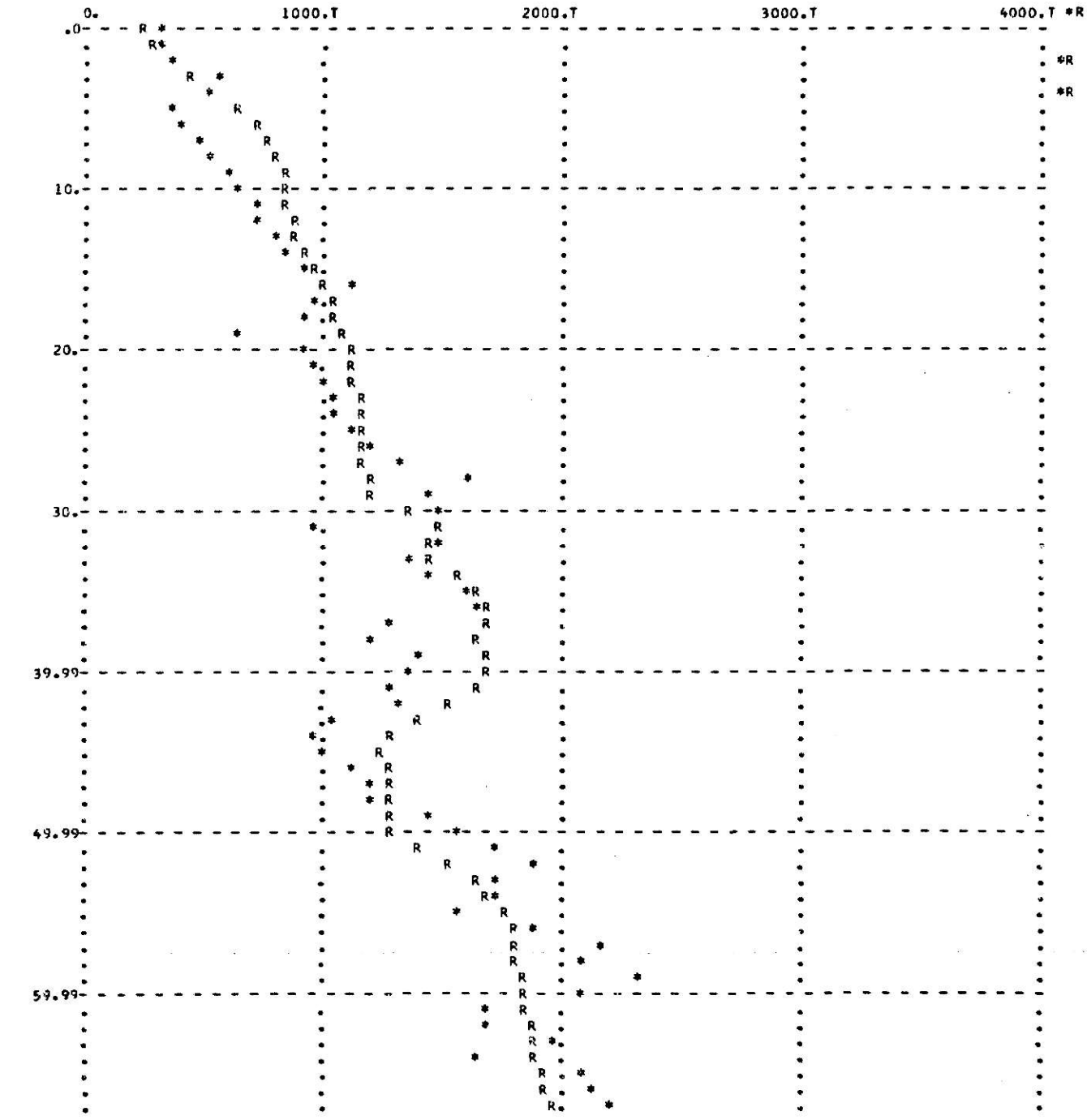
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MANF=+,AVMR=A



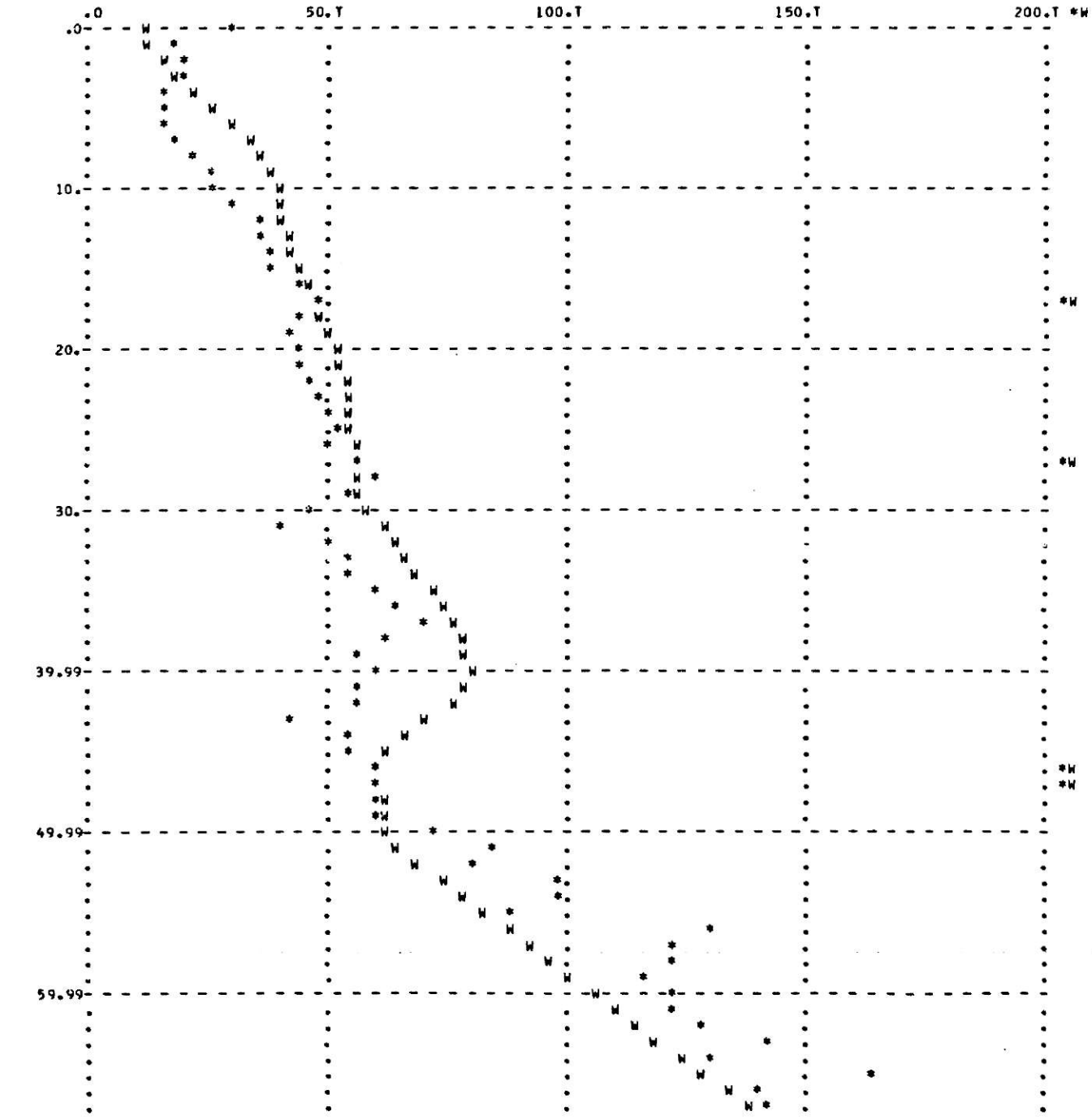
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CORM=*,RMCO=R



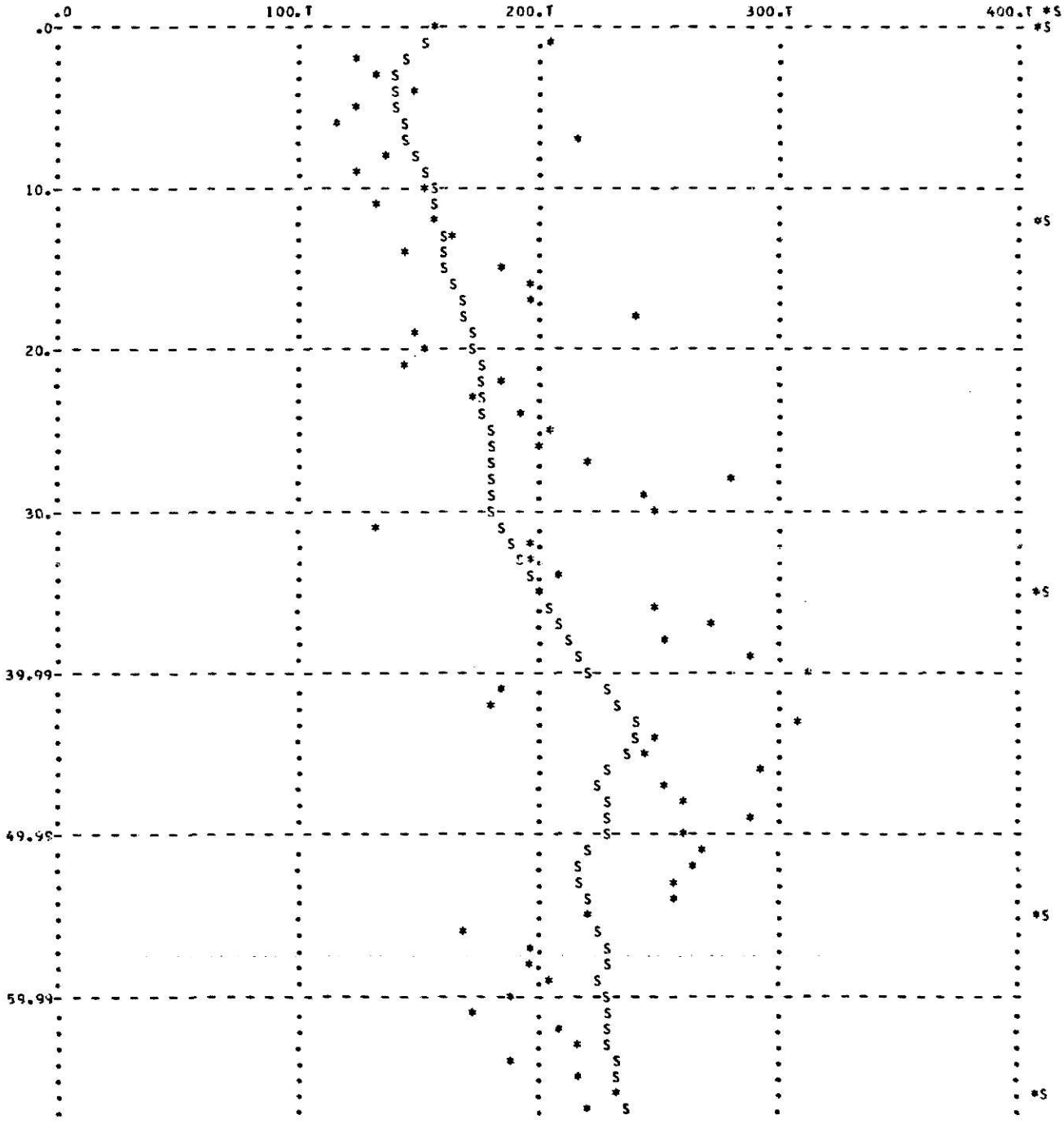
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WAGS=*,WAGE=W



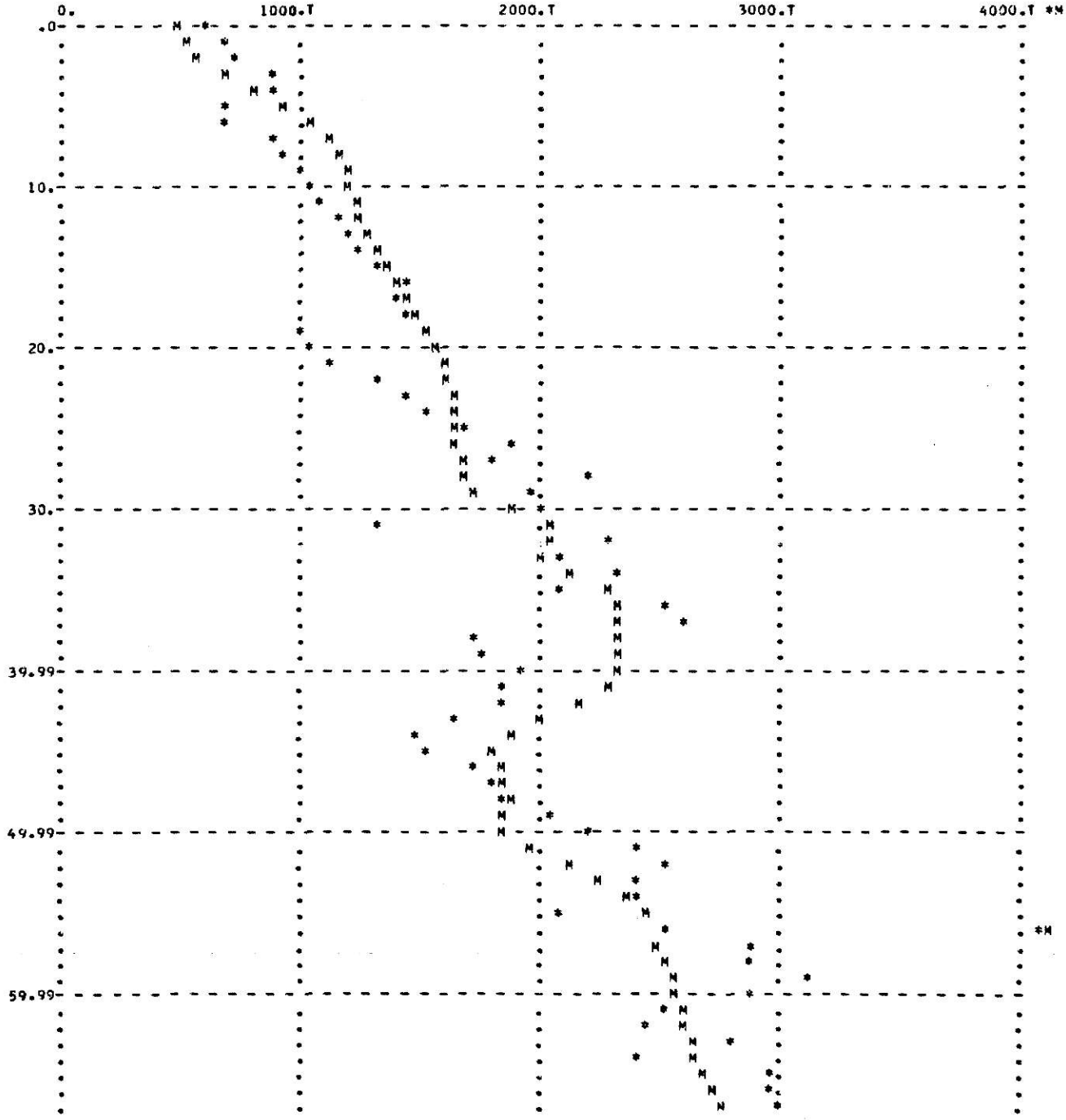
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SALS=*,SALA=S



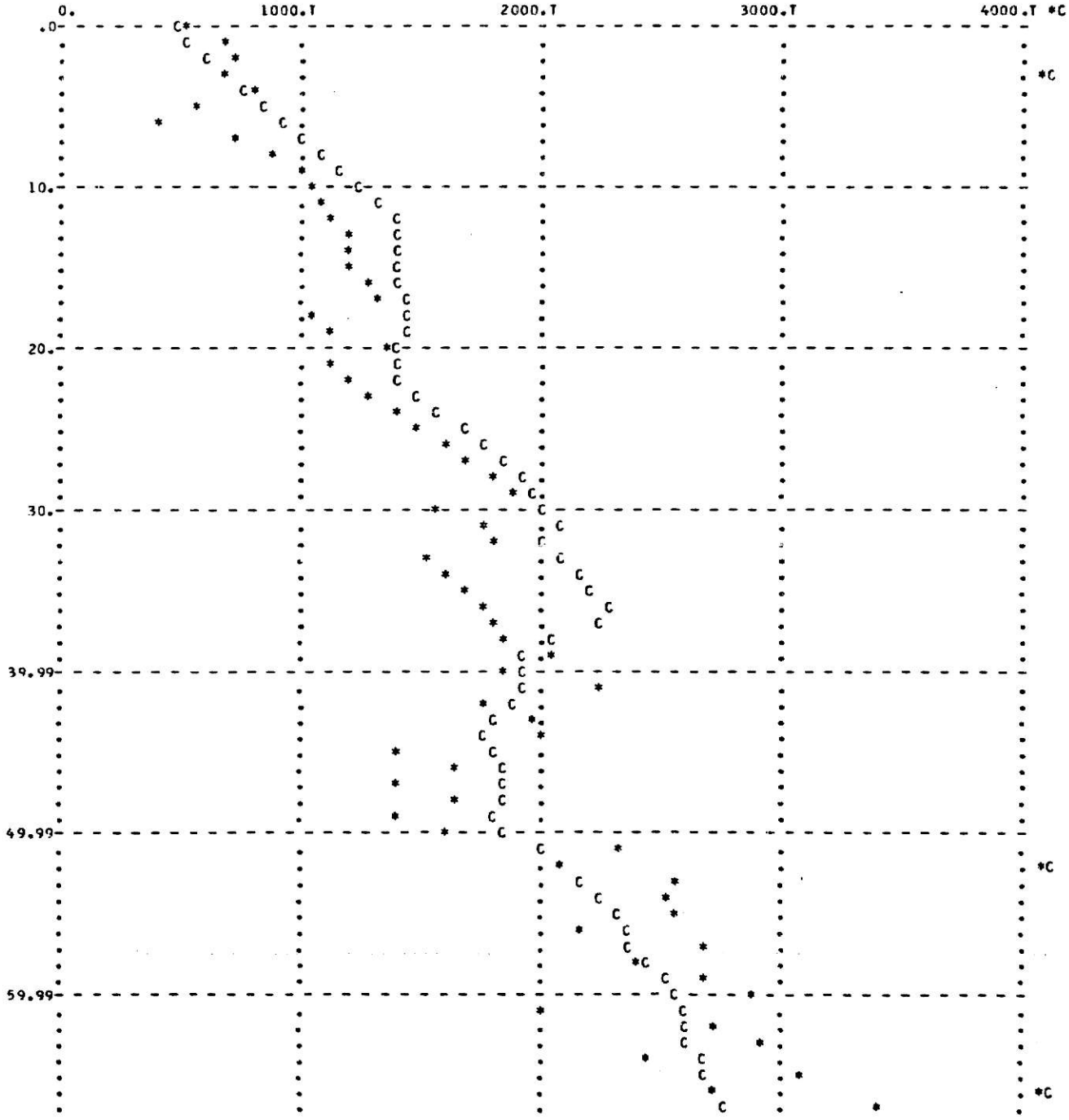
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MACO=*,MANC=M



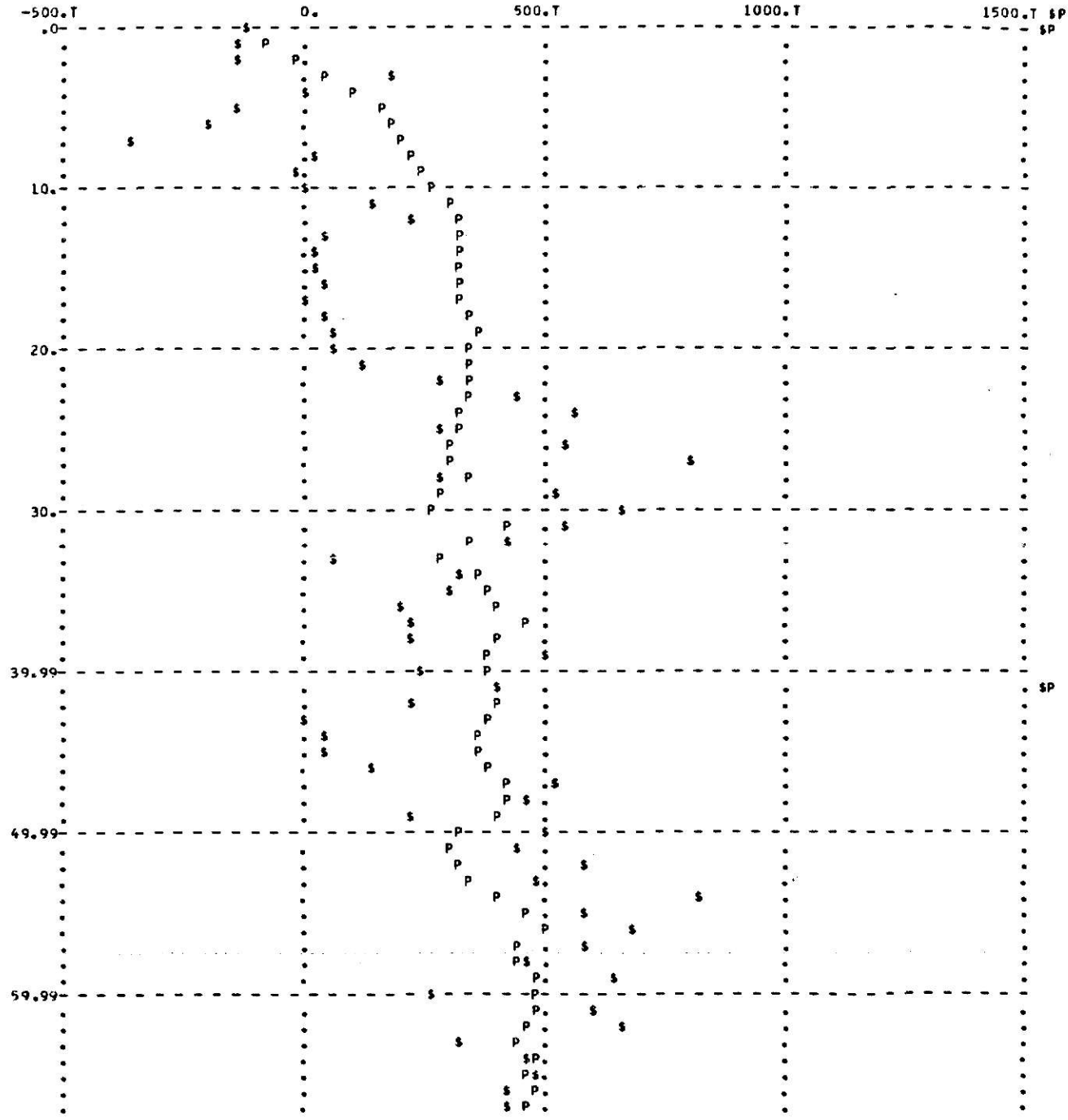
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SACO=*,COSA=C



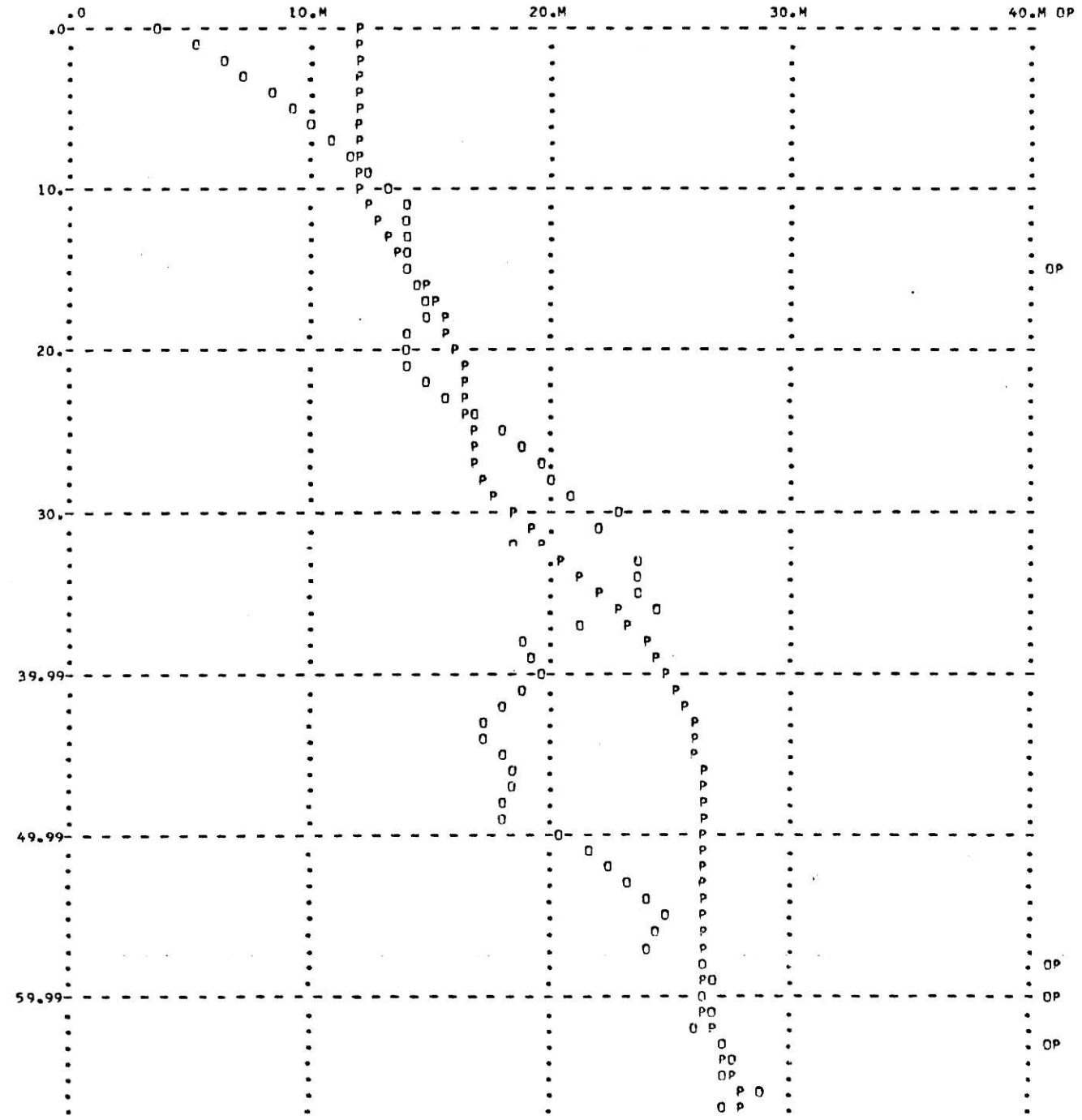
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TRPR=$,TPRO=P



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ORRF=O,PRCA=P



APPENDIX D

Computer Program for New Production Capacity Acquisition Policy

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```
NOTE*****************************************************************
NOTE
NOTE        MODEL OF CIGARETTE MANUFACTURING COMPANY IN MOZAMBIQUE
NOTE
NOTE*****************************************************************
NOTE
NOTE                              THE MARKET
NOTE
NOTE*****************************************************************
NOTE
NOTE     POTENTIAL DEMAND GENERATION SECTOR
NOTE
R      ADDE.KL=(FRBA)(USPC)(AVMR.K)            ADVERTIZING DECISION
C      FRBA=0.10              FRACTION OF REVENUE BUDGETED FOR ADVERTIZING
C      USPC=0.22                        UNIT SELLING PRICE OF CIGARETTES
L      AVMR.K=AVMR.J+(DT)(MARA.JK-AVMR.J)/DAMR   AVERAGE MANUFACTURING RATE
N      AVMR=MARA
C      DAMR=1                          DELAY IN AVERAGING MANUFACTURING RATE
R      APMC.KL=DELAY3(ADDE.JK,DAAM)              ADVERTIZING PRESENTED BY
NOTE                                             MEDIA TO CONSUMER
C      DAAM=0.25              DELAY AT ADVERTIZING AGENCIES AND MEDIA
L      ADAC.K=ADAC.J+(DT)(APMC.JK-ADAC.J)/DAAC   ADVERTIZING AWARENESS
N      ADAC=ADDE                                 OF CONSUMER
C      DAAC=0.5               DELAY IN ADVERTIZING AWARENESS OF CONSUMER
A      CACB.K=ADAC.K/AAOC.K                CONSUMER AWARENESS OF COMPANY'S BRANDS
L      AAOC.K=AAOC.J+(DT)(GRAC)      AVERAGE ADVERTIZING OUTLAY OF COMPETITORS
N      AAOC=1100000
C      GRAC=4900              GROWTH RATE IN ADVERTIZING OF COMPETITORS
A      RPPR.K=0.39+(0.36)(CACB.K)          REPEAT PURCHASE PROBABILITY
A      TPPR.K=0.11+(0.16)(CACB.K)          TRANSFER PURCHASE PROBABILITY
A      PMSC.K=(RPPR.K)(MASH.K)+(TPPR.K)(1-MASH.K)      POTENTIAL MARKET SHARE
N      PMSC=.03
A      MASH.K=SARA.JK/ACSI.K                        MARKET SHARE
A      PODE.K=(PMSC.K)(ACSI.K)                      POTENTIAL DEMAND
L      ACSI.K=ACSI.J+(DT)(GRCI)          AVERAGE CIGARETTE SALES OF INDUSTRY
N      ACSI=61500000
C      GRCI=583000                       GROWTH RATE OF CIGARETTE INDUSTRY
NOTE
NOTE     RETAIL SECTOR
NOTE
R      SARA.KL=(PODE.K)(PRAM.K)                     SALES RATE
A      PRAM.K=TABHL(PRAT,INRA.K,0,1,0.2)       PRODUCT AVAILABILITY MULTIPLIER
A      INRA.K=INVR.K/INNR.K                         INVENTORY RATIO
L      INVR.K=INVR.J+(DT)(SRRI.JK-SARA.JK)          INVENTORY AT RETAIL
N      INVR=INNR
A      INNR.K=(PINR)(PODE.K)             INVENTORY NECESSARY AT RETAIL
C      PINR=0.5               PERIOD OF INVENTORY NECESSARY AT RETAIL
R      SRRI.KL=DELAY3(SSFI.JK,DIST)      SHIPMENTS RECEIVED AT RETAIL INVENTORY
C      DIST=0.5                          DELAY IN SHIPMENT TRANSPORTATION
L      SITR.K=SITR.J+(DT)(SSFI.JK-SRRI.JK)     SHIPMENTS IN TRANSIT TO RETAIL
N      SITR=0
R      ORRF.KL=SRSA.K+(INDR.K-INVR.K-SITR.K)/TAIR       ORDER RATE AT FACTORY
C      TAIR=0.5                          TIME TO ADJUST INVENTORY AT RETAIL
L      SRSA.K=SRSA.J+(DT)(SARA.JK-SRSA.J)/DSRS   SMOOTHED RETAIL SALES
N      SRSA=PODE
C      DSRS=1                            DELAY IN SMOOTHING RETAIL SALES
A      INDR.K=(PIDR)(SRSA.K)                        INVENTORY DESIRED AT RETAIL
C      PIDR=1                            PERIOD OF INVENTORY DESIRED AT RETAIL
```

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NOTE
NOTE*****************************************************************
NOTE
NOTE                          THE COMPANY
NOTE
NOTE*****************************************************************
NOTE
NOTE     ORDER FILLING SECTOR
NOTE
L     UNOF.K=UNOF.J+(DT)(ORRF.JK-SSFI.JK)       UNFILLED ORDERS AT FACTORY
N     UNOF=UODF
L     INVF.K=INVF.J+(DT)(PRFI.JK-SSFI.JK)       INVENTORY AT THE FACTORY
N     INVF=INDF
R     SSFI.KL=CLIP(NSRF.K,RSRF.K,INVF.K,UNOF.K) SHIPMENTS SENT FROM FACTORY
A     NSRF.K=UNOF.K/DFOF              NORMAL SHIPPING RATE FROM FACTORY
A     RSRF.K=INVF.K/DFOF              RESTRICTED SHIPPING RATE FROM FACTORY
C     DFOF=0.1                        DELAY IN FILLING ORDERS AT FACTORY
NOTE
NOTE     MANUFACTURING SECTOR
NOTE
A     MRDF.K=SORF.K+(UNOF.K-UODF.K+INDF.K-INVF.K-WIPF.K)/TAIB MANUFACTURING
NOTE                                          RATE DESIRED AT FACTORY
C     TAIB=3                          TIME TO ADJUST INVENTORY AND BACKLOG
L     SORF.K=SORF.J+(DT)(ORRF.JK-SORF.J)/DSOR SMOOTHED ORDER RATE AT FACTORY
N     SORF=ORRF
C     DSOR=1                          DELAY IN SMOOTHING ORDER RATE
A     INDF.K=MIDF+(PIDF)(SORF.K)            INVENTORY DESIRED AT FACTORY
C     MIDF=1000000                    MINIMUM INVENTORY DESIRED AT FACTORY
C     PIDF=1.5                        PERIOD OF INVENTORY DESIRED AT FACTORY
A     UODF.K=(DFOF)(SORF.K)           UNFILLED ORDERS DESIRED AT FACTORY
A     PRCF.K=CLIP(DSPC.K,SSPC.K,PRCA.K,PRCL)    PRODUCTION CAPABILITY
A     DSPC.K=2*PRCA.K                 DOUBLE SHIFT PRODUCTION CAPABILITY
A     SSPC.K=PRCA.K+PCCO.K            SINGLE SHIFT PRODUCTION CAPABILITY
C     PRCL=40000000                         PRODUCTION CAPCITY LIMIT
A     PCCO.K=CLIP(0.0,OPAF.K,INVF.K,UNOF.K)  PRODUCTION CAPACITY CONTRIBUTED
NOTE                                          BY OVERTIME
A     OPAF.K=(FCCO)(PRCA.K)           OVERTIME PRODUCTION ALLOWED AT FACTORY
C     FCCO=0.4              FRACTION OF CAPACITY CONTRIBUTED BY OVERTIME
R     MARA.KL=CLIP(MRDF.K,PRCF.K,PRCF.K,MRDF.K) MANUFACTURING RATE
N     MARA=ORRF
R     PRFI.KL=DELAY3(MARA.JK,DPLT)    PRODUCTS RECEIVED AT FACTORY INVENTORY
C     DPLT=0.1                        DELAY DUE TO PRODUCTION LEAD TIME
L     WIPF.K=WIPF.J+(DT)(MARA.JK-PRFI.JK)       WORK-IN-PROGRESS AT FACTORY
N     WIPF=0
NOTE
NOTE     PRODUCTION CAPACITY ACQUISITION SECTOR
NOTE
A     PCDF.K=EPOR.K+ECOR.K            PRODUCTION CAPACITY DESIRED AT FACTORY
A     EPOR.K=SORF.K/EFMD.K            ESTIMATED POTENTIAL ORDER RATE
A     EFMD.K=TABHL(EFFT,RUDO.K,0,1,0.2)         EFFICIENCY OF FACTORY IN
NOTE                                          MEETING DEMAND
A     RUDO.K=UODF.K/UNOF.K            RATIO OF DESIRED TO UNFILLED ORDERS
L     PORP.K=PORP.J+(DT)(EPOR.J-PORP.J)/DAPO    POTENTIAL ORDER RATE IN PAST
N     PORP=SORF
C     DAPO=12                         DELAY IN AVERAGING PAST ORDERS
A     PCPO.K=EPOR.K-PORP.K            PAST CHANGE IN POTENTIAL ORDER RATE
A     ECOR.K=(PCPO.K)(ORIC)/DAPO      ESTIMATED CHANGE IN ORDER RATE
C     ORIC=6                DELAY IN RECEIVING AND INSTALLING CAPACITY
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R     PRCO.KL=CLIP(PCOF.K,0.0,PCOF.K,0.0)     PRODUCTION CAPACITY ORDER RATE
A     PCOF.K=(PCOF.K-PRCA.K-PCOO.K)/TAPC      PRODUCTION CAPACITY ORDERS
C     TAPC=1                                  TIME TO ADJUST PRODUCTION CAPACITY
R     PCAR.KL=DELAY3(PRCO.JK,DRIC)            PRODUCTION CAPACITY ADDITION RATE
L     PCOO.K=PCOO.J+(DT)(PRCO.JK-PCAR.JK)     PRODUCTION CAPACITY ON ORDER
N     PCOO=0
R     PCOR.KL=DELAY3(PCAR.JK,ALCF)            PRODUCTION CAPACITY OBSOLESCENCE RATE
C     ALCF=180                AVERAGE LIFETIME OF CAPACITY AT FACTORY
L     PRCA.K=PRCA.J+(DT)(PCAR.JK-PCOR.JK)     PRODUCTION CAPACITY
N     PRCA=12000000
NOTE
NOTE     PERSONNEL REQUIREMENT SECTOR
NOTE
A     TPDF.K=CLIP(TPDU.K,TPDO.K,PRCA.K,AVMR.K)  TECHNICAL PERSONNEL DESIRED
A     TPDU.K=AVMR.K/PTPF      TECHNICAL PERSONNEL DESIRED DURING UNDERCAPACITY
A     TPDO.K=PRCA.K/PTPF      TECHNICAL PERSONNEL DESIRED DURING OVERCAPACITY
C     PTPF=300000             PRODUCTIVITY OF TECHNICAL PERSONNEL AT FACTORY
A     PPDF.K=MPPD+(PRCA.K/PPPF)       PROFESIONAL PERSONNEL DESIRED
C     MPPD=8                  MINIMUM NUMBER OF PROFESSIONAL PERSONNEL DESIRED
C     PPPF=2400000          PRODUCTIVITY OF PROFESSIONAL PERSONNEL AT FACTORY
A     RTPF.K=TPDF.K/(TPDF.K+PPDF.K)   RATIO OF TECHNICAL TO PROFESSIONAL
NOTE                                  PERSONNEL AT FACTORY
A     PCIF.K=(TPDF.K+PPDF.K-PITF.K-PPLF.K)/TPAF PERSONNEL CHANGE INDICATED
C     TPAF=1                  TIME FOR PERSONNEL ADJUSTMENT AT FACTORY
R     PHRF.KL=CLIP(PCIF.K,0,PCIF.K,0) PERSONNEL HIRING RATE AT FACTORY
R     PDRF.KL=CLIP(0,-PCIF.K,PCIF.K,0)  PERSONNEL DISMISSAL RATE AT FACTORY
L     PITF.K=PITF.J+(DT)(PHRF.JK-PBPF.JK)       PERSONNEL IN TRAINING
N     PITF=0
R     PBPF.KL=DELAY3(PHRF.JK,DPTF)    PERSONNEL BECOMING PRODUCTIVE
C     DPTF=0.5                DELAY DUE TO PERSONNEL TRAINING AT FACTORY
L     PPLF.K=PPLF.J+(DT)(PBPF.JK-PDRF.JK)       PRODUCTIVE PERSONNEL LEVEL
N     PPLF=TPDF+PPDF
A     PERC.K=PITF.K+PPLF.K                      PERSONNEL IN THE COMPANY
NOTE
NOTE
NOTE     PROFIT SECTOR
NOTE
A     REVS.K=(USPC)(AVSR.K)                     REVENUE FROM SALES
L     AVSR.K=AVSR.J+(DT)(SSFI.JK-AVSR.J)/DSSR   AVERAGE SHIPPING RATE
N     AVSR=SSFI
C     DSSR=1
A     MANC.K=RMCO.K+WAGE.K+SALA.K+PROE.K                  MANUFACTURING COST
A     RMCO.K=(PKRM)(AVMR.K)/CKRM                          RAW MATERIAL COST
C     CKRM=1000                          CIGARETTES PER KG. OF RAW MATERIAL
C     PKRM=70                            PRICE PER KG. OF RAW MATERIAL
A     WAGE.K=(WARA.K)(RTPF.K)(PERC.K)           WAGES
A     WARA.K=TABHL(WRTA,TIME.K,55,67,12)        WAGE RATE
A     SALA.K=(SALR)(1-RTPF.K)(PERC.K)           SALARIES
C     SALR=12000                                SALARY RATE
A     PROE.K=(UCPR)(AVMR.K)                     PRODUCTION EXPENSES
C     UCPR=.015                                 UNIT COST OF PRODUCTION
A     COSA.K=(UMCO.K)(AVSR.K)                   COST OS SALES
A     UMCO.K=MANC.K/AVMR.K                      UNIT MANUFACTURING COST
A     EXDU.K=(DUTY)(USPC)(AVSR.K)               EXCISE DUTY
C     DUTY=.28                                  DUTY RATE
A     SELE.K=(FRSE)(USPC)(AVSR.K)               SELLING EXPENDITURES
C     FRSE=0.1                FRACTION OF REVENUE FOR SELLING EXPENDITURES
L     ADEX.K=ADEX.J+(DT)(ADDE.JK-ADEX.J)/DSAE   ADVERTIZING EXPENDITURES
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```
N       ADEX=ADDE
C       DSAE=1                    DELAY IN SMOOTHING ADVERTIZING EXPENDITURES
A       TPRO.K=REVS.K-COSA.K-EXDU.K-SELE.K-ADEX.K TRADE PROFIT
NOTE
NOTE
NOTE      TABLES AND SUPPLEMENTARY EQUATIONS
NOTE
T       PRAT=0.0,.32,.55,.72,.85,1.0
T       EFFT=0.0,0.7,0.83,0.92,0.97,1.0
T       WRTA=1000,1500
S       SALE.K=TABLE(STAB,TIME.K,0,67,1)
T       STAB=5301120,5743960,6884420,7470580,8352800,5383000,3798000,
X       6677000,7891000,8415230,7631540,8692900,11151520,9691160,13204800,
X       13011200,14236350,11379190,12709210,14790290,13915990,13806920,
X       13541090,14913780,15017140,17111640,17400920,16491540,22604960,
X       19007000,21377100,21368200,23371000,21720000,17682000,19576000,
X       20280000,19974000,21829050,20086125,24741950,19553700,21517650,
X       20721500,14326000,16119000,13902000,16136000,21024000,20328000,
X       21136000,25337000,22651000,28104000,27640000,28737000,23891000,
X       29910000,26364000,28127000,30686000,20939000,28541000,30561000,
X       24710000,31084000,26790000,32701000
S       MANF.K=TABLE(MTAB,TIME.K,0,67,1)
T       MTAB=5234080,5774320,6896300,9755300,9527100,6313220,7084540,
X       7761760,7398910,9008700,10355400,9915150,13398710,12155730,
X       12093630,12235000,16595320,15061790,16151800,10325290,10915150,
X       17067100,14418120,16861400,18268800,19403400,19124400,18769430,
X       27506300,23888200,23336350,24658000,16989400,24377550,20174800,
X       20356400,18472550,19444600,19186250,19301500,21280000,20516500,
X       20096200,15944800,14697000,14442000,17110000,18502000,20133000,
X       22146000,23814000,26441000,27739000,25698000,26098000,24014000,
X       27916000,32670000,31401000,31837000,31025000,26023000,25109000,
X       28970000,24272000,29325000,29616000,27181000
S       CORM.K=TABLE(RTAB,TIME.K,0,67,1)
T       RTAB=323000,320000,350000,572000,513000,345000,388000,462000,
X       523000,608000,621000,702000,731000,798000,832000,916000,1102000,
X       941000,934000,622000,918000,962000,1006000,1050000,1038000,
X       1112000,1190000,1323000,1616000,1447000,1470000,960000,1492000,
X       1354000,1432000,1583000,1621000,1267000,1186000,1390000,1353000,
X       1292000,1311000,1050000,963000,1009000,1140000,1214000,1213000,
X       1436000,1556000,1731000,1866000,1726000,1734000,1565000,1877000,
X       2149000,2083000,2315000,2068000,1657000,1687000,1974000,1651000,
X       2081000,2136000,2181000
S       WAGS.K=TABLE(WTAB,TIME.K,0,67,1)
T       WTAB=29100,17800,19150,20820,16929,15219,16595,18513,21730,25910,
X       26230,29120,35180,36030,37180,38250,43500,47800,43100,42700,43800,
X       44900,46300,48200,50100,51400,50600,55100,59200,53800,46000,40900,
X       50000,55000,55000,60000,65000,69400,62400,55500,60000,55200,56900,
X       41900,54000,55000,60000,60000,59000,61000,73000,85000,80000,98000,
X       97000,87000,130000,122000,122000,116000,122000,123000,129000,
X       143000,129000,164000,139000,142000
S       SALS.K=TABLE(SALT,TIME.K,0,67,1)
T       SALT=155000,206000,124000,133000,148000,122000,115000,216000,
X       135000,124000,152000,131000,157000,163000,145000,185000,198000,
X       194000,239000,147000,153000,142000,186000,172000,191000,203000,
X       200000,220000,282000,244000,247000,133000,196000,198000,209000,
X       200000,250000,271000,250000,288000,311000,184000,181000,310000,
X       248000,244000,292000,253000,262000,289000,261000,269000,263000,
X       254000,257000,221000,168000,195000,197000,205000,188000,171000,
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X      207000,215000,187000,216000,232000,220000
S      MACO.K=TABLE(MANT,TIME.K,0,67,1)
T      MANT=607000,669000,709000,870000,899000,663000,671000,887000,
X      902000,1003000,1032000,1090000,1143000,1190000,1240000,1311000,
X      1447000,1409000,1427000,984000,1030000,1102000,1309000,1451000,
X      1505000,1662000,1895000,1807000,2185000,1958000,1990000,1327000,
X      2265000,2095000,2318000,2065000,2531000,2611000,1698000,1761000,
X      1907000,1827000,1842000,1623000,1470000,1509000,1722000,1792000,
X      1857000,2039000,2183000,2399000,2524000,2389000,2389000,2095000,
X      2537000,2881000,2892000,3128000,2882000,2503000,2445000,2789000,
X      2402000,2981000,2971000,2983000
S      SACO.K=TABLE(COST,TIME.K,0,67,1)
T      COST=518000,671000,713000,685000,784000,566000,398000,720000,
X      900000,1000000,1050000,1100000,1140000,1200000,1200000,1200000,
X      1300000,1329000,1053000,1139000,1377000,1100000,1200000,1300000,
X      1400000,1500000,1600000,1700000,1800000,1865000,1559000,1775000,
X      1816000,1500000,1600000,1700000,1750000,1800000,1854000,2031000,
X      1852000,2249000,1760000,1953000,1983000,1406000,1637000,1406000,
X      1637000,1405000,1592000,2313000,2059000,2582000,2534000,2569000,
X      2164000,2668000,2385000,2691000,2879000,2005000,2726000,2934000,
X      2416000,3078000,2712000,3408000
S      TRPR.K=TABLE(PROT,TIME.K,0,67,1)
T      PROT=-114000,-139726,-141550,183560,-1686,-134602,-195000,
X      -361900,15600,-16300,-2630,145200,225300,35000,25600,23400,38267,
X      33400,2280,33530,52300,59400,128000,286000,432000,568000,283000,
X      543000,795200,282700,527000,660500,532000,415000,65200,315000,
X      295000,202000,227000,230000.501000,231000.411000.211000.-134.
X      50000,30300,137000,514000,462000,220000,499000,431000,589000,
X      481000,832000,579000,680000,589000,456000,633000,262000,606000,
X      669000,319000,459000,483000,428000
NOTE
NOTE       CONTROL CARDS
NOTE
PRINT 1)SALE/2)MANF/3)CORM/4)WAGS/5)SALS/6)MACO/7)SACO/8)TRPR
PRINT 1)SARA/2)AVMR/3)RMCO/4)WAGE/5)SALA/6)MANC/7)COSA/8)TPRO
PLOT CACB=A,MASH=M,PMSC=P
PLOT SALE=*,SARA=S
PLOT MANF=+,AVMR=A
PLOT CORM=*,RMCO=R
PLOT WAGS=*,WAGE=W
PLOT SALS=*,SALA=S
PLOT MACO=*,MANC=M
PLOT SACO=*,COSA=C
PLOT TRPR=$,TPRO=P
PLOT ORRF=O,PRCA=P
SPEC DT=0.05/LENGTH=67/PRTPER=1/PLTPER=1
RUN STD
```

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
E+00	E+06 E+06	E+06 E+06	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03	E+03 E+03
.0	5.301 2.845	5.234 3.690	323.0 258.3	29.10 12.30	155.00 156.00	607.0 481.9	518.0 481.9	-114.00 -59.81
1.	5.744 3.922	5.774 3.971	320.0 277.9	17.80 12.86	206.00 151.59	669.0 502.0	671.0 528.5	-139.73 -40.72
2.	6.884 5.054	6.896 4.919	350.0 344.4	19.15 15.07	124.00 143.35	709.0 576.6	713.0 595.5	-141.55 5.05
3.	7.471 6.086	9.755 6.223	572.0 435.6	20.82 18.49	133.00 139.03	870.0 686.4	685.0 674.3	183.55 46.78
4.	8.353 7.136	9.527 7.589	513.0 531.2	16.93 22.50	148.00 138.74	899.0 806.3	784.0 759.7	-1.68 76.60
5.	5.383 8.161	6.313 8.920	345.0 624.4	15.22 26.70	122.00 140.10	663.0 925.0	566.0 849.7	-134.59 100.46
6.	3.798 9.132	7.084 10.166	388.0 711.6	16.59 30.85	115.00 142.02	671.0 1037.0	398.0 937.7	-195.00 120.26
7.	6.677 10.069	7.762 11.236	462.0 786.5	18.91 34.68	215.99 144.47	887.0 1134.2	720.0 1023.4	-361.88 136.87
8.	7.891 10.961	7.399 11.728	523.0 820.9	21.73 37.36	135.01 149.13	902.0 1183.4	900.0 1114.1	15.56 149.15
9.	8.415 11.829	9.009 11.922	608.0 834.6	25.91 38.81	124.00 152.65	1003.0 1204.9	1000.0 1202.2	-16.30 166.16
10.	7.632 12.662	10.355 12.055	621.0 843.8	26.23 39.60	152.00 154.74	1032.0 1219.0	1050.0 1287.1	-2.63 188.58
11.	8.693 13.469	9.915 12.234	702.0 856.4	29.12 40.22	131.00 156.12	1090.0 1236.3	1100.0 1367.3	145.18 213.55
12.	11.151 14.250	13.398 12.514	731.0 876.0	35.18 40.96	157.00 157.38	1143.0 1262.0	1140.0 1443.0	225.29 238.99
13.	9.691 15.010	12.156 12.911	798.0 903.8	36.03 42.00	163.00 158.92	1190.0 1298.3	1200.0 1514.7	35.04 263.53
14.	13.204 15.692	12.094 15.202	832.0 1064.2	37.18 44.46	145.00 158.23	1240.0 1494.9	1200.0 1537.8	25.60 298.14
15.	13.011 16.461	12.235 16.311	916.0 1141.8	38.25 46.86	184.99 162.16	1311.0 1595.4	1200.0 1629.9	23.40 312.09
16.	14.236 17.197	16.594 17.147	1102.0 1200.3	43.50 49.34	198.00 165.82	1447.0 1672.6	1300.0 1698.5	38.26 318.15

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
17.	11.381	15.063	941.1	47.80	194.00	1409.0	1329.0	33.40
	17.640	17.925	1254.7	51.99	169.71	1745.3	1753.5	324.67
17.999	12.708	16.151	934.0	43.10	238.97	1427.0	1053.2	2.30
	18.077	18.961	1327.3	54.79	173.93	1840.4	1752.7	314.58
18.999	14.788	10.331	622.3	42.70	147.09	984.4	1138.9	33.50
	18.364	18.301	1281.1	57.64	178.40	1791.7	1819.2	311.65
19.999	13.917	10.914	917.6	43.80	152.99	1029.9	1376.7	52.28
	18.368	18.432	1290.2	59.77	185.07	1811.6	1837.2	309.19
20.999	13.807	17.058	961.9	44.90	142.02	1101.9	1100.4	59.39
	18.585	18.951	1326.6	61.52	188.61	1861.0	1831.3	303.81
21.998	13.542	14.423	1005.9	46.30	185.93	1308.6	1199.8	127.88
	18.926	19.537	1367.6	63.41	191.36	1915.4	1845.7	303.57
22.998	14.911	16.857	1049.9	48.20	172.03	1450.7	1299.8	285.69
	19.290	20.072	1405.0	65.29	194.01	1965.4	1878.7	308.21
23.998	15.017	18.266	1038.0	50.10	190.96	1504.9	1399.8	431.68
	19.633	20.518	1436.3	66.98	196.45	2007.5	1916.4	314.20
24.998	17.107	19.401	1111.8	51.40	202.97	1661.6	1499.8	567.67
	19.940	20.874	1461.2	68.42	198.56	2041.3	1950.9	319.65
25.997	17.400	19.125	1189.8	50.60	200.01	1894.4	1599.7	283.76
	20.209	21.158	1481.1	69.58	200.34	2068.3	1979.9	324.18
26.997	16.494	18.770	1322.6	55.09	219.94	1807.3	1699.7	542.24
	20.449	21.395	1497.6	70.53	201.82	2090.9	2003.9	328.04
27.997	22.586	27.479	1615.1	59.19	281.80	2183.8	1799.7	794.40
	20.672	21.607	1512.5	71.33	203.10	2111.0	2024.5	331.59
28.997	19.019	23.900	1447.6	53.82	244.13	1958.8	1864.8	284.44
	20.884	21.808	1526.6	72.06	204.23	2130.0	2043.3	335.17
29.996	21.368	23.338	1469.9	46.03	246.99	1989.9	1560.1	526.11
	21.093	22.004	1540.3	72.74	205.27	2148.4	2061.7	338.94
30.996	21.368	24.653	962.0	40.92	133.44	1329.6	1774.2	659.98
	21.300	22.194	1553.6	73.39	206.26	2166.2	2080.2	342.96
31.996	23.363	17.021	1489.8	49.96	195.74	2261.1	1815.8	532.53
	21.503	22.377	1566.4	74.03	207.20	2183.3	2098.9	347.20
32.996	21.727	24.345	1354.6	54.98	197.99	2095.7	1501.4	415.51
	21.704	22.549	1578.5	74.63	208.09	2199.4	2117.7	351.56
33.995	17.701	20.194	1431.6	55.00	208.95	2317.0	1599.5	66.82
	21.900	22.712	1589.8	75.20	208.94	2214.6	2136.2	355.99

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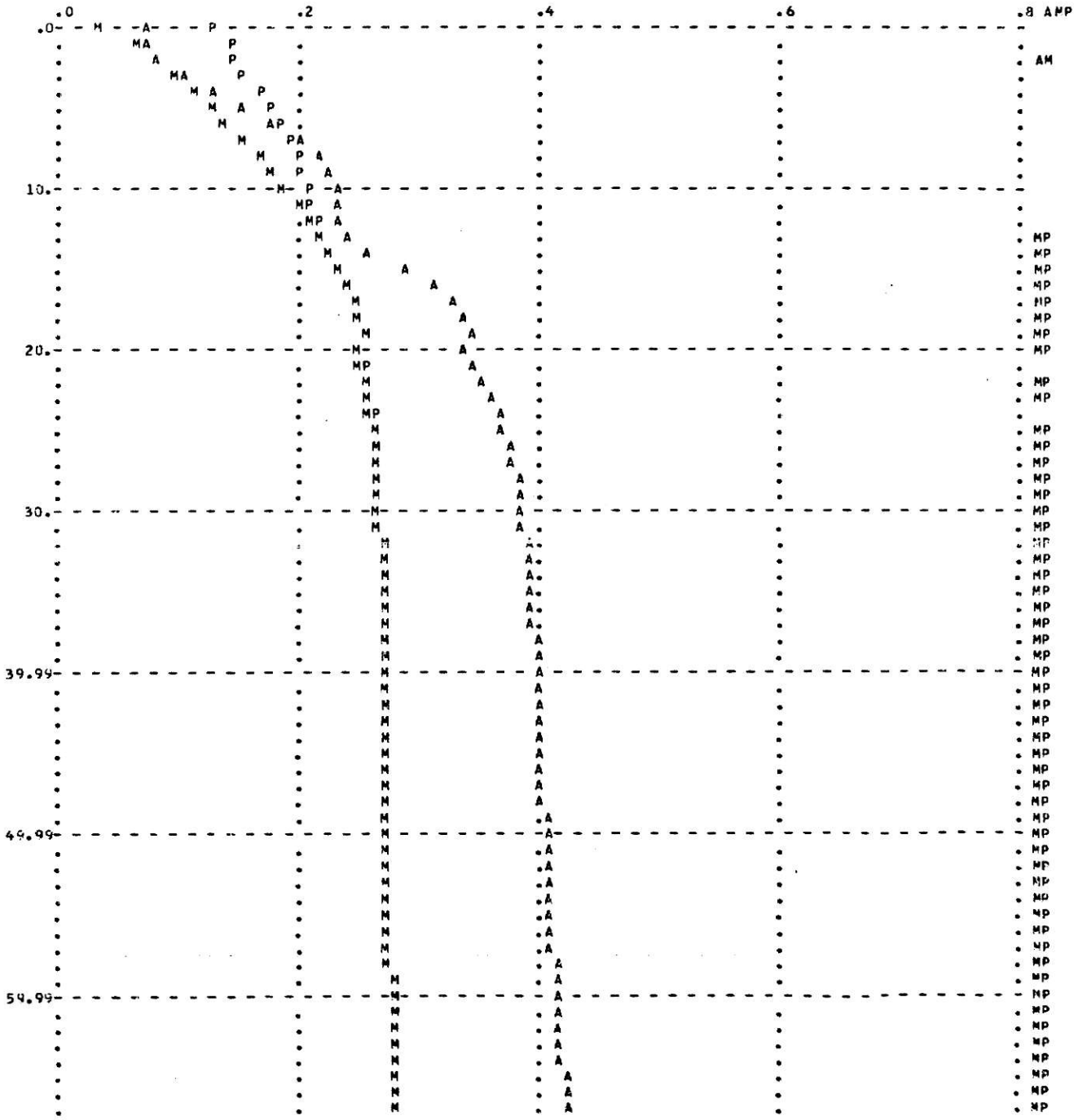
TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
34.995	19.567	20.358	1582.3	59.98	200.04	2066.2	1699.5	313.78
	22.091	22.864	1600.5	75.74	209.74	2229.0	2154.4	360.44
35.995	20.276	18.980	1620.8	64.97	249.74	2528.6	1749.7	295.10
	22.279	23.009	1610.7	76.25	210.51	2242.5	2172.1	364.88
36.995	19.976	19.442	1268.9	69.38	270.89	2610.6	1799.7	202.50
	22.463	23.149	1620.4	76.73	211.24	2255.6	2189.5	369.32
37.994	21.819	19.190	1186.5	62.44	250.12	1703.1	1853.7	226.86
	22.645	23.284	1629.8	77.19	211.94	2268.2	2206.6	373.78
38.994	20.096	19.301	1388.8	55.54	287.78	1760.6	2030.0	229.98
	22.825	23.415	1639.1	77.64	212.62	2280.6	2223.5	378.26
39.994	24.714	21.268	1353.2	59.97	310.86	1906.1	1853.1	499.35
	23.004	23.545	1648.2	78.08	213.28	2292.7	2240.3	382.76
40.994	19.587	20.523	1292.4	55.23	184.80	1827.5	2246.5	232.71
	23.182	23.674	1657.2	78.52	213.93	2304.7	2257.1	387.29
41.993	21.505	20.099	1310.9	56.89	181.02	1841.9	1763.2	409.82
	23.359	23.801	1666.1	78.95	214.58	2316.6	2273.8	391.85
42.993	20.727	15.973	1051.8	42.00	309.12	1624.5	1951.7	212.36
	23.536	23.928	1675.0	79.37	215.22	2328.5	2290.5	396.43
43.993	14.371	14.706	963.6	53.91	248.44	1471.1	1982.8	1.36
	23.713	24.055	1683.8	79.79	215.86	2340.3	2307.1	401.03
44.993	16.106	14.444	1008.7	54.99	244.03	1508.7	1410.2	49.63
	23.890	24.182	1692.8	80.22	216.50	2352.2	2323.8	405.64
45.992	13.919	17.090	1139.0	59.96	291.64	1720.4	1635.3	30.45
	24.068	24.310	1701.7	80.64	217.14	2364.2	2340.6	410.26
46.992	16.119	18.491	1213.4	60.00	253.30	1791.5	1407.8	136.17
	24.246	24.440	1710.8	81.07	217.79	2376.2	2357.4	414.90
47.992	20.985	20.120	1213.0	59.01	261.93	1856.5	1635.1	510.97
	24.425	24.571	1720.0	81.50	218.44	2388.5	2374.2	419.56
48.992	20.334	22.129	1434.2	60.98	288.78	2037.5	1406.9	462.43
	24.605	24.704	1729.3	81.94	219.11	2400.9	2391.1	424.24
49.991	21.129	23.800	1555.0	72.90	261.24	2181.8	1590.4	222.06
	24.787	24.839	1738.8	82.39	219.78	2413.5	2408.2	428.92
50.991	25.300	26.418	1729.5	84.89	268.93	2397.1	2306.7	496.55
	24.969	24.977	1748.4	82.84	220.46	2426.4	2425.3	433.63
51.991	22.675	27.727	1864.8	80.05	263.05	2522.9	2061.3	431.61
	25.153	25.118	1758.2	83.30	221.16	2439.4	2442.6	438.35

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TIME	SALE SARA	MANF AVMR	CORM RMCO	WAGS WAGE	SALS SALA	MACO MANC	SACO COSA	TRPR TPRO
52.991	28.053	25.717	1727.3	97.83	254.08	2390.3	2577.2	587.54
	25.338	25.261	1768.2	83.77	221.87	2452.8	2460.0	443.08
53.99	27.644	26.094	1733.9	97.01	256.97	2389.0	2534.5	482.03
	25.525	25.407	1778.5	84.24	222.59	2466.4	2477.6	447.83
54.99	28.726	24.034	1566.6	87.10	221.35	2097.9	2568.7	828.58
	25.713	25.556	1788.9	84.73	223.33	2480.3	2495.3	452.60
55.99	23.939	27.877	1873.9	129.57	168.53	2532.6	2168.0	581.53
	25.903	25.708	1799.5	88.74	224.09	2498.0	2516.7	453.84
56.99	29.848	32.621	2146.2	122.08	194.72	2877.5	2662.8	678.97
	26.095	25.863	1810.4	92.84	224.86	2516.0	2538.3	455.01
57.99	26.401	31.414	2083.7	122.00	196.98	2891.9	2388.0	589.95
	26.289	26.021	1821.5	97.00	225.64	2534.4	2560.2	456.14
58.989	28.108	31.832	2312.5	116.06	204.91	3125.5	2687.7	457.43
	26.484	26.183	1832.8	101.21	226.44	2553.2	2582.2	457.24
59.989	30.658	31.034	2070.7	121.93	188.19	2884.7	2876.9	631.06
	26.682	26.348	1844.3	105.47	227.26	2572.3	2604.5	458.29
60.989	21.048	26.079	1661.6	122.99	171.19	2507.3	2014.8	266.16
	26.881	26.516	1856.1	109.80	228.09	2591.7	2627.1	459.31
61.989	28.454	25.119	1686.7	128.93	206.59	2445.7	2717.7	602.06
	27.082	26.687	1868.1	114.18	228.94	2611.5	2649.8	460.29
62.988	30.537	28.925	1970.6	142.84	214.91	2785.0	2931.6	668.26
	27.285	26.861	1880.3	118.63	229.81	2631.6	2672.8	461.23
63.988	24.780	24.328	1654.9	129.17	187.33	2406.6	2422.2	323.18
	27.490	27.038	1892.7	123.13	230.69	2652.1	2696.0	462.13
64.988	31.006	29.263	2075.8	163.57	215.65	2973.9	3069.9	457.29
	27.697	27.219	1905.3	127.70	231.58	2672.9	2719.4	462.99
65.988	26.843	29.612	2135.3	139.31	231.80	2971.1	2716.6	482.70
	27.905	27.403	1918.2	132.34	232.50	2694.1	2743.1	463.80
66.987	32.626	27.212	2180.4	141.96	220.15	2982.8	3399.2	428.70
	28.116	27.589	1931.2	137.04	233.42	2715.5	2767.0	464.58

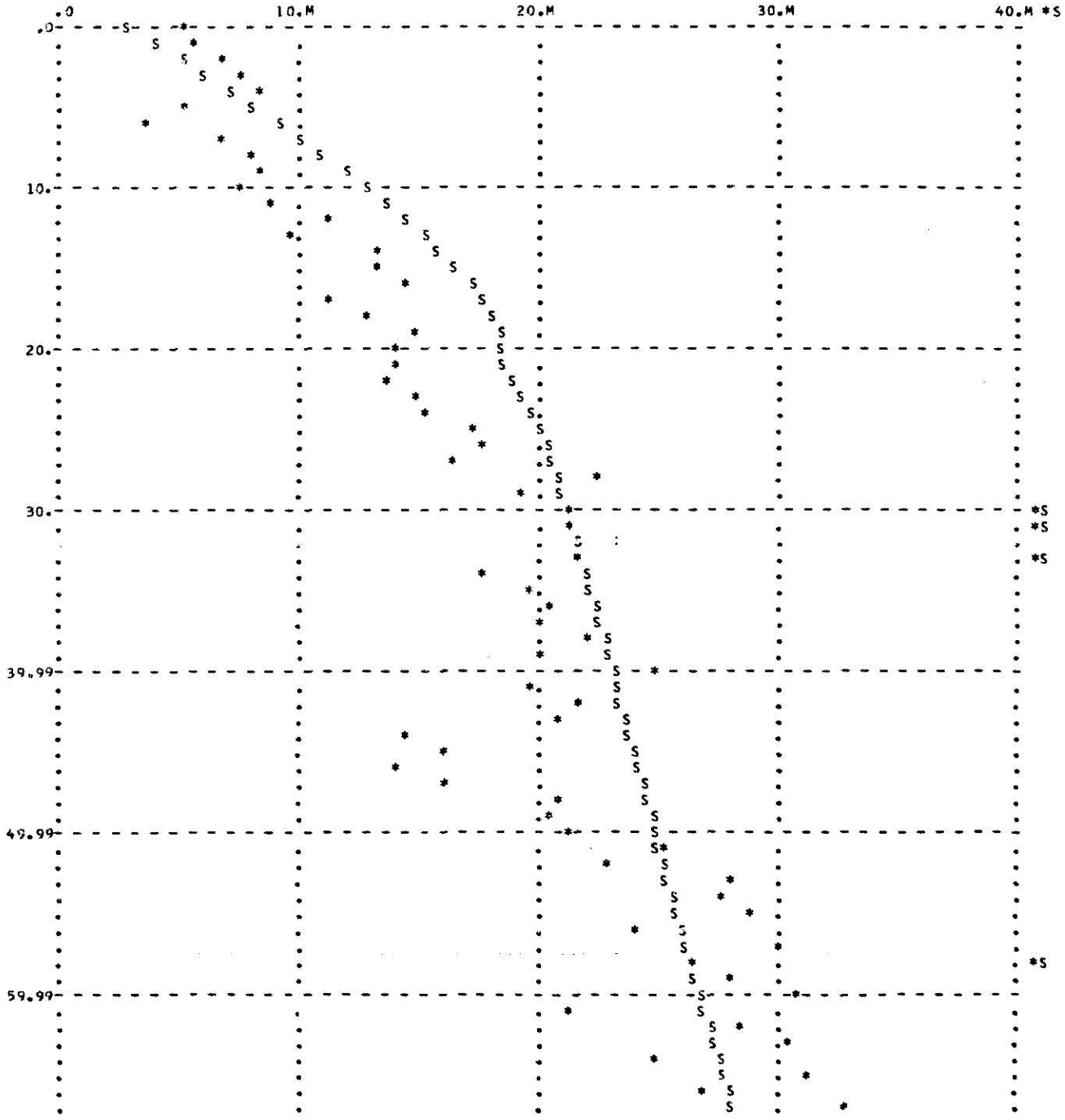
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CACB=A,MASH=M,PMSC=P



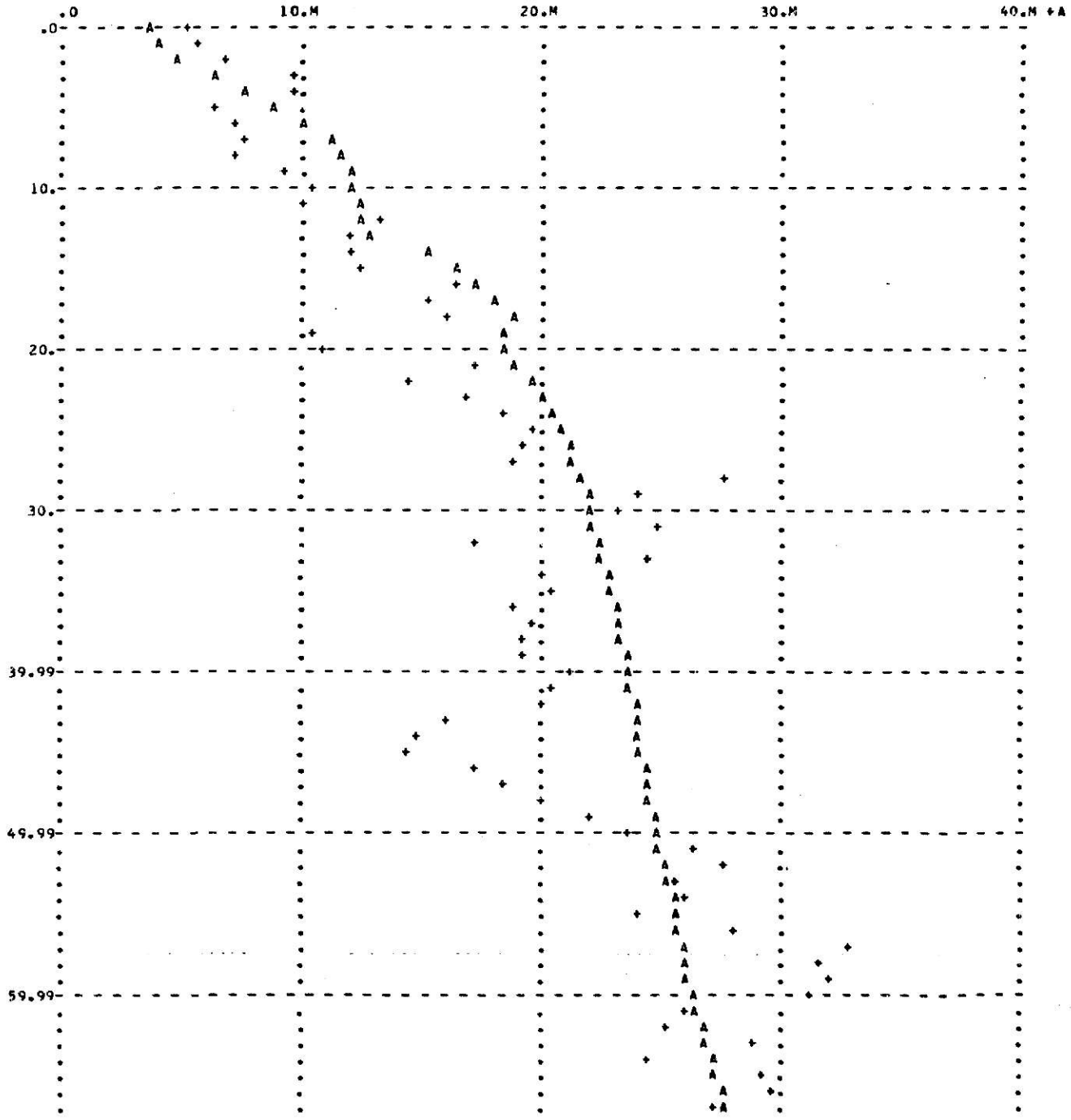
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SALE=*,SARA=S



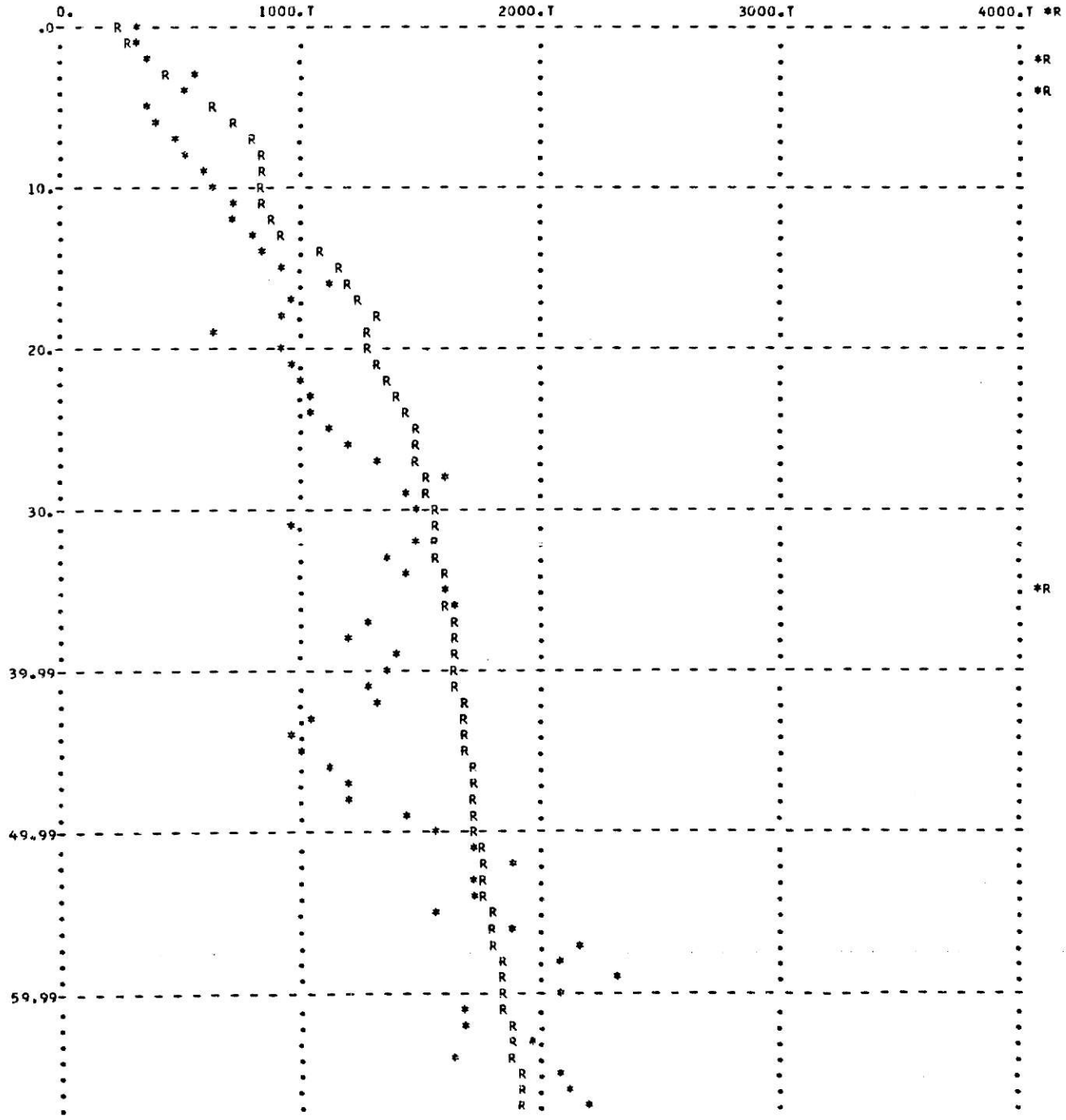
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MANF=+,AVMR=A



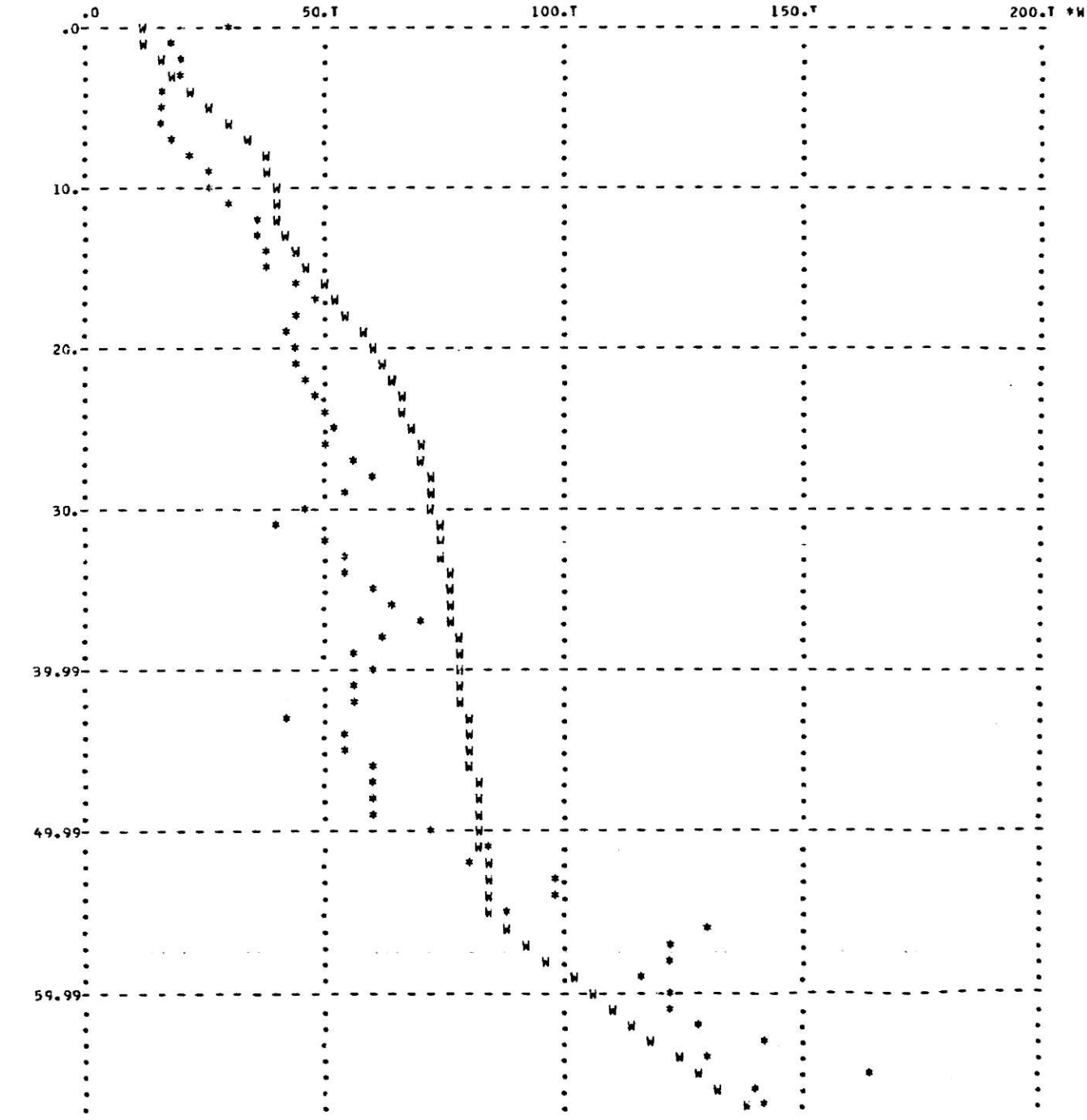
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CORM=*,RMCG=R



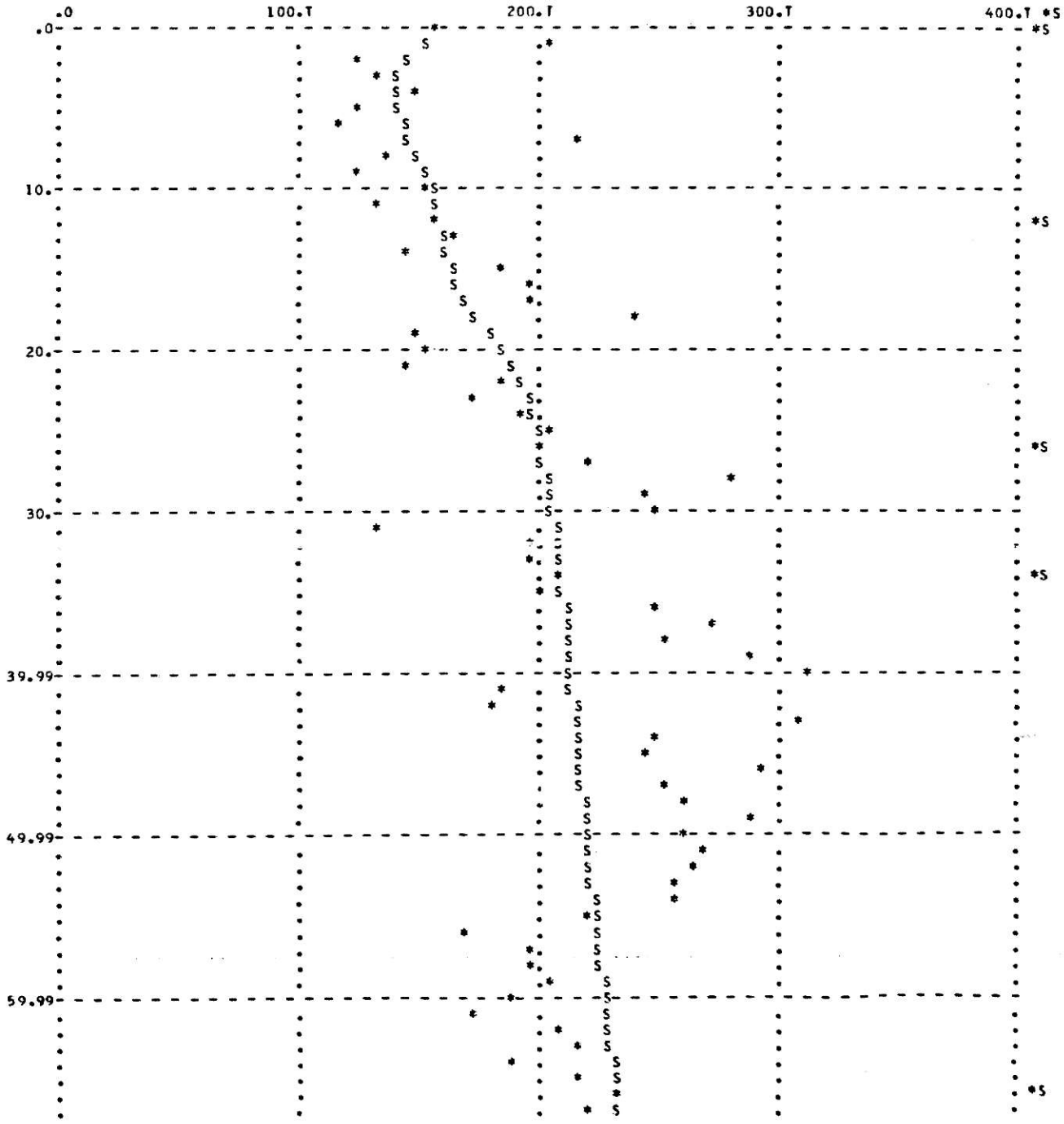
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WAGS=*,WAGE=W



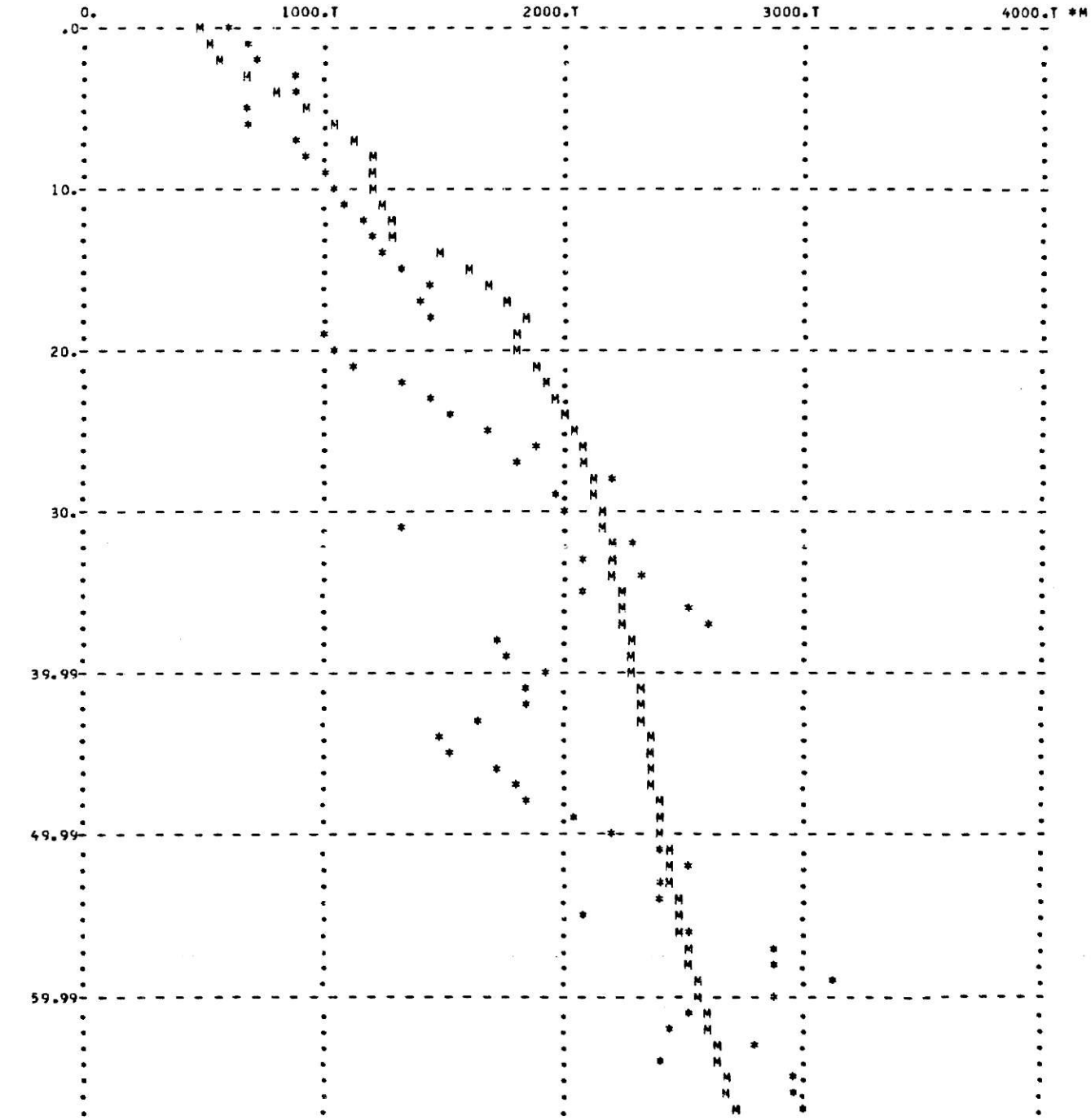
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SALS=*,SALA=S



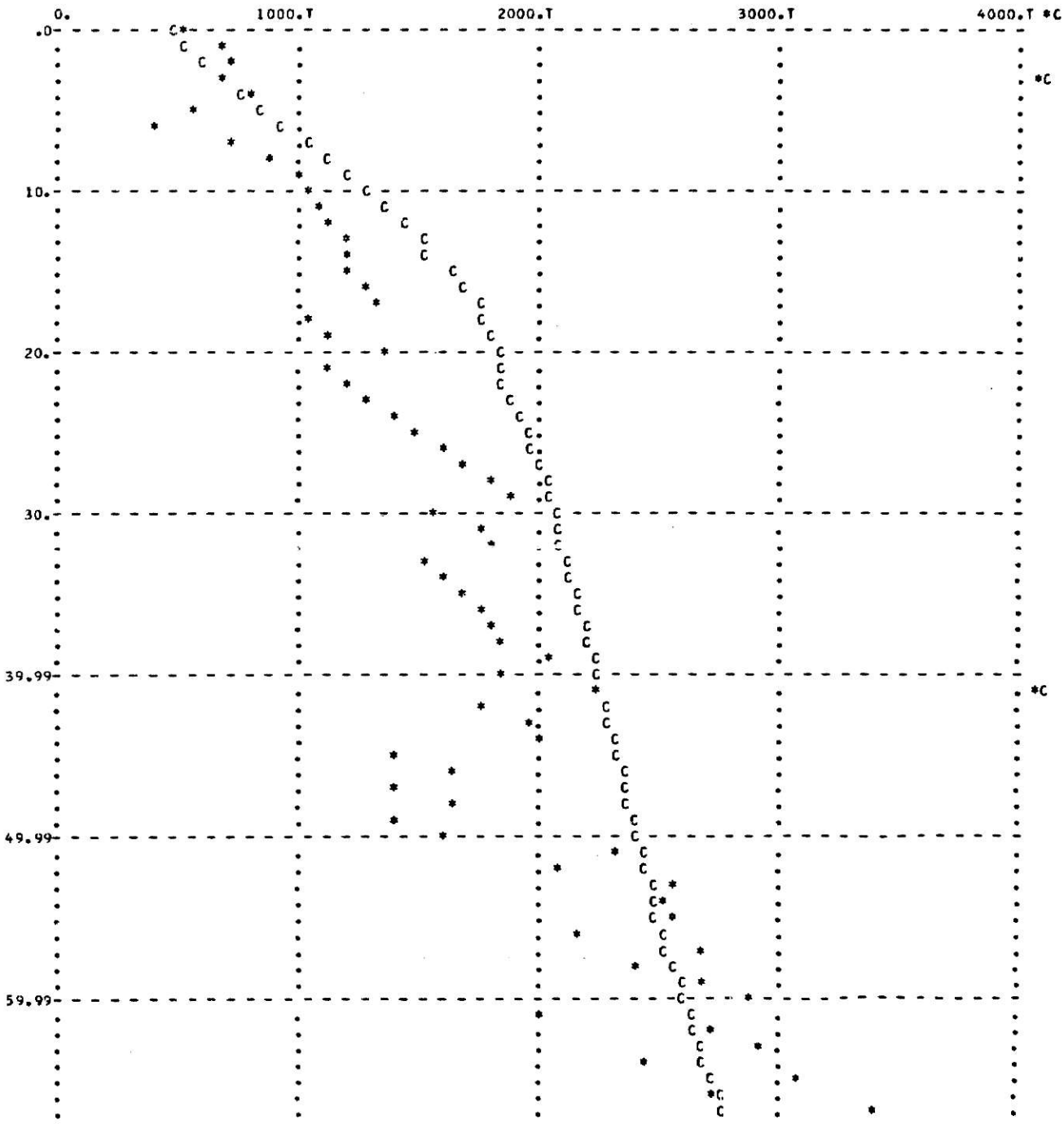
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MACO=*,MANC=M



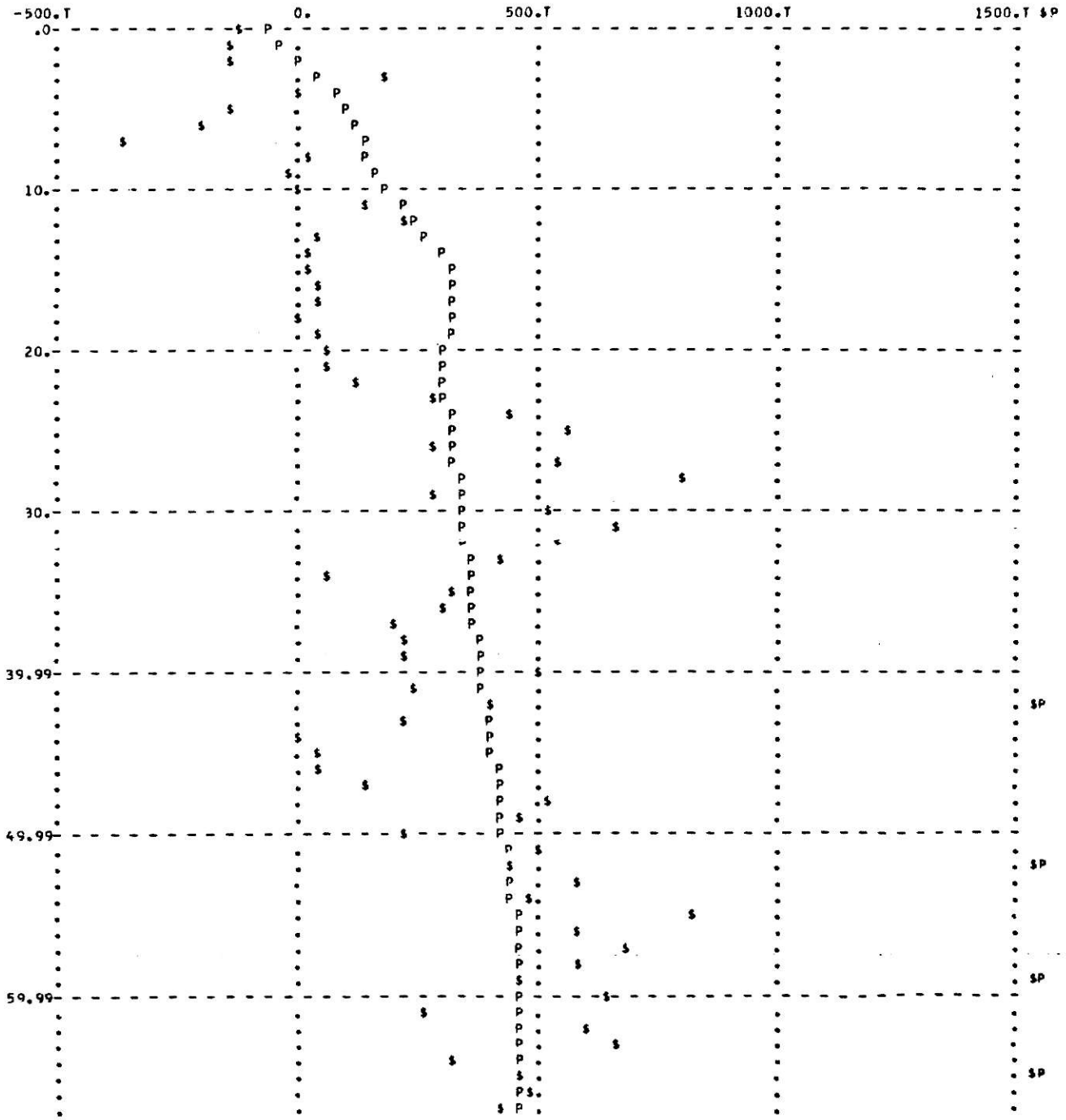
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SACO=*,COSA=C



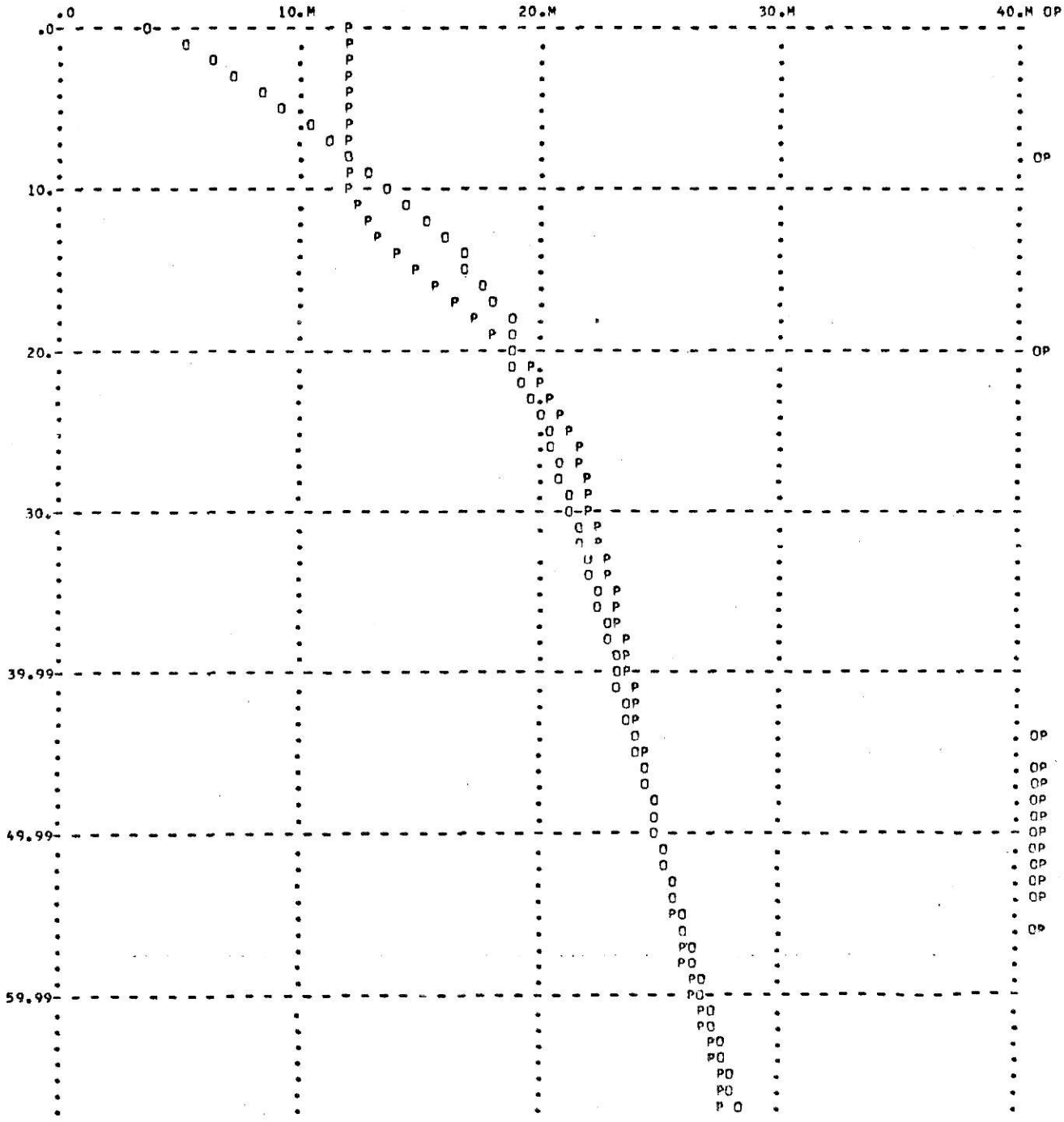
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TRPR=$,TPRO=P



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OHRF=O,PRCA=P



POLICY FORMULATION FOR A CIGARETTE MANUFACTURING COMPANY
A DYNAMIC SYSTEM SIMULATION

by

GEORGE MANUEL MACROPULOS

B. S., University of the Witwatersrand,
Republic of South Africa, 1972

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Industrial Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

This thesis deals with the design and development of an industrial dynamics model for a cigarette manufacturing company. The purpose of the study is to investigate how present strategies in the company are affecting growth, and to suggest policy changes that will yield a rapid profitable growth.

The management of the cigarette company is interested in uncovering strategies to improve growth. Recently, large capital outlays for advertizing and capacity expansion have been made in an attempt to enhance sales, profits and market penetration. The results of these expenditures have not entirely met the company's expectations. Although the company has captured a substantial share of the market, growth has by no means been profitable. Through the use of a computer simulation model, this study observes system behavior, and investigates alternative policies in the areas of promotional expenditures and capacity expansion.

The model developed was divided into two subsystems; the market and the company. Rather than attempt an all-inclusive description of company activity, the factors that are basic determinents of growth were isolated from the vast number of details that could influence the interactions between the market and the company.

Model validation incorporated tests for sensitivity and performance in duplicating historical data of the actual system. The model complied well with the basic requirements of representing the company as a system.

The company's current policy on advertizing was found to be satisfactory but a more aggressive production capacity acquisition policy is warranted in order to not restrict growth.

The model is only an initial attempt and does not by any means contain all the relevant system characteristics. Seen in this light the model can be used as a basis on which a broader and more comprehensive model can be developed in the future.