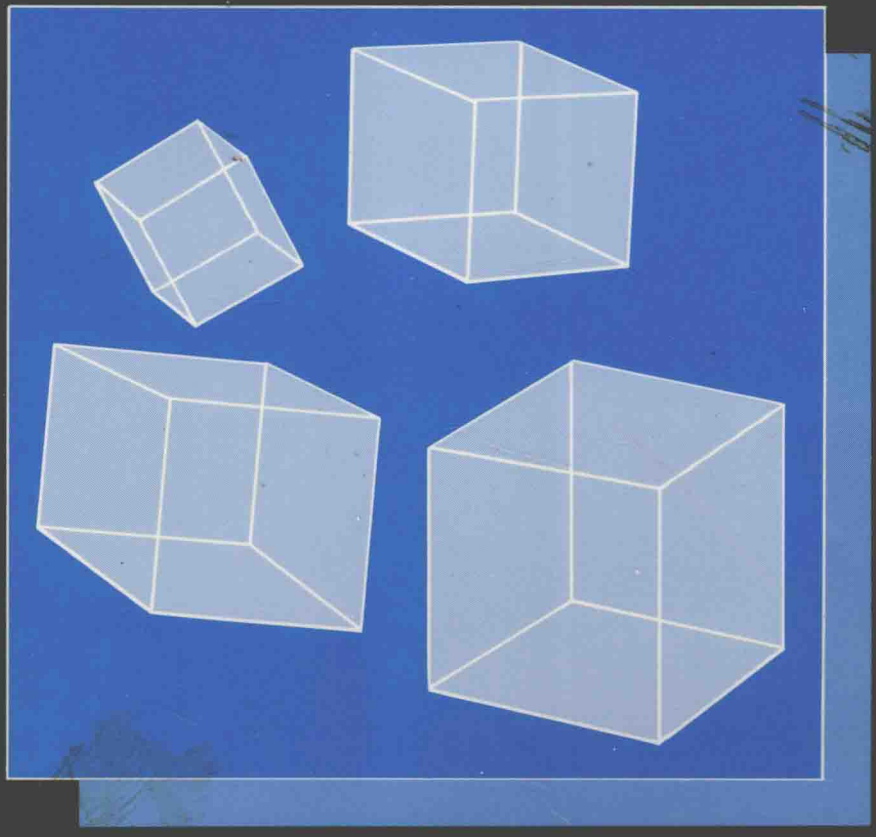
Decision Support Systems for Production and Operations Management

for use with IBM PC



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for use with IBM® PC

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Preface

The material covered in the Introductory Production and Operations Management course is ideally suited to the development and utilization of computer-assisted planning aids. With the arrival of the personal computer, the availability and accessibility of computers has become much easier for both instructor and student. Whereas the mainframe computer has always had a tendency to appear to be distant or removed from the user (as it actually was), the personal computer is more like a typewriter, telephone or slide rule in its function to the user.

The availability of the thirteen software programs that go along with this volume provides both the instructor and student the opportunity to utilize these programs as learning tools of the respective POM techniques.

One of the prime considerations in the development of these programs has been the notion of user friendliness. Many of the POM techniques that are programmed in this software package have previously been available in mainframe software packages. However, the user friendliness of these packages frequently was not quite up to desirable levels. Also the packages were usually developed as individual packages and user rules for one package usually had little relationship to user rules for another package.

The software programs described in this volume are not only user friendly but the operating instructions for each program are virtually identical for each package. Hence, once the user becomes familiar with one program, whatever he has learned is directly applicable to all other programs in this volume.

The student who is expected to experiment with the thirteen computer programs and who does the assignments at the end of each chapter will be thoroughly trained in the use of the techniques and will also gain a deeper understanding of all material in the Production and Operations Management course.

Becoming familiar with these programs and the techniques they represent will also enable the student/user to appreciate the benefits and advantages that are provided by in-depth exploration of POM problems, especially those that can be modeled by one of the programs available in this volume.

Any type of new software is generally not error-free. We have made extraordinary efforts to catch all errors through extensive testing and extensive use by hundreds of students. However, if you find any errors, we would like to hear from you so that they can be corrected in future versions.

Numerous individuals have participated in the testing of the software and the book. We want to express our thanks to all of those who made a contribution. We also especially want to thank Valerie Solly who was responsible for typing the several drafts of the book.

DECISION SUPPORT SYSTEMS FOR PRODUCTION AND OPERATIONS MANAGEMENT

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Overview of Decision Support Systems for Production and Operations Management

Introduction

DSS for Production and Operations Management (POM) is a software package designed to be used in the POM course. The package consists of a diskette which contains the computer programs and this book, which serves as the instruction manual for using the programs and also provides summary descriptions of each of the underlying models. The diskette contains BASIC source programs for modeling, solving and analyzing the most commonly encountered problems in POM. The programs are written in the Disk BASIC language for the IBM Personal Computer with a minimum of 64K bytes of RAM, and two disk drives. However, an installed version of the package can be used on a machine with just one drive as well. The Disk Operating Systems (DOS) version 2.0 or higher is required.

Preparing a Backup Copy of Diskette

The DSS-POM diskette contains the BASIC source programs for thirteen POM models. The diskette has not been copy protected and may not be copied, except for a backup copy, and when used with this book or with an Irwin POM book. The user should make a backup copy of the disk. An easy way of doing this is to perform the three steps outlined below.

1 - Place the DOS disk in drive A:
2 - Type DISKCOPY A: B:
3 - Follow the prompts from the DISKCOPY program.

Installing Your Diskette

The DSS-POM diskette provided by the publisher cannot be used directly on the IBM Personal Computer. That is, it does not contain the boot record and the BASIC language. For your convenience a batch file called INSTALL.BAT, with necessary commands to install the diskette, ave been included with the programs. Use the instructions below to install your diskette.

Place the DOS disk in drive A: and your DSS-POM disk in drive B: and type

B:INSTALL

Then follow the prompts from the INSTALL program to complete the installation procedure.

How to Load the Programs

Once you have installed the DSS-POM disk, it can be used to start the system, that is, to boot the system (without the need for the DOS disk) and immediately place you in the "Start Up Menu." This can be done in one of two ways. First, if the computer is OFF, place the installed DSS-POM diskette in drive A: and then turn the machine ON. Second, if the machine is ON, place the DSS-POM disk in drive A:, then simultaneously hold down "Alt" and "Ctrl" keys and press the "Del" key (this will reboot the system).

An AUTOEXEC.BAT file containing a procedure has been included with the programs. The task of this procedure is to execute the BASIC language (upon each reboot) and then load and run a program called MENU.BAT. MENU will display an initial logo and then the Start Up Menu. The Start Up Menu contains the list of all POM programs available. You may then select the desired program by entering the corresponding number in the Start Up Menu.

Saving the Completed Problems

If you plan to save your completed problems on disk for later use, you will need a formatted diskette (see the DOS instructions on how to format diskettes). This diskette may be placed in drive B: and when a POM program asks you to enter a Save File Name, precede the name with B: to save the data diskette. Note that you can save completed problems on your program diskette as well (when entering a save file name do not precede it by B:). However, due to its limited remaining storage capacity this is not advisable. If you try to save data on an already full disk, you will get a disk full error and lose your input data. This feature is, however, important when you are using the programs on a computer with single disk drive.

Printing the Results

There are two ways you can print the completed problems as well as the results from the DSS-POM programs on the printer. Before you use any of these approaches make sure that the printer is ON. The first approach is to print the entire contents of a screen. This is done by holding one of the two shift keys (marked by upward arrows) down and pressing the "PrtSc" key. This approach is used to print one screen at a time. The second method is to toggle the printer "on" for an entire session. This is done by holding the "Ctrl" key down and pressing the "PrtSc" key. The printer will then print the preceding messages and commands that appear on the screen. You can toggle the printer OFF by repeating the toggle ON procedure. That is, press "Ctrl" and "PrtSc" keys simultaneously. The above methods for printing may be used any time during a session.

DSS-POM Programs: A Review

In order to minimize the amount of time a user must spend in learning how to operate each new program we have tried to keep the instructions for each program similar. For this reason each program operates through a

Main Menu. This Main Menu in most cases (except for the Layout Analysis Program, which has an extra option) consists of six options. These six options are as shown below:

1. Data Input Module
2. Print Data Module
3. Edit Data Module
4. Save Data Module
5. Run Module
6. End Program

The first option, Data Input Module, is used for inputting problem data specific to that program into the computer. The data may be entered through the keyboard or from a data file saved in previous sessions when you used option 4. The second option, Print Data Module, is used to print the problem data on the screen to verify the correctness of the data which was inputted through the keyboard or obtained from a previously completed problem. It is recommended that after each data input process (option 1) and edit process (option 3) you request option 2 to verify the correctness of the problem data to be used for solving the particular problem.

Option 3, Edit Data Module, is provided for correcting any errors in the data or for revising the previously entered data. Moreover, in some instances this option can also be utilized to perform Sensitivity Analysis by varying the problem parameters of decision models such as linear programming, forecasting, inventory analysis, etc. The fourth option, Save Data Module, is provided to store problem data on diskettes for future use. Upon the execution of this option the computer will ask you to enter a save-file name. The name must be consistent with the convention of your system.

The fifth option, Run Module, will solve the problem at hand. This option will perform successfully only if the problem at hand is consistent. For example, a PERT/CPM problem which can only have one end node will produce unpredictable and/or meaningless output if several end nodes are indicated. The last option, End Program, will terminate the program and return control to the START UP MENU.

Summary Description of Thirteen Programs

The thirteen programs included in the DSS-POM package are among the most commonly used techniques in POM and may be found in nearly all POM textbooks. The thirteen programs consist of:

1. Forecasting Analysis
2. Multiple Regression
3. Facilities Layout Analysis
4. Locational Layout Analysis
5. Line Balancing
6. Linear Programming
7. Transportation Method
8. Assignment Method

9. Inventory Analysis
10. Aggregate Planning
11. Material Requirements Planning
12. Project Management-CPM/PERT
13. Quality Assurance

Below we present a brief summary for each program to familiarize the user with its contents and limitations.

The first program, called "Forecasting Analysis," is designed to perform time series forecasting. The program includes three forecasting methods consisting of exponential smoothing without trend, exponential smoothing with trend, and the method of weighted moving averages. The program can solve problems with up to 100 data points.

The second program, called "Multiple Regression," solves multiple regression problems with up to ten independent variables and 60 observations. The solution consists of the regression function equation as well as the associated Analysis of Variance table.

The third program, called "Facilities Layout Analysis," is designed to solve facilities layout problems. The input data consists of the preference ratings for department adjacencies. The program contains two solution methods. The first method consists of generating random layouts (for a prespecified number of trials) and storing the best layout. The second method, called "Pairwise Exchange," requires an initial layout which may be generated at random (by the computer) or entered by the user. The program then attempts to improve the current layout by performing a pairwise exchange of facilities. This program is capable of solving problems with up to 20 facilities.

The fourth program, called "Locational Layout Analysis," solves facilities location problems. The input data to this program consists of the two matrices of interdepartmental work flows and location distances. The solution methods provided here are the same as those for the facilities layout problem. That is, the first approach assigns departments to locations at random and stores the best assignment (the assignment with minimum transportation cost). The second approach attempts to improve an initial assignment through pairwise exchange of assignments. The program can solve problems with as many as 20 locations.

The fifth program, called "Line Balancing," solves line balancing problems with up to thirty tasks and up to thirty stations. The solution method is based on the heuristic solution method which assigns earlier tasks to the higher product of A and B, where A is processing time in minutes and B is number of follower tasks. The output lists the stations in order of appearance with the assigned tasks listed opposite each station. Three other solution methods are also available.

The sixth program, called "Linear Programming," can solve linear programming problems using the regular simplex method. The program uses the full tableau for demonstration purposes. The problem may be in maximization or minimization form. The constraints should be entered

according to the following order: first less than or equality, next greater than or equality, and last equality constraints. The program adds an artificial variable to each equality constraint and one artificial variable for all greater than or equality constraints in addition to their surplus variables. The program can solve problems with 15 variables and 15 constraints.

The seventh program, called "Transportation Method," is designed to solve transportation problems. The algorithm implemented is the usual transportation simplex method with the northwest corner rule to produce the initial solution. The program checks for equality of total supplies and total demand. When unequal, it asks the user whether it should add the appropriate dummy row or column with zero transportation costs. This program can solve problems with as many as 20 sources and 20 destinations.

The eighth program, called "Assignment Method," can solve assignment problems. The problem must have equal numbers of rows and columns. The program can solve problems with as many as 20 assignments.

The ninth program, called "Inventory Analysis," solves inventory management problems. Five models have been provided. They include the economic lot size with and without shortage, the economic run size with and without shortage, and the economic lot size model with quantity discounts.

The tenth program, called "Aggregate Planning," is designed to solve aggregate production planning problems. The input data consists of the beginning inventory, number of planning periods, production rate, production cost for regular time and overtime, and inventory holding cost. Moreover, for each period, the demand, number of regular time workdays, and overtime workdays are needed. The program can simulate production plans with up to 30 planning periods.

The eleventh program, called "Material Requirements Planning," solves material requirements planning problems. The program is designed for a single finished product with multiple orders. The total number of orders (planned receipts) is limited to five orders. Although there is no limit on the number of levels for subassemblies, the total number of assemblies and subassemblies must not exceed 100. The input data consists of the master production schedule and the product structure tree.

The twelfth program, called "Project Management," is designed to solve project management problems using PERT/CPM technique. Both deterministic and probabilistic models are included. For the probabilistic models the output includes several confidence intervals of different levels. The program can solve problems with up to 20 events (nodes) and 50 activities (edges).

The final and thirteenth program is "Quality Assurance." The two options that are covered in this program are Operating Characteristic Curves and Quality Control Charts. The operating characteristic curve is plotted for sample size n and maximum number of defectives c allowed. Both sample mean and attribute quality control charts are included in the program.

When Something Goes Wrong

In developing the DSS-POM computer programs, the most common erroneous entries were thought of and related compensations were built into the programs. However, it is still possible for a program to result in a system abort as a result of an erroneous request. The worst possibility is that you lose the data that you had just typed in. For this reason, make a habit of saving your problem data as soon as you are finished entering the data. Also, save the problem data (using the same file name) after each edit session. If something should go wrong and you cannot figure out the reason, try the following set of instructions one step at a time.

1. Did you press the "Caps Lock" key once at the beginning?

2. If the last prompt on the screen is "ok", type "RUN" and press the RETURN key. If you obtain the desired results, continue with DSS-POM programs. Otherwise type RUN "MENU" and press the RETURN key. If you obtain the desired results, continue with your DSS-POM programs. Otherwise continue with step 3.

3. If the last prompt on the screen is B type A: and go to step 4.

4. Type BASICA MENU then press the RETURN key. After a few moments the initial logo should appear.

5. If the machine does not respond to anything you enter, reboot the machine by holding down simultaneously the two keys "Alt" and "Ctrl" and then press "Del".

6. If a disk drive light has remained "on" for the past few minutes, hold down "Ctrl" and then press the "Break" key. Then go to step 2.

7. If none of the above has occurred and there is still something wrong, turn the machine off. Wait for at least one minute. Then place the DSS-POM disk in drive A: and turn the machine on. If you obtain the desired results continue with the DSS-POM programs. Otherwise, continue with step 8.

8. Ask the computer consultant in your area for advice.

This completes the general overview of the Decision Support System package for Production and Operations Management. Immerse yourself in it and we are sure you will enjoy using it.

Chapter 1

Forecasting Analysis

Introduction

There are a variety of techniques for forecasting on the basis of past historical data. These historical data are usually referred to as time series since they consist of a series of actual figures over a past time period.

Much research has been done to find the best forecasting method based on the basis of the squared error minimization criterion. The search for the best method has been rather elusive because some forecasting methods work better on certain sets of historical data than other methods. Hence, the best forecasting method can usually be found after the data has been generated but not before.

Not all forecasting methods are all equally easy to apply. Some are rather difficult to apply and to understand for the user. Some of these complex forecasting methods may sometimes give marginally lower forecasting error rates than the easier-to-apply and easier-to-understand forecasting methods. Because of their ease of application, the easier-to-apply and easier-to-understand forecasting methods are usually more popular.

In this chapter we shall present computer models for time series forecasting that utilize relatively easy to understand forecasting methods. They consist of the weighted moving average forecasting method, the exponential smoothing forecasting method without trend, and the exponential smoothing forecasting method with trend effects. The user thus has a choice of three different methods. A fourth method using seasonal effects will be discussed in the next chapter.

Below we shall explain how each forecasting method works and the user can then decide which method he chooses to apply. The first method to be discussed is the weighted moving average forecasting method.

Weighted Moving Average Forecasting

Weighted moving average forecasting uses the weighted average of the most recent n periods. The value for n must be determined by the decision maker but is usually relatively small, say 3 or 4. The term "moving" is used because as each subsequent period forecast is made, it is based on the most recent n periods and the n periods thus move along the time series chain. The weights can be equal for each of the n periods or the weights can vary in each of the n periods. However, if the weights vary, the sum of the weights must equal one (1).

Suppose that we need to make a forecast for period 4 on the basis of historical data for the prior three periods (i.e., n = 3). Also suppose that the weight for period 1 is 0.2, for period 2 is 0.3, and for period 3 is 0.5. The actual observed values for periods 1, 2, and 3 are 25,