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Decision support systems :

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DECISION SUPPORT SYSTEMS:
USING MICROCOMPUTER SOFTWARE
FOR INSTRUCTION ON PROBLEM SOLVING AND DECISION MAKING

by

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My heartfelt thanks to my teammate Bradley - who showed me that together, we can make dreams into reality. Thanks also to my parents, who have always provided the me with the confidence and support to try, to fail and to succeed. Finally, I wish to thank my employer, American Telephone & Telegraph Technologies, Inc., whose tuition refund program enabled me to pursue this degree.

I. ABSTRACT

Decision Support Systems (DSS) usage has grown with the availability of personal computers and the increased complexity of of computer software. A DSS is used to improve the effectiveness of the problem solving process. DSS is a product of computer software evolution that began with Electronic Data Processing (EDP) and continued through Management Information Systems (MIS). While EDP and MIS provided a service to certain corporate users, they could not handle the need for partially-structured problem solving. Thus, the DSS evolved as the next phase in computer software.

For software to be qualified as a DSS, it must have certain general and technical attributes. Flexibility and ease of use are necessary in an interactive environment. Technically, the software must provide database management, model base management, and dialog generation. Model base management covers such analysis tools as linear programming, statistical forecasting, economic and statistical analysis, and simulation.

Recent software introductions have increased the power of DSS by using the attributes within other problem solving methodologies. Expert Systems (ES) use the analytical tools of a DSS but do more than predict a probable outcome. The goal of

the ES is to determine the "correct" alternative, according to criteria based on "expert" opinions and experience. Decision Insight Systems (DIS), another problem solving software approach based on DSS, uses subjective data to define the rules of the problem. The distinctions between each of these software systems may be finer than their manufacturers depict in their product documentation.

Spreadsheets can be viewed as another type of DSS. Because they are inexpensive and easy to use, most personal computer users are well acquainted with the spreadsheet. These facts make the spreadsheet an ideal tool for instruction in the decision making process. Two spreadsheet software packages are presented as hands-on exercises in problem solving. Familiarization with these tools and processes will better prepare the student for the type of problems to be found in his or her employment field.

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II. DECISION SUPPORT SYSTEMS OVERVIEW

The decrease in hardware costs of the microcomputer and the increase in sophistication and availability of software have resulted in an increasing use of Decision Support Systems (DSS) to aid in decision making. "A manager who makes the most successful decisions is often the one who can assess the consequences, prospects, and risks of any plan quickly, and with this information act decisively."[1] Experimentation with this information, often called "What-if" analysis, allows the manager to see the various scenarios that can become possible solutions to the problem. Software tools that provide this type of analysis are called DSS.

The term DSS, originally coined in the 1970's, has been used to describe many kinds of software on the market today. The main function of a DSS is to assist in the decision making process. The most common and acceptable definition of DSS is:

> "an interactive system that provides the user with easy access to decision models and data in order to aid managers and executives in the decision making process."[2]

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[1] Whyte, Roderick G., "What is a Decision Support System?", Industrial Management and Data Systems, July-August 1986, p. 28.

[2] Vazsonyi, Andrew, "Decision Support Systems: The New Technology of Decision Making?", Interfaces, November 1978, p. 73.

The purpose of the DSS then is to improve the effectiveness of the problem solving process. While managers are most often thought to be the primary users and beneficiaries of a DSS, it should be noted that anyone having to make decisions as a regular part of their employment may find a DSS helpful in their particular situation. Furthermore, DSS are not just for top level management. Operational management, the first level, needs detailed information on daily operations. Tactical or middle management deals with control information in a yearly time frame. Finally, top management has informational needs beyond the current year to set goals and develop long range plans.[3] Each of these types of managers are required to solve problems that can be aided by a DSS. Also, the subordinates of these managers are often required to gather the information necessary for analysis and will need the DSS to build the pertinent model.

DSS is a product of computer software evolution which began forty years ago.[4] Electronic Data Processing (EDP) was the first software tool which marked the start of widespread

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[3] Mittra, Sitansu <u>Decision Support Systems - Tools and Techniques.</u> 1986, p. 6.

[4] Hall, J. A., "Management Information Systems", <u>Management Accounting,</u> July 1983, pp. 10, 23

computer usage for business applications. EDP was mainly a data collection process that mechanized transaction processing and record keeping. This phase was characterized by processing large groups of data to eliminate manual procedures.

In the mid-1960's, Management Information Systems (MIS) evolved by applying analysis to the data collected by the EDP process. The data became information that could be used by a manager to assess the status of the operations under his control. MIS used large databases to produce reports that ranged from detailed to summary types of information. These reports also included "exception reports," used to highlight problem areas.

Neither EDP or MIS could handle partially-structured or ill-defined problems. The need for rapid and easily developed reporting formats and the desire for modeling and statistical analysis led to the emergence of the more recent phase of computer software development: the DSS. The flexibility of the DSS, coupled with the availability of DSS microcomputer software, has caught the attention of many business users who had previously shunned the use of the computer. Page A1 in the Appendix lists the characteristics of the EDP, MIS, and DSS phases of computer software development.[5]

Software claiming to be a DSS can be evaluated by a study of the characteristics of the software. A good DSS "helps helps managers at all levels, is flexible and responds quickly to managers' questions, provides "What-if" capabilities, and allows the personal decision making styles of the manager to be utilized."[6] The characteristics can be divided into two categories: general and technical. The general attributes of a DSS include flexibility and interactive use by non-computer oriented users. Technical attributes include database management, model base management, and dialog generation capabilities. Database management involves access and manipulation of the data. Model base management can be broken down into different types of analytical tools: linear programming, statistical forecasting, econometric and statistical analysis, and simulation. Additional model types can be found on page A5 in the Appendix.[7] Knowledge base, action language, and repre-

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[5] Finlay, Paul N., "Decision Support Systems", <u>Data Processing,</u> October 1986, p. 434-435.

[6] Mittra, Sitansu <u>Decision Support Systems - Tools and Techniques.</u> 1986, p. 6.

[7] Mittra, Sitansu, <u>Decision Support Systems: Tools and Techniques,</u> 1986, p. 71.

sentative language comprise the dialog generation component of DSS. These attributes refer to the ease of use of the DSS.[8] Graphics and report writing features are examples of the dialog component of the DSS technical attributes.

A manufacturing DSS can be used to illustrate the DSS components. The database component would include information concerning the economy, legal environment, competition, markets, purchasing, inventory, accounting, transportation, production, warehousing, and technology data. The model base integrates analysis of the different areas of data covered in the database by using the analytical tools available. The various modes of communication between the user and the computer describe the dialog management component. Question and answer or menu driven dialog types are examples of the manufacturing DSS dialog management. A diagram on page &FIG03PGE. of the Appendix shows a typical manufacturing of the DSS.[9]

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[8] Athappilly,Kuriakose and Galbreath, Ron S. "Practical Methodology Simplifies DSS Software Evaluation Process", Data Management, February 1986, p. 11.

[9] Attaran, Mohsen and Bidgoli, Hossein, "Developing an Effective Manufacturing Decision Support System", Business, October-November 1986, p. 11.

Decision support in manufacturing provides information on the processes necessary to produce products. Ironically, the advent of automation has reduced the amount of manual effort to produce output, but has increased the need to monitor the factory so as to assure effective resource allocation. The relationship between the system that processes and controls the manufacturing operations, known as MRP, and DSS is widely disputed. Some manufacturing users believe a DSS is a step beyond MRP, while others see DSS and MRP as being one and the same. One other school of thought places DSS as the process prior to MRP. Probably the best definition of the relationship is to say that DSS enhances MRP by providing "What-if" scenarios based on MRP data. To illustrate this theory, Ferrell Drewry, manager of market support for the SAS Institute in Cary, NC, states that "users want to plan much tighter schedules to keep from carrying as much inventory. What if the demand changes, supplies are disrupted, or the price of raw materials changes?"[10] The user of a DSS can apply this knowledge to more accurately plan the factory processes.

The marketers of DSS software have created a variety of terms to describe and differentiate the features of their

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[10] Drewry, Ferrel, "Manufacturing Decision Support Systems", Manufacturing Systems, November 1986, p. 46.

packages. Usually, examination of the characteristics of the software is the only method to determine exactly what functions the software provides. The recent advances in Expert Systems (ES) haved confused the terminology issue even further. DSS produces "numbers: break points, net return on investment. They don't suggest the appropriate course for managers to take."[11] On the other hand, the outcome of an ES is a recommended solution. Furthermore, ES are based on rules written in English sentences or pseudo-English. ES also explains the reasoning behind the derived solution. In short, ES do more than predict the probable outcome. ES and DSS both may have mathematical and statistical capabilities. The distinction grows more blurred as new software releases have incorporated the best of both tools. For example, Smart Forecasts II, from Smart Software of Belmont, Mass., is a statistical DSS that uses expert system technology. As the Vice President of the company states, "you're not hooked into a machine developed plan. The user can fine tune or override it based on his own knowledge."[12] At best, a fine distinction

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[11] Thibault, Roger, "'Decision Support Software' Carries a Variety of Meanings", PC Week, October 14, 1986, p.122.

[12] Hartunian, Nelson, "'Decision Support Software' Carries a Variety of Meanings", PC Week, October 14, 1986, p. 123.

between ES and DSS exists. The combination of the two yields a powerful tool for problem solving.

Another version of DSS recently introduced is the Decision Insight System (DIS). DIS is a type of software developed to "use both quantitative and qualitative models and problem solving heuristics to help people solve ill-structured or unstructured decision problems."[13] Software that performs purely statistical analysis, such as linear regression, or software that handles only well structured problems, such as linear programming, do not qualify as a DIS. The difference between DIS and DSS is the subjective data required in a DIS. The user of the DIS "learns" while using the software by examining and analyzing each of the tradeoffs in a decision problem. DIS is used to solve the following types of decision problems: scoring, binary, allocation, diagnostic, design, and strategy. Once again, only a detailed review of the characteristics of the DSS will determine whether it is truly a DIS.

Choosing a DSS for problem solving grows more difficult as the amount of available software expands. The basic requirements for a DSS are:

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[13] Golden, Bruce L., Hevner, A. and Power, D., "Decision Insight Systems for Microcomputers: A Critical Evaluation", Computers and Operations Research, Volume 13, 1986, p. 287.

1. A control module that uses non-procedural English-like commands.

2. A model building module having optimizing and non-optimizing capabilities.

3. A data storage model that uses a relational database to store data.

4. The capability to perform "What-if" analysis. [14]

The software that meets these requirements must also meet the users particular needs so as to achieve the set objective. The software must be evaluated for compatibility, maintainability, reliability, and user friendliness. Ongoing considerations involve the monitoring of costs and the support level offered by the vendor. A detailed list of DSS evaluation criteria starts on page A2 of the Appendix. This list provides a beginning checklist to compare the various packages available.[15]

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[14] Mittra, Sitansu, Decision Support Systems: Tools and Techniques, 1986, p. 407.

[15] Athappilly,Kuriakose and Galbreath, Ron S. "Practical Methodology Simplifies DSS Software Evaluation Process", Data Management, February 1986, p. 14.

Development of a DSS using a purchased software package faces a number of problems. To assure success of the design and implementation of the DSS:

1. Show early, quick, concrete results in the development cycle.

2. Accomodate unique and variable requirements to provide flexibility.

3. Develop a comprehensive data acquisition strategy to improve the quality and accuracy of the data.

4. Integrate the data used with other relevant pools of data to facilitate conclusions drawn on all available data.

5. Take into account existing systems to avoid redundancy and to take advantage of the data and processes already defined.

6. Provide a wide range of outputs: report and graphic, on paper and on the computer screen.

7. Design the user interface so that non-computer oriented people will have little trouble using the system.

8. Use accurate estimates when determining cost/ benefits.[16]

Using these guidelines, it is clear whether the requirements of a good DSS will be met. Additionally, it is important when designing a DSS for another user to involve that user in the development process. It is possible to have the end user design his own output, thus creating the ad-hoc query capability in the DSS.

The benefits of using a DSS can usually be traced to direct or indirect improvements to the profit of the company. Direct improvements can be realized from such factors as reduced inventories and improved forecasts. Indirectly, the decreased time lapse necessary to arrive at a decision can also be included in the list of benefits. Certain intangible benefits, such as improved graphics and better accuracy of the data may also be realized. Costs of a DSS are accumulated through itemizing the design, maintenance, update, access and capital or hardware/software investments. Increased complexity and capacity of the software normally increases the cost of the DSS.

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[16] Alexander, David J., "Planning and Building a DSS", Datamation, March 15, 1986, pp. 116-117.

There are certain risks in using a DSS. Mainly these risks result from the possibility of inaccuracy of the data used, a problem inherent in the microcomputer proliferation and not confined to DSS software. "Re-inventing the wheel" may occur as each user designs his own problem models. It is possible that complex DSS applications may be better suited for development by a trained computer professional who follows a software design process that includes reviews throughout development. A large system should always be reviewed for potential flaws to assure that the resulting system will be usable. Employing the trained professional may eliminate the costs incurred when significant time is invested DSS development, only to find the user change jobs, the system not perform to expectations, or the software chosen to be deficient. When costs, benefits, and risks are carefully evaluated and analyzed, a true picture of the expected value of the DSS can be presented. Given the "cheap technology" of today's computer field, most DSS microcomputer software tends to have benefits that far outweigh the costs and risks.

As microcomputer usage has flourished in academia, business, services, and home usage, certain software has become standard from widespread usage. The spreadsheet has emerged as one of the most commonly used software packages because it is a familiar representation which is easily understood and because of its affordable cost. Business users have found spreadsheets to be an answer to the ever-increasing backlog of requests to be handled by the corporate MIS group. Theoretically, MIS should be the guardian of the corporate data: assuring integrity and accuracy while providing various access methods to the data. The end user, therefore, should be using spreadsheets to handle smaller, unique needs for data analysis. As users have embraced spreadsheets for decision making, software manufacturers have met the need for DSS tools for the microcomputer. Initially, DSS existed only on mainframes as cumbersome, complex programs that required substantial knowledge on the part the user on the system requirements. The DSS software for the microcomputer can be learned quickly and can be run at the whim of the user.

"The benefits of using a spreadsheet for DSS are that is uses an existing storehouse of information and can state the relationship between cells automatically."[17] Furthermore, data is organized in a fashion that requires little translation from thought process to computer. Spreadsheets allow the user to see the immediate effect of changes to the model developed. This "What-if" analysis is the most frequent use of the

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[17] Cubbage, Paul, "Spreadsheets Are Used In Decision-Support Role", PC Week, July 19, 1986, p. 102

spreadsheet. Most spreadsheets include on-line help functions, standard functions such as present value and rate of return, and the use of macros to issue special commands. The first spreadsheet software systems to be introduced were "Visi-calc", "Multi-plan" and "LOTUS 1-2-3". Significant analysis has been performed to assess the best of the three,[18] but there is a wide range of similar products currently available that have improved on these original three products.

The value of spreadsheets as a DSS increases with the capabilities available. Database access has become a standard feature, and some now provide true multi-dimensional database representation. With multi-dimensional databases, various views of the data can be designed.

Optimization capabilities, often called prescriptive modeling because a course of action is prescribed as the outcome of the problem, are of great value to the DSS user. When considered in the basic form, spreadsheets are a "descriptive model of a problem which simply describes the relationships among known or estimated quantities...and varia-

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[18] Whitehouse, Gary E. and Morse, Lucy, "IE's Must Look At Equipment, Needs in Choosing Spreadsheets", Industrial Engineering, March 1985, p. 22.

bles."[19] The combination of spreadsheets and optimization provides data in an easily understood format while giving the optimal solution. Recent software releases have include such features as goal seeking and single and multiple regression analysis.

In an academic environment, the case study approach has been utilized for years as an effective learning methodology. Likewise, the computer is being used in many of the instructional areas. The case study approach is ideally suited for the application of computers to a particular functional area. In the manufacturing and business areas, this hands-on technique builds a repertoire of tools that the student can put to use in his chosen field of employment. Case scenarios can be developed that closely approximate the real environment.

The case studies that follow are designed for upper level college students to gain an understanding of the usage of different types of DSS. The computer and its software are the tools by which the future manager can gain insight to support the selection of decision alternatives. Both case studies presented use spreadsheets for "What-if" analysis. One

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[19] Evans, James R., "Spreadsheets and Optimization: Complementary Tools for Decision Making", Production and Inventory Management, First Quarter 1986, p. 36.

requires the use of a multi-dimensional database, while the second case uses optimization software. The case studies require the student to create a model of the situations described. The problems are created to give the student a solid base of understanding on two types of microcomputer DSS.

III. CASE STUDY I: Setting Volume-Based Prices in a Multi-Plant Corporation

Purpose of Study:

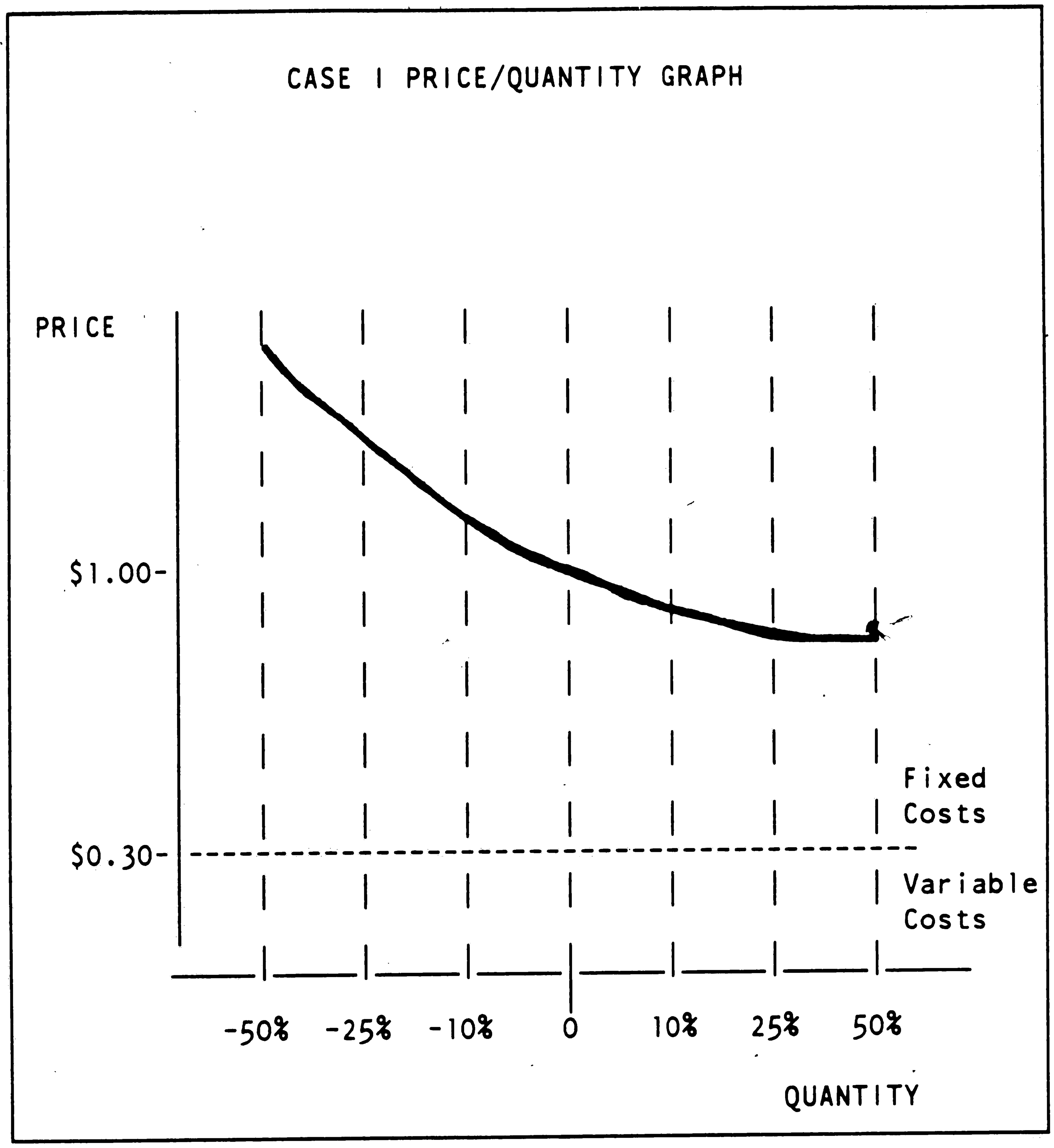
The purpose of this case study is to follow the line of logic necessary to develop a tool to aid in determination of volume-based prices for the corporation. Development of this tool will provide "What-if" analysis capabilities on a variety of views of the data. The actual values of the indicators involved in the problem are not the ultimate goal of the study. In fact, the user of the tool may choose one of many possible solutions to the pricing problem. Familiarity with the software and the development of a working application that meets the specified criteria will determine the level of success in the solution to this problem.

Case Overview:

XYZ Corporation is a small manufacturing company with plants in Chicago, Boston and Denver. The firm produces three major products and these products are manufactured at all three plants. Each of the plants operate in different market segments of the of the country. The difference in market segments for each plant results in variations in the cost and price of the products between locations.

The products manufactured by XYZ are equivalent in quality and capabilities to other competitors' products. Therefore, the buyers of these products usually purchase based on price discounts. Prices vary continually as the each company strives to lower prices through engineering improvements. The obvious goal of the XYZ corporation is to maximize profit by gaining the largest possible market share for their products. Each plant has capacity constraints which must be considered when seeking market share.

Prices for the products are set based on the cost and the quantity ordered by the buyer. A standard cost and price is determined for a base quantity value in units. From this quantity, the price can vary up or down depending on the amount of quantity difference. This relationship is graphically described on the chart that follows.



For example, given a base quantity of 200 units, a price could vary by five percent for each increment of 50 units. This value can be referred to as the price variance. Since the fixed costs are spread across the number of units sold, a cost variance is also determined.

When the demand is determined, the price and cost at that quantity can be used to determine revenue, profit, and markup. XYZ corporation's major competitor also uses this volume based pricing strategy. The competitor's prices are published and available to any prospective buyer, as are the prices of XYZ corporation. The competitor's product costs, as well as XYZ's costs, are not published to buyers since this data is the key to the companies success in a competitive environment.

The Problem:

The product manager of XYZ Corporation is faced with the objective of maximizing profit by reducing prices in the attempt to increase market share. Volume-based prices must be developed to attain the corporate objective. The manager will need a "What-if" capability to see the effect of different pricing strategies on profit and revenue for the corporation as a whole as well as each plant. The task is to develop a multi-dimensional database using "VP-Planner"[20] for XYZ corporation that uses the pricing strategy described. Demand and capacity values are available in yearly quantities for five years. The application must print the database structure and

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[20] VP-Planner Software, Paperback Software International, 1986, Chicago, Il.

calculations used. It must also show the values for the corporation in the following spreadsheet formats. All solutions should be transportable on a floppy disk.

1. All cost, price, and competitors price values plus demand, capacity, revenue, profit, and markup for the three plants for Year 1 of Product A.

2. Five years of profit data for all products, along with a total by year and product at Chicago.

3. Show the cost base and average cost base for all products at all plants in Year 1.

4. All cost, price, and competitors price values plus demand, capacity, revenue and markup for Year 1 at Chicago for all products manufactured there.

5. For Product B in Chicago, show the data outlined in #4 for five years to emphasize long term trends in the data.

Data to be used a starting point for the development of the database is given on page A6 of the Appendix.

<u>The Solution:</u>

This problem can be solved in many different ways. The database structure shown on page A6 of the Appendix consists of a four dimensional database where dimension 1 is Time, dimension 2 is Accounts, dimension 3 is Products, and dimension 4 is Plants. Dimension 2 includes most of the logic necessary to derive the pricing levels. Totals are included in dimension 1 for five years, in dimension 3 for three products, and in dimension 4 for three plants. From this database, the five types of analysis views can be constructed and are shown beginning on page A12 of the Appendix.

This solution creates a database where the product manager can change any component of cost, price, and competitor's price to see the effects on profit, markup, revenue, and capacity utilized, as well as determine the price and cost at the demand quantity compared to what a competitor offers. The base quantities and variance rates are included for maximum flexibility in "What-if" analysis. Many more views of the data are possible once the process of using the multi-dimensional database has been learned.

Analysis of Software:

"VP-Planner" is based on the popular "LOTUS 1-2-3" spreadsheet software. Paperback Software, creators of

"VP-Planner", used the same concepts in "LOTUS 1-2-3" but added extra features to increase the power and ease of usage of the spreadsheet techniques. In fact, the products are so similar that LOTUS has launched a copyright infringement suit against Paperback Software on the basis that they have used the "look and feel" of the LOTUS products (which were introduced earlier). One of the notable additions is the multi-dimensional database option that allows the user to create any combination of data for analysis, allowing up to five dimensions. To use this feature, the documentation must be closely followed. Fortunately, the documentation takes the user through the process step by step and comes with a sample database. "VP-Planner" uses function keys throughout the software in addition to the "first letter of the word" or cursor placement. With this approach, "VP-Planner" has improved on the "user friendliness" in the basic spreadsheet packages. The software also has the capability to access and update "dBASE II" and "dBASE III" data. Browsing the databases is accomplished by a cross-sectional technique that asks the user to choose the dimensions, or worksheet parameters, that meet the user's information needs. It is far easier to use the "VP-Planner" browse than the "dBASE" browse method.

"VP-Planner" is an effective tool for "What-if" analysis. Only the addition of compatible modeling software, such as

"What's Best!", "What's Best!",[21] could improve the spread-sheet package.

[21] What's Best! Software, General Optimization Incorporated, 1986, Berkeley, Ca.

IV. CASE STUDY II: Budgeting in Manufacturing Firms Using Optimization[22]

Purpose of Case:

The purpose of this case study is to apply linear programming concepts to a business problem by translating goals and constraints into a format usable by microcomputer spreadsheet and linear programming software. Since the values of the data are given, it is possible to reach an optimal solution to the problem. Furthermore, the financial statements for the corporation can be developed from the optimal solution. This case integrates manufacturing and accounting decision making by use of the personal computer.

Case Overview:

Traditional budgeting procedures in a manufacturing environment have been based on functional area budgets, such as sales and production, to develop the plant master budget. This method of budget development runs into problems when one area must be adjusted, thus affecting a revision in some or

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[22] Jaaskelainen, V. Linear Programming and Budgeting 1975, pp. 35-72

all of the other functional areas. To avoid this rework and thereby decrease the amount of time necessary to devise the master budget, the best approach is to develop the budgets simultaneously. The benefit of the simultaneous approach is that all budgets for a plant will be compatible with one another.

To illustrate this budgeting technique, a planning situation is described where two plants sell two types of products that have the same raw material requirements. Of the two plants, one plant is considered the parent plant which centrally manages the financing of the operations of both plants. The other plant is the subsidiary of the parent plant; To identify the values associated with each plant, the subscripts "P" and "S" will be used for the Primary and Subsidiary plants, respectively. The planning horizon for the corporation covers a single period. Sales, production, and raw material purchase levels are the target of the model. Sales need not equal production, and raw material use is not required to be equal to purchases.

The marketing organization for the firm has determined the maximum sales possibilities for both the primary and subsidiary plants as follows:

Product	Price $/unit	Maximum demand
A (P)	3.50	250,000
B (P)	4.50	300,000
A (S)	3.80	180,000
B (S)	4.60	150,000

Differences in price and demand are the result of the two different marketing areas involved. The demand for A and B in each plant is assumed to be independent of each other.

Capacity analysis for both plants consists of a single value to simplify the planning model. Overtime and additional shift work is not considered in this model. Capacity values and constraints are as follows:

Plant	Product A	Product B	Available Capacity
P	0.5	0.6	285000
S	0.6	0.7	200000

Inventory levels for a single period model do not take into account building for stock to meet variable or seasonal demand. For the primary plant, ending levels of both raw materials and finished products have been defined by management to meet the next period's demand. In the subsidiary plant, management has determined that the levels of inventory for raw materials and finished products must decrease by ten percent from the beginning levels. Inventory values for finished products are as follows:

Plant	Product	Beginning Inventory	Ending Inventory
P	A	30,000	25,000
P	B	18,000	28,000
S	A	20,000	
S	B	15,000	

Raw material levels are based on the finished product bill of materials. The bill indicates that three units of raw material "W" are used in ever every unit of "A". Similarly, two units of raw material "U" are needed to manufacture one unit of "B". The current purchase prices for "W" and "U" have been quoted by suppliers as $0.15 and $0.265 respectively. Inventory levels for the raw materials are as follows:

Plant	Product	Beginning Inventory	Ending Inventory
P	W	45,000	55,000
P	U	90,000	80,000
S	W	20,000	
S	U	30,000	

The cost structure of the two plants is based on the assumption that the firm uses a variable standard cost system where only the variable costs are considered to be product costs. As the following table describes, the standard raw material cost of Product "A" is $.045 per unit of product. The costs for direct material must be consistent with the raw material usage. Also, labor costs of the products must be consistent with the direct labor hours. The capacity is measured with the direct labor hours. The variable overhead costs are assumed to be distributed on the basis of the direct labor hours. The cost structure of both plants is as follows:

Parent Plant Cost Structure	Product -A--	-B--
Raw materials		
3 units of raw material "W" at $0.15/unit	0.45	-
2 units of raw material "U" at $0.265/unit	-	0.53
Direct Wages		
0.5 hours at $1.80 per hour	0.90	-
0.6 hours at $1.80 per hour	-	1.08
Variable Overhead $1.00 per direct labor hour	0.50	0.60
Total Variable Costs	1.85	2.21

Subsidiary Plant Cost Structure	Product -A--	-B--
Raw materials		
3 units of raw material "W" at $0.15/unit	0.45	-
2 units of raw material "U" at $0.265/unit	-	0.53
Direct Wages		
0.6 hours at $1.60 per hour	0.96	-
0.7 hours at $1.60 per hour	-	1.12
Variable Overhead $1.20 per hour	0.72	0.84
Total Variable Costs	2.13	2.49

Comparison of the cost structures of the two plants shows the production in the subsidiary plant is less efficient than the parent plant. Note, however, that the standard rate for variable overhead is twenty per cent higher than in the parent plant. Standard raw material costs are equal in both plants.

The beginning balance of both plants inventory levels of raw materials and finished products have been extended by the appropriate standard cost or price. The book value listed covers the fixed assets in both plants. For ease of analysis, the work in progress level will remain at the level of the beginning balance during the period. Prepaid expenses also are unchanged during the period. The Accounts Payable for raw materials must be paid in the period, along with accrued income tax and accrued salaries and wages. Since no work force adjustments are considered in this model, the beginning balance of salaries and wages will be the same as the ending balance.

The shareholders capital will not change during the period. Two payments are required for long term debt during the period, comprised of $5,000 interest and a repayment of $10,000. A $20,000 dividend distribution will be made and will also involve a fixed cash payment. The projected net income will increase the undistributed profits in the projected balance sheet.

The beginning balance sheet for the firm is as follows:

Assets				
Current Assets				
Cash			112 000	
Accounts receivable			110 000	
Inventories				
Raw Materials				
W (P) (0.15)	45 000	6 750		
U (P) (0.265)	90 000	23 850		
W (S) (0.15)	20 000	3 000		
U (S) (0.265)	30 000	7 950	41 550	
Work in Progress			97 000	
Finished Products				
A (P) (1.85)	30 000	55 500		
B (P) (2.21)	18 000	39 780		
A (S) (2.13)	20 000	42 600		
B (S) (2.49)	15 000	37 350	175 230	535 780
Prepaid Expenses				6 200
Fixed Assets				1 058 220
				$ 1 600 200

Liabilities		
Accounts Payable		
Raw Materials	38 000	
Salaries and Wages	78 000	
Taxes	55 000	
Other	37 350	208 500
Long Term Debt		100 000
Equity		
Shareholders' capital	1 000 000	
Undistributed profit	291 700	1 291 700
		$ 1 600 200

Fixed Expenses include selling, administration, and manufacturing. These expenses must be incurred regardless of other plans. Each expense is divided into depreciation and expenses that must be paid in cash during the planning period. Although the fixed assets figure in the beginning balance shown previously listed a combined value for both plants, depreciation at each plant is shown separately below. The values for fixed expenses are as follows:

Fixed Costs	Parent Plant	Subsidiary Plant
Selling		
Depreciation	60 000	10 000
Cash Expense	250 000	200 000
	310 000	210 000
Administration		
Depreciation	50 000	10 000
Cash Expense	290 000	90 000
	340 000	100 000
Manufacturing		
Depreciation	110 000	30 000
Cash Expense	155 000	210 000
	265 000	240 000

Certain additional information is necessary to complete the model. The beginning balance of accounts receivable will be collected during the period. Payment terms are 90 percent of the sales of "A" and 85 percent of the sales of "B". Also, the beginning balance of accounts payable will be paid during the period. Payment terms are 93 percent of raw material purchases of "W" and 85 percent of raw material purchases of "U". Sales commissions on purchases for both plant districts are 2 per cent to distributors. Payment terms on sales and on purchases are valid for both plants. The payment of these commissions takes place one period later and therefore will not be reflected in the liquidity constraint for the period. However, these variable selling costs must be taken into account in finding the optimal problem solution.

The capital expenditure budget involves a payment of $250,000 during the period. New loans dollar amount is $26,120 on which the interest rate is 10 per cent. Payment of interest is paid one period later. An ending cash balance of $100,000 is required.

With the two plant model, transportation costs must be included. An assumption can be made that the cost of transportation of one unit of product from one plant to the has the same cost regardless of direction. (i.e. Products transported from P to S or S to P have the same costs.) These costs, paid in cash, are $0.30 per unit for "A" and $0.40 per unit for "B". The different cost structure at each plant requires the cost difference to be reflected at the moment the product is transported between plants. This means that both plants transfer products at their own standard costs and receive products valued at their own standard values. The cost difference either increases or decreases the objective depending on the direction of the transportation.

The Problem:

Generate a model using microcomputer spreadsheet software, such as "LOTUS 1-2-3", "Symphony", or "VP-Planner" along with "What's Best!" optimization packages. List constraint values that are input to the problem solution. Develop the maximum profit, sales, production and raw material purchase values for both plants. From these values, develop the following corporate budgets: Sales, Production and Inventory, Raw Material Purchases, and Cash. Also show the Projected Income Statement and the Projected Balance Sheets.

The Solution:

Using "What's Best!" Optimization software, the maximum profit for this model was $1,535,461.28. This value is based on sales of Product A of 203,000 units for the parent plant and 162,083 units for the subsidiary. Both are slightly below the maximum demand possible defined by their marketing organization. The sales for Product B, however, match the maximum demand value possible with sales of 300,000 units at the parent plant and 150,000 at the subsidiary. This result is due to the optimization software finding Product B to have the highest contribution to profit and therefore chose to utilize capacity with the highest possible units of "B".

The purchases of raw material "W" were 604,000 units for the parent and 478,250 units for the subsidiary. Raw material "U" values were 610,000 units at the parent and 294,000 at the subsidiary. Both plants operate at maximum capacity when production of Product "A" was 198,000 units and 160,083 units for parent and subsidiary and production of Product "B" was 310,000 and 148,500 for parent and subsidiary, respectively. These values include no transportation of product from plant to plant. Experimentation with the values for production capacity may lead to an optimal solution that requires such transportation.

The computer generated spreadsheet solution to this problem begin on page A29 of the Appendix. Formulas used for the cells of the spreadsheet are documented in the Appendix starting on page A31 . Sales, Production and Inventory, Raw Material, and Cash Budgets are detailed on pages A18, A21, A22, and A23 of the Appendix. Page A25 contains the Projected

Income Statement and page A27 shows the Projected Balance Sheets.

<u>Analysis of Software:</u>

"What's Best!" software finds the optimal solution to a problem using a spreadsheet for data input. By using the spreadsheet on a personal computer, the difficulties with traditional linear programming methods, mainly the need for mainframe computing power and the translation of data to the required input format, are removed. "What's Best!" was designed to function on "LOTUS 1-2-3" or "Symphony" spreadsheet packages. The manufacturer claims that "WHAT'S BEST!" is also compatible with other spreadsheet "clones". However, the version requested for use with "VP-Planner" could not be implemented. Therefore, the problem solution for this case study was implemented on "LOTUS 1-2-3" without software compatibility problems.

The procedures necessary to use "What's Best!" are extremely simple. The software has a menu type approach to defining Adjustable cells, the Best formula, and the Constraints. This method is referred to in the product documentation as the "ABC's" - an effective method to remind the user of the steps involved in preparing the problem.

After the solution has been determined, "What's Best!" returns the calculated numbers to the original spreadsheet. The spreadsheet is an easily understood display which reduces the additional training necessary to use this product.

"What's Best!" error messages are clear and well documented. Unfortunately, in a situation where the user has defined an infeasible situation, the software can do little more than list the conflicting data. This is not a limitation of the software; indeed, the error list is quite helpful. It is difficult to revise a poorly designed optimization problem.

There are three versions of "What's Best!" software, each having different limitation levels. The personal version was used for this case study, which has the smallest data limits. The other versions, Commercial and Professional, allow higher numbers of cells, constraints, coefficients, and optimizable cells. A scaling problem was encountered using the values from Case Study II. The documentation defined this problem as resulting from a high variance between the lowest and highest values used to compute the solution. The error message suggested the user change certain input values to avoid possible inaccuracy. In this study, and any complex problem needing optimization, it can be difficult to impossible to change the values of the problem. After trying to follow the suggested methods to avoid this error and finding the scaling message still in effect, the user can only hope that the version used was too small for his needs. This case study was not a large involved problem, since it contained only two plants. Because of this scaling error, the loan and interest values in the case solution were given as fixed values. This does not greatly affect the use of the case study for instructional purposes, but it would be an interesting exercise to let the software calculate these values when the software could handle the scaling differences.

Overall, "What's Best!" provides an excellent, easy to use tool for problems requiring optimization. A manufacturing company could find many uses for this software: determination of product mix, scheduling problems, selection of optimal routing, and blending of raw materials at minimal cost. Because of the many potential uses, "What's Best!" is recommended for use in both student instruction and industry problem solving.

V. DSS AND SPREADSHEET ANALYSIS

A DSS that uses a spreadsheet as the means of data input and output benefits from the public acceptance and familiarity associated with spreadsheets. The spreadsheet itself can be considered a DSS as it contains the three required elements: dialog, model base, and database management. However, these elements are not fully utilized in the spreadsheet when considered alone.

Of the three requirements, the dialog management component is utilized to the smallest degree. To interface with the DSS user or builder, some type of pseudo-English or fourth generation language is necessary to define "if-then-else" situations. For increased user-friendliness, some spreadsheets have the capability to create user defined "macros", which allow frequently used groups of commands to be stored and used as one command. These macros are not especially easy to define since they use symbols and expressions instead of English-like terminology.

The model base component is not usually included in basic spreadsheet software, but can be utilized by spreadsheet compatible add-on software. For example, "What's Best!" supplies the optimization technique of the many model types possible. Although not tested in the solutions to these case studies, software such as Execucom Systems' MindSight provides additional modeling tools such as linear regression and advanced financial analysis tools such as an accelerated cost recovery system.[23]

Most spreadsheets use some form of database for data extraction and storage. "VP-Planner" from Paperback Software, used to solve Case Study I, not only allows "dBASE II" and "dBASE III" database access and update, but has its own multi-dimensional database structure. Having access to many sets of data expands the type of analysis possible in a DSS.

A good DSS also contains additional characteristics, as shown on page A2 of the Appendix. Perhaps the most important feature for the success of future DSS software will be a link to the mainframe from the microcomputer. The need for the many functional areas of a corporation to be using the same data is growing in importance as microcomputer usage expands. There is spreadsheet software available for use on the micro-computer that meet many of the DSS evaluation criteria. McDonnell Douglas software microCUBE has a goal seeking feature, a third dimension for data consolidation, color

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[23] Thompson, Keith, "Beyond Spreadsheets", Macworld, April 1986, p.98.

enhancement for modified fields, mainframe communication, menu/command driven user interface, report generation facilities and graphics.[24] Similarly, pcEXPRESS from Information Resources provides the previous features plus a fourth generation application development language. Both packages have a significant cost, with list prices starting at $1200. The MindSight software also has the same capabilities but is designed for use on the Macintosh personal computer.

As manufacturers add more powerful DSS features to their software packages, the software approaches the area of Artificial Intelligence (AI). Expert Systems (ES) are a form of AI that holds particular interest for the DSS user. ES and DSS can be viewed as enhancing one another when used together. Executive Information Systems (EIS) is another approach to decision making. While EIS "helps top managers determine what decision needs to be made", a DSS "helps analysts/managers make specific decisions."[25] Industry analysts expect EIS to grow from a $15 million industry in 1986 to $115 million in 1990.

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[24] "McDonnell Douglas microCUBE Closes the Gap Between Decision Support Systems and Spreadsheets", New Release, August 6, 1986.

[25] Desmond, John, "Repositioning of DSS Leaders Seen by Nineteen Ninety", Software News, September 1986, p.39.

DSS has laid the foundation for future development of tools and techniques to aid in decision making. Spreadsheets will continue to be helpful as a simple method to interface between the user and the computer software. A background including spreadsheets as a DSS will be an asset to the user for use in industry and as a basis for the creation of new computer techniques for problem solving.

VI. APPENDIX

EVOLUTION PHASE COMPARISON

	EDP	MIS	DSS
Type of system:	Custodial operational systems	Internal control budgeting system	Planning systems
Focus:	On data, storage & efficient processing	On efficient & structured information flow	On effective decisions, use of models, user friendliness, flexibility, adaptability, & quick response
Objectives:	Prespecified	Prespecified	*Ad hoc* contingent
Organizational level:	Operational level	All management levels	All management levels
Type of situation:	Within fixed procedures	Within fixed policies	Within a given scenario
Designed by:	Computer people	Computer minded people	User initiated & controlled
Design perspective:	Technical	Organizational	Individual small group
Hardware software orientation:	Hardware	Hardware & software	Software
Models i) Fixed logic ii) Deterministic data		Fixed logic Mainly deterministic data	Evolutionary logic Probabilistic data
Output i) Rigid format ii) Declarative summary reports iii) An answer iv) 'Other' information		General format Standardized interrogative reports An answer Information	User specified format Iterative interactive unstructured Insight, learning, dialogue Intelligence
Time scale:	Past and present	Past, present & future	Present and future
Context:	Context independent	Context independent	Context dependent
Exactitude:	Precision and accuracy	Precision and accuracy	Accuracy
Implementation:	'Classical' system methodology	Prototyping of inputs/outputs	'Breadboarding'
Validation:	'Classical' system methodology	'Classical' system methodology	Appropriateness

DSS EVALUATION CRITERIA

Data Management
Common database manager
Security
Simultaneous access
Data selection
Data dictionary
Automatic audit trails

Analysis
What if
Sensitivity
Impact
Goal seek
Monte Carlo
Optimization

Cost Factors
Initial license fee
Modular pricing
Maintenance
Documentation
Resource allocation
Consolidations and allocations
Mathematical/Financial functions
User-defined functions
Currency conversion
Size restrictions

Communication Linkages
Databases
Languages
Special purpose software packages

Graphics
Basic plots and graphs
Complex charts
Multicolor support
Format and layout
Multiple graphs per page
Compatibility with graphics devices
Previewing of output

Forecasting and Statistics
Time as a special dimension
Multiple regression
Curve fitting
Time series/seasonal adjustment
Basic statistical functions
Multivariate statistics

Modeling
Multidimensionary
Nonprocedurality
Procedural logic (within definitions)
Simultaneous equations (detection and solution)

User Friendliness
Consistent, natural language commands
Command abbreviations
Help command/clear error message
Undo command
Menus and prompts
Novice and expert modes
Meaningful identifiers
Documentation
Data entry/editing-full screen
Spreadsheet display of results

Command Languages
User-defined commands
Input/Ouput
Warnings and error messages

Hardware & Operating System
Time-sharing option
Mainframe compatibility
Operating systems compatibility
Microcomputer supported
Printer and plotter supported
Hardware manufacturer recommendation

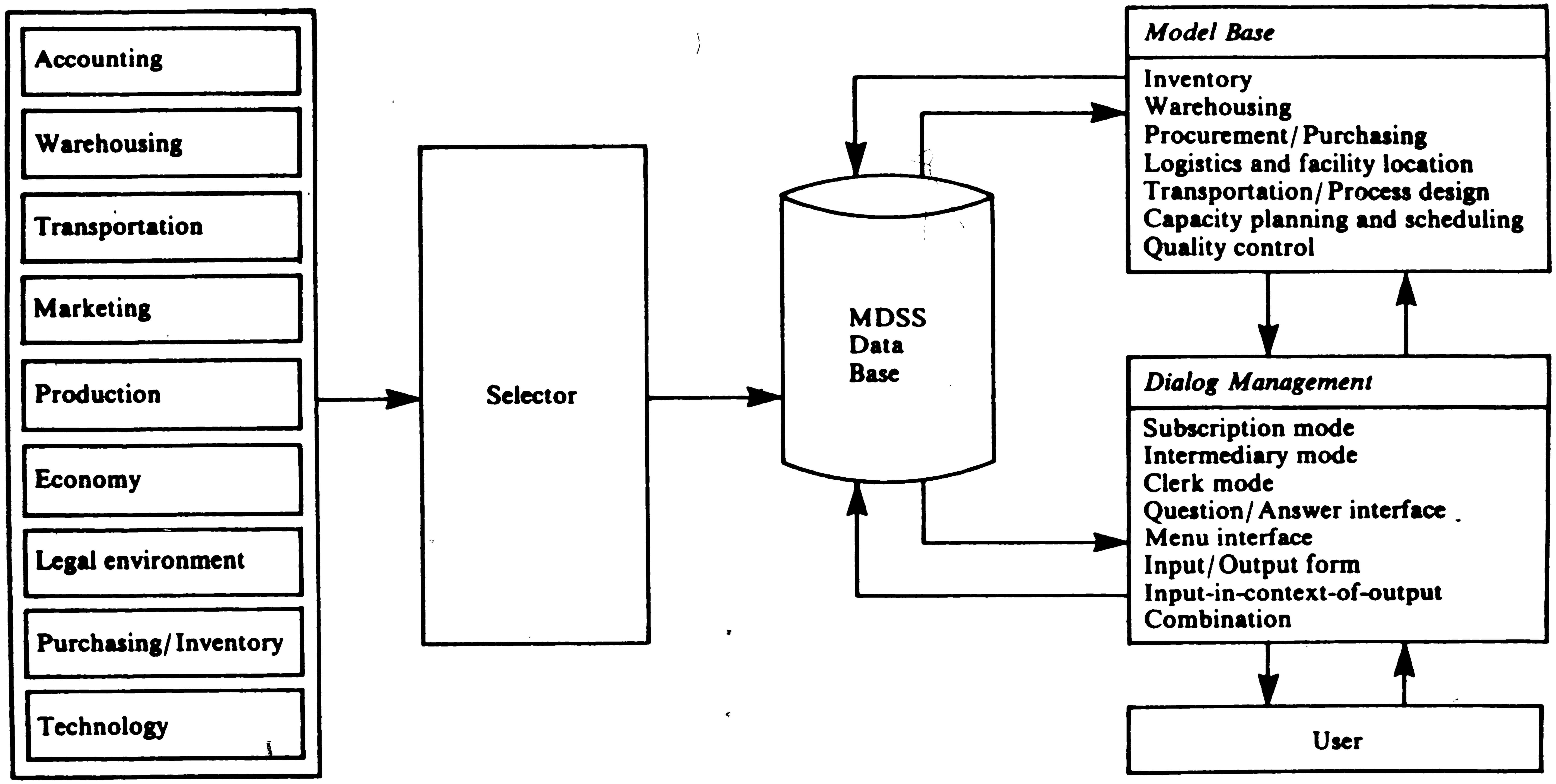
DSS EVALUATION CRITERIA (cont.)

Vendor Support

Consulting
Hot line
Training
Quality of staff
Active R&D
Financial stability
Local branch offices
Technical support personnel
Continuing enhancements
Growth of customer base
University support group
Time sharing access
Organized user group

Reporting

Custom report formats
Standard report format
Edit and test for report formats
Standard symbols and conversions
Report variables and computations



MANUFACTURING DSS COMPONENTS

MODEL TYPES

<u>Optimizing</u>

1. Mathematical
   a. Dynamic
   b. Non-Linear
      1) Separable
      2) Convex
      3) Quadratic
   c. Linear
      1) Resource Allocation
      2) Scheduling
      3) Network Analysis
      4) Transportation
2. Inventory
3. Portfolio
4. Marketing

<u>Non-optimizing</u> <u>or</u> <u>Statistical</u>

1. Quantitative
   a. Regression Analysis
   b. Linear Regression
   c. Forecasting
   d. Time Series Analysis
   e. Trend Curves
2. Qualitative
   a. Delphi
   b. Subjective Probability
   c. Cross Impact

CASE I GIVEN DATA

Year 1 - Chicago	Product A	Product B	Product C
Base cost	2.50	4.40	8.50
Competitor's Base Price	3.50	5.10	10.00
Capacity	300.00	600.00	600.00

Year 1 - Denver	Product A	Product B	Product C
Base cost	3.00	4.00	8.00
Competitor's Base Price	4.00	5.00	9.50
Capacity	200.00	100.00	900.00

Year 1 - Boston	Product A	Product B	Product C
Base cost	3.00	4.30	8.50
Competitor's Base Price	3.50	5.20	10.80
Capacity	1000.00	600.00	700.00

CASE I DATABASE STRUCTURE

General Information:
****

Database Name: XYZCORP3.DIM
Number of Dimensions: 4
Length of Names: Short - 8 characters.
Long - 30 characters.
Decimal Place Dimension is dimension 2.
Number display:
- Amounts are displayed to 4 Decimal Places.
- Rates are displayed to 4 Decimal Places.

Structure size in bytes: 57
NUL account category: 0

Dimensions:
****

Dimension 1 is: TIME
The short name is: TIME
There are 6 categories in this dimension.

	Short Names	Long Names
1.	YR1	YEAR 1
2.	YR2	YEAR 2
3.	YR3	YEAR 3
4.	YR4	YEAR 4
5.	YR5	YEAR 5
6.	TOTYRS	TOTAL YEARS

Dimension 4 is: PLANTS
The short name is: PLNT
There are 4 categories in this dimension.

	Short Names	Long Names
1.	CHI	CHICAGO
2.	BOS	BOSTON
3.	DEN	DENVER
4.	TOTPLNT	TOTAL PLANTS

CASE I DATABASE STRUCTURE (cont.)

Dimension 2 is: ACCOUNTS
The short name is: ACCT
There are 23 categories in this dimension.

	Short Names	Long Names	
1.	CBASE	COST BASE	Rate
2.	CPQTY	COST/PRICE BASE QTY	Rate
3.	CCHG	COST CHG COMP OF RATE	Rate
4.	CQTYVAR	COST/QTY VARIANCE RATE	Rate
5.	CQTYCHG	COST/QTY CHG CHG COMP OF RATE	Rate
6.	PBASE	PRICE BASE	Rate
7.	PCHG	PRICE CHG COMP OF RATE	Rate
8.	PQTYVAR	PRICE/QTY VARIANCE RATE	Rate
9.	PQTYCHG	PRICE/QTY CHG COMP OF RATE	Rate
10.	XPBASE	COMPET BASE PRICE	Rate
11.	XPCHG	COMPET PRICE CHG COMP OF RATE	Rate
12.	XPQTYVAR	COMPET PRICE/QTY VARIANCE RATE	Rate
13.	XPQTYCHG	COMPET PRICE/QTY CHG COMP-RATE	Rate
14.	XQTY	COMPET PRICE BASE QTY	Rate
15.	PDEMQTY	PRICE AT DEMAND QTY	Rate
16.	CDEMQTY	COST AT DEMAND QTY	Rate
17.	XDEMQTY	COMPET PRICE AT DEMAND QTY	Rate
18.	DEMAND	DEMAND	Amount
19.	CAP	CAPACITY	Amount
20.	REV	REVENUE	Amount
21.	PROF	PROFIT	Amount
22.	MARKUP	MARKUP	Amount
23.	CAPU	CAPACITY UTILIZED	Amount

Dimension 3 is: PRODUCTS
The short name is: PROD
There are 4 categories in this dimension.

	Short Names	Long Names
1.	PRODA	PRODUCT A
2.	PRODB	PRODUCT B
3.	PRODC	PRODUCT C
4.	TOTPROD	TOTAL PRODUCTS

CASE I DATABASE STRUCTURE (cont.)

General Information:
****

Database Name: XYZCORP3.DIM
Number of Dimensions: 4

Logic Statements:
****

Dimension 1 is: TIME
There are 1 logic statements defined or provided for in this dimension.

1. TOTYRS=YR1+YR2+YR3+YR4+YR5

Dimension 2 is: ACCOUNTS (Average Rates)
There are 3 logic statements defined or provided for in this dimension.

1. CQTYVAR=CCHG/CQTYCHG
2. PQTYVAR=PCHG/PQTYCHG
3. XPQTYVAR=XPCHG/XPQTYCHG

Dimension 2 is: ACCOUNTS (Budget)
There are 0 logic statements defined or provided for in this dimension.

Dimension 2 is: ACCOUNTS (Actuals)
There are 10 logic statements defined or provided for in this dimension.

1. CQTYVAR=CCHG/CQTYCHG
2. PQTYVAR=PCHG/PQTYCHG
3. XPQTYVAR=XPCHG/XPQTYCHG
4. REV=PDEMQTY*DEMAND
5. PROF=-1*(CDEMQTY*DEMAND)+REV
6. MARKUP=PDEMQTY/CDEMQTY*100
7. CAPU=DEMAND/CAP*100
8. PDEMQTY=(DEMAND-CPQTY)*(-PQTYVAR)+PBASE
9. CDEMQTY=(DEMAND-CPQTY)*(-CQTYVAR)+CBASE
10. XDEMQTY=(DEMAND-XQTY)*(-XPQTYVAR)+XPBASE

CASE I DATABASE STRUCTURE (cont.)

Dimension 3 is: PRODUCTS
There are 1 logic statements defined or provided for in this dimension.

1. TOTPROD=PRODA+PRODB+PRODC

Dimension 4 is: PLANTS
There are 1 logic statements defined or provided for in this dimension.

1. TOTPLNT=CHI+BOS+DEN

CASE I DATABASE STRUCTURE (cont.)

List of all categories for INPUT TIME

1 YEAR 1
2 YEAR 2
3 YEAR 3
4 YEAR 4
5 YEAR 5

List of all categories for COMPUTED TIME

6 TOTAL YEARS

List of all categories for INPUT BUDGET ACCOUNTS

1 COST BASE
2 COST/PRICE BASE QTY
3 COST CHG COMP OF RATE
4 COST/QTY VARIANCE RATE
5 COST/QTY CHG CHG COMP OF RATE
6 PRICE BASE
7 PRICE CHG COMP OF RATE
8 PRICE/QTY VARIANCE RATE
9 PRICE/QTY CHG COMP OF RATE
10 COMPET BASE PRICE
11 COMPET PRICE CHG COMP OF RATE
12 COMPET PRICE/QTY VARIANCE RATE
13 COMPET PRICE/QTY CHG COMP-RATE
14 COMPET PRICE BASE QTY
15 PRICE AT DEMAND QTY
16 COST AT DEMAND QTY
17 COMPET PRICE AT DEMAND QTY
18 DEMAND
19 CAPACITY
20 REVENUE
21 PROFIT
22 MARKUP
23 CAPACITY UTILIZED

CASE I DATABASE STRUCTURE (cont.)

List of all categories for COMPUTED BUDGET ACCOUNTS

List of all categories for INPUT PRODUCTS

1 PRODUCT A
2 PRODUCT B
3 PRODUCT C

List of all categories for COMPUTED PRODUCTS

4 TOTAL PRODUCTS

List of all categories for INPUT PLANTS

1 CHICAGO
2 BOSTON
3 DENVER

List of all categories for COMPUTED PLANTS

4 TOTAL PLANTS

CASE I SOLUTION SPREADSHEETS

Accounts for Product A Year 1 at All Plants

	CHI	BOS	DEN	TOT/AVG
COST BASE	2.5000	3.0000	3.0000	2.8333
COST/PRICE BASE QTY	200.0000	200.0000	200.0000	200.0000
COST CHG COMP OF RATE	.0200	.0200	.0250	.0217
COST/QTY VARIANCE RATE	.0004	.0004	.0005	.0004
COST/QTY CHG CHG COMP OF RATE	50.0000	50.0000	50.0000	50.0000
PRICE BASE	3.5000	3.5000	3.5000	3.5000
PRICE CHG COMP OF RATE	.0500	.0500	.0500	.0500
PRICE/QTY VARIANCE RATE	.0010	.0010	.0010	.0010
PRICE/QTY CHG COMP OF RATE	50.0000	50.0000	50.0000	50.0000
COMPET BASE PRICE	3.5000	3.5000	4.0000	3.6667
COMPET PRICE CHG COMP OF RATE	.0300	.0600	.0500	.0467
COMPET PRICE/QTY VARIANCE RATE	.0006	.0012	.0010	.0009
COMPET PRICE/QTY CHG COMP-RATE	50.0000	50.0000	50.0000	50.0000
COMPET PRICE BASE QTY	200.0000	200.0000	200.0000	200.0000
PRICE AT DEMAND QTY	3.4000	3.2000	3.3000	3.3000
COST AT DEMAND QTY	2.4600	2.8800	2.9000	2.7467
COMPET PRICE AT DEMAND QTY	3.4400	3.1400	3.8000	3.4600
DEMAND	300.0000	500.0000	400.0000	1200.0000
CAPACITY	300.0000	1000.0000	200.0000	1500.0000
REVENUE	1020.0000	1600.0000	1320.0000	2620.0000
PROFIT	282.0000	160.0000	160.0000	442.0000
MARKUP	138.2100	111.1100	113.7900	121.0367
CAPACITY UTILIZED	100.0000	50.0000	200.0000	116.6667

xyz9

CASE I SOLUTION SPREADSHEETS (cont.)

Profit at Chicago for All Years, All Products

	PRODA	PRODB	PRODC	TOTPROD
YR1	282	222	756	1260
YR2	282	222	0	504
YR3	360	222	0	582
YR4	412	252	0	664
YR5	412	132	0	544
TOTYRS	1748	1050	756	3554

xyz8

CASE I SOLUTION SPREADSHEETS (cont.)

Cost Base for Year1 for All Plants, All Products

	CHI	BOS	DEN	AVERAGE
PRODA	2.50	3.00	3.00	2.83
PRODB	4.40	4.30	4.00	4.23
PRODC	8.50	8.50	8.00	8.33
AVERAGE	5.13	5.27	5.00	

xyz7

Accounts for All Chicago Products, Year1

	PRODA	PRODB	PRODC	TOT/AVG
CBASE	2.5000	4.4000	8.5000	5.1333
CPQTY	200.0000	200.0000	200.0000	200.0000
CCHG	.0200	.0300	.0200	.0233
CQTYVAR	.0004	.0006	.0004	.0005
CQTYCHG	50.0000	50.0000	50.0000	50.0000
PBASE	3.5000	5.2000	10.0000	6.2333
PCHG	.0500	.0600	.0500	.0533
PQTYVAR	.0010	.0012	.0010	.0011
PQTYCHG	50.0000	50.0000	50.0000	50.0000
XPBASE	3.5000	5.1000	10.0000	6.2000
XPCHG	.0300	.1000	.0500	.0600
XPQTYVAR	.0006	.0020	.0010	.0012
XPQTYCHG	50.0000	50.0000	50.0000	50.0000
XQTY	200.0000	200.0000	200.0000	200.0000
PDEMQTY	3.4000	5.0800	9.6000	6.0267
CDEMQTY	2.4600	4.3400	8.3400	5.0467
XDEMQTY	3.4400	4.9000	9.6000	5.9800
DEMAND	300.0000	300.0000	600.0000	1200.0000
CAP	300.0000	600.0000	600.0000	1500.0000
REV	1020.0000	1524.0000	5760.0000	8304.0000
PROF	282.0000	222.0000	756.0000	1260.0000
MARKUP	138.2100	117.0500	115.1100	123.4567
CAPU	100.0000	50.0000	100.0000	83.3333

xyz6

Accounts for Product B at Chicago

	YR1	YR2	YR3	YR4	YR5	TOT/AVG
CBASE	4.4000	4.3000	4.2000	4.1000	4.0000	4.2000
CPQTY	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000
CCHG	.0300	.0300	.0300	.0300	.0300	.0300
CQTYVAR	.0006	.0006	.0006	.0006	.0006	.0006
CQTYCHG	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000
PBASE	5.2000	5.1000	5.0000	5.0000	4.5000	4.9600
PCHG	.0600	.0600	.0600	.0600	.0600	.0600
PQTYVAR	.0012	.0012	.0012	.0012	.0012	.0012
PQTYCHG	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000
XPBASE	5.1000	5.1000	5.1000	5.0000	5.0000	5.0600
XPCHG	.1000	.1000	.1000	.1000	.1000	.1000
XPQTYVAR	.0020	.0020	.0020	.0020	.0020	.0020
XPQTYCHG	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000
XQTY	200.0000	200.0000	200.0000	200.0000	200.0000	200.0000
PDEMQTY	5.0800	4.9800	4.8800	4.8800	4.3800	4.8400
CDEMQTY	4.3400	4.2400	4.1400	4.0400	3.9400	4.1400
XDEMQTY	4.9000	4.9000	4.9000	4.8000	4.8000	4.8600
DEMAND	300.0000	300.0000	300.0000	300.0000	300.0000	1500.0000
CAP	600.0000	600.0000	600.0000	600.0000	600.0000	3000.0000
REV	1524.0000	1494.0000	1464.0000	1464.0000	1314.0000	7260.0000
PROF	222.0000	222.0000	222.0000	252.0000	132.0000	1050.0000
MARKUP	117.0500	117.4500	117.8700	120.7900	111.1700	116.8660
CAPU	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000

xyz5

CASE II SALES BUDGET

Parent Plant	Total	Product A		
	$	Price	Units	$
Sales	2 060 500	3.50	203 000	710 500
Selling Costs	41 210	0.07		14 210
Net Sales	2 019 290			696 290
Costs of Sales	1 038 550	1.85		375 550
Contrib. Margin	980 740			320 740

	Product B		
	Price	Units	$
Sales	4.50	300 000	1 350 000
Selling Costs	0.09		27 000
Net Sales			1 323 000
Costs of Sales	2.21		663 000
Contrib. Margin			660 000

CASE STUDY II: SALES BUDGET (cont.)

Subsidiary Plant

	Total	Product A		
	$	Price	Units	$
Sales	1 305 917	3.80	162 083	615 917
Selling Costs	24 846	0.07		11 346
Net Sales	1 281 071			604 571
Costs of Sales	718 737	2.13		345 237
Contrib. Margin	562 334			259 334

	Product B		
	Price	Units	$
Sales	4.60	150 000	690 000
Selling Costs	0.09		13 500
Net Sales			676 500
Costs of Sales	2.49		373 500
Contrib. Margin			303 000

CASE STUDY II: SALES BUDGET (cont.)

	Total $
Sales	3 366 417
Selling Costs	66 056
Net Sales	3 300 361
Costs of Sales	1 757 287
Contrib. Margin	1 543 074

CASE II PRODUCTION AND INVENTORY BUDGET

Parent Plant	Product A	Product B
Desired Ending Inventory	25 000	28 000
Plus: Sales	203 000	300 000
Total Requirements	228 000	328 000
Less: Beginning Inventory	30 000	18 000
Required Production	198 000	310 000

Subsidiary Plant	Product A	Product B
Desired Ending Inventory	18 000	13 500
Plus: Sales	162 083	150 000
Total Requirements	180 083	163 500
Less: Beginning Inventory	20 000	15 000
Required Production	160 083	148 500

CASE II RAW MATERIAL BUDGET

Parent Plant	Raw Material W	Raw Material U
Desired Ending Inventory	55 000	80 000
Plus: Production Reqs.	594 000	620 000
Total Requirements	649 000	700 000
Less: Beginning Inventory	45 000	90 000
Required Purchases	604 000	610 000

Subsidiary Plant	Raw Material W	Raw Material U
Desired Ending Inventory	18 000	27 000
Plus: Production Reqs.	480 250	297 000
Total Requirements	498 250	324 000
Less: Beginning Inventory	20 000	30 000
Required Purchases	478 250	294 000

CASE II CASH BUDGET

Beginning Cash		112 000
Cash receipts		
Fixed		
Accounts Receivable	110 000	
Variable		
Sales		
A (P): (.9) (3.5) (203000)	639 450	
B (P): (.95) (4.5) (300000)	1 284 000	
A (S): (.9) (3.8) (162083)	554 325	
B (S): (.95) (4.6) (150000)	655 500	
New Loans	26 120	3 269 395
Funds Available		$ 3 381 395

CASE STUDY II: CASH BUDGET (cont.)

Cash Expenditures			
Fixed			
Accounts Payable		93 000	
Existing Loans			
Amortization	10 000		
Interest	5 000	15 000	
Dividends		20 000	
Investment budget		250 000	
Fixed Expenses			
A:	695 000		
B:	500 000	1 195 000	1 573 000
Variable			
Production			
A (P):	277 200		
198000 ((.5)(1.80)+.5))			
B (P):	520 800		
310000 ((.6)(1.80)+.6))			
A (S):	268 940		
160083 ((.6)(1.60)+.72))			
B (S):	291 060	1 358 000	
148500 ((.7)(1.60)+.84))			
Purchases			
W (P):	84 560		
604000 (.93)(.15)			
U (P):	134 200		
610000 (.85)(.265)			
W (S):	66 955		
478250 (.93)(.15)			
U (S):	64 680	350 395	3 281 395
294000 (.85)(.265)			
Ending Cash Balance			$ 100 000

CASE II PROJECTED INCOME STATEMENT

Parent Plant

	Total $	Product A	Product B
Sales	2 060 500	710 500	1 350 000
Less: Var. Selling Costs	41 210	14 210	27 000
Net Sales	2 019 290	696 290	1 323 000
Less: Cost of Sales	1 038 550	375 550	663 000
Contribution	980 740	320 740	660 000
Less: Fixed Costs	915 000		
Profit before tax	65 740		

Subsidiary Plant

	Total $	Product A	Product B
Sales	1 305 917	615 917	690 000
Less: Var. Selling Costs	24 846	11 346	13 500
Net Sales	1 281 071	604 571	676 500
Less: Cost of Sales	718 737	345 237	373 500
Contribution	562 334	259 334	303 000
Less: Fixed Costs	550 000		
Profit before tax	12 334		

CASE II: PROJECTED INCOME STATEMENT (cont.)

Corporate Total

	Total $
Sales	3 366 417
Less: Variable Selling Costs	66 056
Net Sales	3 300 361
Less: Cost of Sales	1 757 287
Contribution	1 543 074
Less: Interest Expense	7 612
Value of Objective Function	1 535 462
Less: Fixed Costs	1 465 000
Profit Before Tax	70 462
Income Tax	35 231
Net Operating Profit	35 231

CASE II PROJECTED CORPORATE BALANCE SHEET

Beginning Cash		112 000
Cash receipts		
Fixed		
Accounts Receivable	110 000	
Variable		
Sales		
A (P): (.9) (3.5) (203000)	639 450	
B (P): (.95) (4.5) (300000)	1 284 000	
A (S): (.9) (3.8) (162083)	554 325	
B (S): (.95) (4.6) (150000)	655 500	
New Loans	26 120	3 269 395
Funds Available		$ 3 381 395

CASE II: PROJECTED CORPORATE BALANCE SHEET (cont.)

Cash Expenditures			
Fixed			
Accounts Payable		93 000	
Existing Loans			
Amortization	10 000		
Interest	5 000	15 000	
Dividends		20 000	
Investment budget		250 000	
Fixed Expenses			
A:	695 000		
B:	500 000	1 195 000	1 573 000
Variable			
Production			
A (P):	277 200		
198000 ((.5) (1.80)+.5))			
B (P):	520 800		
310000 ((.6) (1.80)+.6))			
A (S):	268 940		
160083 ((.6) (1.60)+.72))			
B (S):	291 060	1 358 000	
148500 ((.7) (1.60)+.84))			
Purchases			
W (P):	84 560		
604000 (.93) (.15)			
U (P):	134 200		
610000 (.85) (.265)			
W (S):	66 955		
478250 (.93) (.15)			
U (S):	64 680	350 395	3 281 395
294000 (.85) (.265)			
Ending Cash Balance		$	100 000

CASE II SOLUTION SPREADSHEET

* Single Period Multi-Plant Model *

Primary Plant Products

	A				B							
Profit	1535461.28											
Price	3.50				4.50							
Sales	203000.00	<	250000.00	47000.00	300000.00	<	300000.00	0.00	285000.00	<	285000.00	0.00
Capacity hrs/unit	0.50				0.60							
Production	198000.00	>	198000.00	0.00	310000.00	>	310000.00	0.00				
Ending Inven.	25000.00				28000.00							
Begin Inven.	30000.00				18000.00							
Raw Mtl. Usage	3.00				2.00							
Ending Bal.	55000.00				80000.00							
Begin Bal.	45000.00				90000.00							
Price $/unit	0.15				0.27							
Purchases	603999.90	>	604000.00	-0.10	610000.00	>	610000.00	0.00				
Tot. Var. Cost $/unit	1.85				2.21							
Var. Selling Costs	0.07				0.09							
Var. Overhead $1/hr	0.50				0.60							
Collect Rate-Sales	0.90				0.95							
Payment Rate-Purchases	0.93				0.85							
Amt. New Loans	26120.00											
Interest Expense	7612.00											
Interest Rate	0.10											
Direct Wages/hr	1.80											
Net Cash Expend.	951000.00											

CASE II SOLUTION SPREADSHEET (cont.)

Subsidiary Plant Products

	---A---				---B---							
Price	3.80				4.60							
Sales	162083.30	<	180000.00	17916.70	150000.00	<	150000.00	0.00				
Capacity hrs/unit	0.60				0.70				199999.98	<	200000.00	0.02
Production	160083.30	>	160083.30	0.00	148500.00	>	148500.00	0.00				
Ending Inven.	18000.00				13500.00							
Begin Inven.	20000.00				15000.00							
Raw Mtl. Usage	3.00				2.00							
Ending Bal.	18000.00				27000.00							
Begin Bal.	20000.00				30000.00							
Price $/unit	0.15				0.27							
Purchases	478250.00	>	478249.90	0.10	294000.00	>	294000.00	0.00				
Tot. Var. Cost $/unit	2.13				2.49							
Var. Overhead $1/hr	0.72				0.84							
Transport Costs	0.30				0.40							
A Units P to S	0.00											
B Units P to S	0.00											
A Units S to P	0.00											
B Units S to P	0.00											
Direct Wages/hr	1.60											
Net Cash Expend.	500000.00											
Cash Constraint	1451000.00	<	1737995.02	286995.02								

S. M. Smith 04/87

CASE II CELL FORMULAS

```
A1: [W25] '* * * * * * * * * * * * * * * * * * * * Single Period

A2: [W25] 'Primary Plant Products
C2: [W11] "
D2: [W3] "
E2: [W11] "
F2: [W11] "
G2: [W3] "
H2: [W11] "
I2: [W3] "
J2: [W11] "
K2: "
C3: [W11] '---------------A------------------     -------------
A4: [W25] "Profit
C4: [W11] (C5-C18-C17)*C6+(H5-H18-H17)*H6-C23+(C17-C47-C50)
 *C51+(H17-H47-H50       -C18-C47)*C36+(H35-H18-H47)*H36
A5: [W25] "Price
C5: [W11] 3.5
H5: [W11] 4.5
A6: [W25] "Sales
C6: U [W11] 203000
D6: U [W3] "<
E6: [W11] 250000
F6: [W11] +E6-C6
H6: U [W11] 300000
I6: U [W3] "<
J6: [W11] 300000
K6: +J6-H6
A7: [W25] "Capacity hrs/unit
C7: [W11] 0.5
H7: [W11] 0.6
L7: [W11] +C7*C8+H7*H8
M7: U [W3] "<
N7: [W11] 285000
O7: +N7-L7
A8: [W25] "Production
C8: U [W11] 198000
D8: U [W3] ">
E8: [W11] +C6-C10+C9+C53-C51
F8: [W11] +C8-E8
H8: U [W11] 310000
I8: U [W3] ">
J8: [W11] +H6-H10+H9+C54-C52
K8: +H8-J8
```

```
A9: [W25] "Ending Inven.
C9: [W11] 25000
D9: [W3] '
H9: [W11] 28000
A10: [W25] "Begin Inven.
C10: [W11] 30000
H10: [W11] 18000
A12: [W25] "Raw Mtl. Usage
C12: [W11] 3
H12: [W11] 2
A13: [W25] "Ending Bal.
C13: [W11] 55000
H13: [W11] 80000
A14: [W25] "Begin Bal.
C14: [W11] 45000
H14: [W11] 90000
A15: [W25] "Price $/unit
C15: [W11] 0.15
H15: [W11] 0.265
A16: [W25] "Purchases
C16: U [W11] 603999.9
D16: U [W3] ">
E16: [W11] +C12*C8-C14+C13
F16: [W11] +C16-E16
H16: U [W11] 610000
I16: U [W3] ">
J16: [W11] +H12*H8-H14+H13
K16: +H16-J16
A17: [W25] "Tot. Var. Cost $/unit
C17: [W11] 1.85
H17: [W11] 2.21
A18: [W25] "Var. Selling Costs
C18: [W11] 0.02*C5
H18: [W11] 0.02*H5
A19: [W25] "Var. Overhead $1/hr
C19: [W11] 0.5
H19: [W11] 0.6
A20: [W25] "Collect Rate-Sales
C20: [W11] 0.9
H20: [W11] 0.95
A21: [W25] "Payment Rate-Purchases
C21: [W11] 0.93
```

CASE II CELL FORMULAS (cont.)

```
H21: [W11] 0.85
A22: [W25] "Amt. New Loans
C22: [W11] 26120
D22: U [W3] '
E22: [W11] '
F22: [W11] '
A23: [W25] "Interest Expense
C23: [W11] 7612
A24: [W25] "Interest Rate
C24: [W11] 0.1
A25: [W25] "Direct Wages/hr
C25: [W11] 1.8
A26: [W25] "Net Cash Expend.
C26: [W11] 951000
D26: U [W3] "
F26: [W11] "
A30: [W25] "
B30: U [W3] "
C30: [W11] "
D30: [W3] '
A32: [W25] 'Subsidiary Plant Products
C32: [W11] "
D32: [W3] "
E32: [W11] "
F32: [W11] "
G32: [W3] "
H32: [W11] "
I32: [W3] "
J32: [W11] "
K32: "
L32: [W11] "
M32: [W3] "
N32: [W11] "
O32: "
C33: [W11] '---------------A------------------
A34: [W25] '
C34: [W11] '
A35: [W25] "Price
C35: [W11] 3.8
H35: [W11] 4.6
A36: [W25] "Sales
C36: U [W11] 162083.3
```

```
D36: U [W3] "<
E36: [W11] 180000
F36: [W11] +E36-C36
H36: U [W11] 150000
I36: U [W3] "<
J36: [W11] 150000
K36: +J36-H36
A37: [W25] "Capacity hrs/unit
C37: [W11] 0.6
H37: [W11] 0.7
L37: [W11] +C37*C38+H37*H38
M37: U [W3] "<
N37: [W11] 200000
O37: +N37-L37
A38: [W25] "Production
C38: U [W11] 160083.3
D38: U [W3] ">
E38: [W11] +C36+C51+C39-C40-C53
F38: [W11] +C38-E38
H38: U [W11] 148500
I38: U [W3] ">
J38: [W11] +H36+C52+H39-H40-C54
K38: +H38-J38
A39: [W25] "Ending Inven.
C39: [W11] 18000
D39: [W3] "
H39: [W11] 13500
A40: [W25] "Begin Inven.
C40: [W11] 20000
H40: [W11] 15000
A42: [W25] "Raw Mtl. Usage
C42: [W11] 3
H42: [W11] 2
A43: [W25] "Ending Bal.
C43: [W11] 18000
H43: [W11] 27000
A44: [W25] "Begin Bal.
C44: [W11] 20000
H44: [W11] 30000
A45: [W25] "Price $/unit
C45: [W11] 0.15
H45: [W11] 0.265
```

CASE II CELL FORMULAS (cont.)

```
A46: [W25] "Purchases
C46: U [W11] 478250
D46: U [W3] ">
E46: [W11] +C42*C38-C44+C43
F46: [W11] +C46-E46
H46: U [W11] 294000
I46: U [W3] ">
J46: [W11] +H42*H38-H44+H43
K46: +H46-J46
A47: [W25] "Tot. Var. Cost $/unit
C47: [W11] 2.13
H47: [W11] 2.49
A48: [W25] '
C48: [W11] '
H48: [W11] '
A49: [W25] "Var. Overhead $1/hr
C49: [W11] 0.72
H49: [W11] 0.84
A50: [W25] "Transport Costs
C50: [W11] 0.3
H50: [W11] 0.4
A51: [W25] "A Units P to S
C51: U [W11] 0
H51: [W11] '
A52: [W25] "B Units P to S
C52: U [W11] 0
D52: U [W3] '
E52: [W11] '
F52: [W11] '
A53: [W25] "A Units S to P
C53: U [W11] 0
A54: [W25] "B Units S to P
C54: U [W11] 0
A55: [W25] "Direct Wages/hr
C55: [W11] 1.6
A56: [W25] "Net Cash Expend.
C56: [W11] 500000
A58: [W25] "Cash Constraint
C58: [W11] (C26+C56)
D58: U [W3] "<
E58: [W11] +C20*C5*C6+H20*H5*H6+C20*C35*C36+H20*H35*H36
     +C22-C21*C15*C16-     C21 *C8
     -(H7*C25+H19)*H8-(C37*C55+H49)
     *H38-C50*C51-C50*C53-H50*C52-H50*C54
```

CASE II CELL FORMULAS (cont.)

F58: [W11] +E58-C58

L58: [W11] 'S. M. Smith 04/87
A60: [W25] '
B60: [W3] '
C60: [W11] '
D60: [W3] '

VII. <u>BIBLIOGRAPHY</u>

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VIII. PERSONAL DATA

Sandra M. Smith was born on January 9, 1958 to Mr. and Mrs. Richard P. Moyer in Falls Church, Virginia. The Moyers' later relocated to the Lehigh Valley area of Pennsylvania. After graduating from Whitehall High School in May, 1975 she was accepted by Lehigh County Community College, Schnecksville, Pennsylvania. Upon completing the freshman year, she transferred to Bloomsburg University, then Bloomsburg State College, in Bloomsburg, Pennsylvania. She was graduated in May 1979 with a Bachelor of Science degree in Business Administration and a minor in Computer Science.

Upon graduation she returned to Allentown, Pennsylvania where she accepted a full-time position with A T & T Technology Systems as an Information Systems Designer. She remains with A T & T where she met her husband, Bradley. They were married in November, 1982. Currently, she is project leader of the Long Term Forecasting information systems for the manufacturing division of A T & T.

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