9. *BUSINESS MODELING & DECISION SUPPORT SYSTEMS*

Page

There is a board range of definitions of decision support. However, here we mean computer software systems that help in formulating or deciding on a specific business decision. This chapter will discuss tentative conclusions about the process of developing these systems for business applications. It is based on more than 30 years of personal experience in constructing these types of systems. The purpose of the chapter is to assist in understanding the issues in effective design of similar systems. However, it is not intended as a complete treatise on the subject. It is design to augment other sources and represents a personal view of this subject. Since these systems are developed using computer and information technology, we must expect these conclusions may be transitory as that technology changes.

9.1. THE NATURE OF BUSINESS DECISION SUPPORT

Decision support offers a range of tools and functions for commercial applications. These tools differ in terms of the types of models, expectations, and analyses needed.

9.1.1. MERGING KNOWLEDGE

The effectiveness of business modeling and the corresponding decision support systems is derived from the concept that value of the sum of the collective knowledge is greater than the value of its constituted parts. The very effort to merge knowledge creates additional insights. A main function of the modeling effort is the merger and identification of sources of knowledge. In order to effectively build a business decision support system we typically require the mergers of knowledge held by different people and organizations.

9.1.1.1. Market Structure

Most business modeling should start with influence diagrams, which lay out the factors influencing the desired result. This forms the structure of the problem. This structure contains the underlying assumptions that the modeling process will depend on. Changes in this structure often require major revisions of the modeling process.

9.1.1.2. Survey Research

Typically, survey information is desired to estimate market reaction and to obtain a consensus of key knowledge sources. Market behavior is often assessed by use of survey data. Similarly, estimates of the likelihood of future uncertain events are obtained by survey techniques[1].

9.1.1.3. Expert Knowledge-base

Relationships based on historical behavior and the opinions of experts are often imposed on the model. For example, value is often assumed to be log-normally distributed. This is based on a experience in measuring value by consumers. The sales management often is required to estimate market and competitive reactions based on personal experience.

9.1.1.4. Heuristics

During the model building process "expert" knowledge are considered separately from "guesses" regarding uncertain events. While expert opinion is assumed in a model to be "true," guesses are handled as changeable. These are considered to be heuristic entries. The models are so constructed that these inputs are expected to be readily changed.

9.1.1.5. Relationships, Constraints and Economics

Constraints of any type are greatly welcome in modeling. Constraints in the form of relationships and those imposed by conservation principles provide a great multiplier effect in obtaining results. It should be noted that philosophically, constraints and objectives are interchangeable[2].

9.1.2. USES OF DECISION MODELS

Decision support systems differ in what they are intended to do. We can roughly divide support systems in to those that intend to provide insight into strategic issues from those intended to handle specific operational problems. However, it should be noted that some applications tend to cross these lines. For example, portfolio selection systems tend to be used both for strategic and operational applications.

9.1.2.1. Strategic Support and Guidance

Strategic business problems such as new facilities planning or product pricing continuously arise. Decision support systems can be designed to provide "advise" and

---

[1] The Delphi method is discussed in the Forecasting section of these notes.

[2] This comes out of the dual forms of formulating mathematical programming problems. Constraints and objectives can be switched without changing the actual structure of the problem. This concept of duality is a very useful since management teams are very reluctant to impose constraints but very willing to impose objectives.

general guidance. It is convenient to divide these systems into those intended for the analysts' own use and those that will be put into the hands of the decision-maker.

9.1.2.1.1. The Analysts' Hands

In most cases, the analyst is the system's developer. As such, systems that will be used only by the analyst need not have a comfortable user interface or be really user friendly.

9.1.2.1.2. Hands of the Decision Maker

Ideally, all strategic decision support systems should be handled by the decision-maker. This, however, requires that the system is very user friendly and that the decision-maker is comfortable with these types of analytical tools. In any event, the systems need to be specifically designed for the use of the non-developer.

9.1.2.2. Operational Problem Solving

Operational decision support systems have traditionally been developed for engineering applications and are considered to be a part of "operations research." These have included facilities design and inventory control.

9.1.2.2.1. Purchase Aids

There are special groups of support systems that focus on the purchase process. These are used both as sales aids in helping advice customers on purchase selections and forecasting tools of purchase behavior. Recently, these types of tools have been implemented on the World Wide Web.

9.1.2.2.2. Operational Solutions

Operations, by its nature, require endless choices and decisions. Most of these, fortunately, are simple. However, complex choices can be helped with decision support systems that can sought out many of the confounding issues. Generally, the goal is either to obtain an optimum solution or at least to estimate the impact of changes.

9.1.3. USERS' AND DEVELOPERS' EXPECTATIONS

While decision support systems have been available for at least forty years, they are still not widely used.   The following are some of the key reasons that have been proposed:

9.1.3.1. Clash of Cultures

The use of decision support requires taking an analytical approach to problem solving. Decision support developers typically come out of an engineering or operations research background, which is highly analytical. Decision teams, however, tend to contain a large fraction of sales and business management, many of whom have little analytical backgrounds. Teams, therefore, often have little confidence in analytical models and rely heavily on experience and qualitative research. This creates a clash of cultures and approaches.

9.1.3.2. Users' Wants and Needs

Business teams often desire "true" answers to problems. Analytical models and decision support systems while helpful do not provide the foolproof absolute answers. In fact, assuming that these models result in the "best" answer is likely to be highly dangerous since they rest uncertain assumptions. What they mainly provide is insight and range of probably satisfactory solutions. Due to the inability of analytical tools to provide "true" answers, senior management downgrades their value.

9.1.3.3. Perceived Costs

Business modeling and systems development is perceived as an expensive undertaking. Historically, this is been correct. During the early development period, from 1960 to 1980, using mainframe computers and in-house engineering staff, systems were expensive to produce. However, that is not presently the situation in many cases[3].

9.1.3.4. Getting Them Built

While there are some tools for developing particular decision support models, most systems need to be developed ad hoc. As such, there is a heavy demand on the skills of the developers. Unfortunately, decision support system development is not taught in most university programs. Practitioners tend to have mixture of business and engineering training which is fairly rare. While some multinational corporations have developed in-house capability, most have not and rely on contractors. The skills of these contractors unfortunately vary widely.

9.1.3.5. Getting Them Used

Ideally, we would want senior management to be hands on users of these systems. Unfortunately, these managers often believe (or express the belief) that it is not their job to use computer systems. "If managers manage, should analysts analyze?" This is extension of the old resistance of management to the use computer keyboards and type. As an older corporate executive told me, "secretaries type, not executives."

9.1.3.6. Getting Users Up to Speed

Even when senior management is willing to use the decision support systems, there are a number of barriers against enabling them. These include the lack to training tools and materials. It should be noted that senior managers are typically several levels above the developer and his team. As such, it is often perceived as inappropriate for senior management to take direct instruction from developers[4].

---

[3] Market models, for example, can be constructed for under $20,000 including data collection

[4] We have been experimenting with video training attached to *Excel* decision support systems as a means of reducing this problem. However, at this point we do not have sufficient feedback to determine whether providing this facility will measurably increase the use of the decision support system by senior management.

9.2. <u>DEVELOPING SYSTEMS</u>

Decision support systems are computer programs in one form or other. Development of these systems requires the appropriate selection of tools. The availability of tools has changed over time and depends on the needs of the resulting support facilities.

9.2.1. THE CHANGING ENVIRONMENT

Fairly sophisticated computerized decision support systems have been developed over the past four decades. While the fundamental characteristics and purposes of these programs have not changed over this period, the platforms and human interfaces have drastically changed. This has reflected drastic changes in computer systems and the capabilities as well as shifts in the expectations of the users.

9.2.1.1. Mainframes (1960-1980)

During the earliest period all computing was done on "mainframes". During this period, there were basically two types of systems developed:

> (1) Financial models based on accounting systems and developed by the information systems organization as part of the standard financial accounting operation; and

> (2) Engineering economic models focusing mainly on operations and developed by the corporate engineering staff.

All systems were designed for use by analysts rather than by end users. They were developed using procedural languages (mainly *Cobol* or *Fortran*).

9.2.1.2. Personal Computers (1980 - 1990)

The personal computer revolutionized the delivery of business decision support by making these systems potentially available to the end user. During the first part of this period, however, the personal computers were limited in speed and memory making the development of sophisticated systems difficult. Customer and sales-force computing was introduced at this time with special purpose programs including sales aids. These systems were also developed mainly using procedural languages such as *QuickBasic*.

9.2.1.3. Windows Environment (1990-?)

The advent of the *Windows* operating system initially reduced the cost effectiveness of custom produced decision support systems due to the increased expense of development. However, this environment has produced an expansion in the software support packages including *Microsoft Excel* and various 4th generation programming languages. The vast increase in speed and memory of personal computers during this period has resulted in an increased capability of decision support. Developing decision support systems under *Microsoft Windows* mainly uses spreadsheet and database tools such as *Excel* and *Access,* or specifically designed programming languages (*VisualBasic*, *VisualC*).

9.2.1.4. Connectivity (Future)

The future of decision support may well rest on the potential of connectivity. At present, the Internet is used mainly to transmit fully structured decision support systems to the decision-makers. In the future, however, the decision support system may be integrated into the World Wide Web. At present, there are a number of sales oriented decision support applications available on the web. These are mainly designed to help in the purchase process.

9.2.2. EXCELLENCE IN DESIGN

Over the past thirty years of developing decision support system, we have found the following characteristics critical for successful adoption of systems. Success of these systems is measured by their immediate use, the reliance on the systems in key decision processes and their longevity (continued use).

9.2.2.1. User Friendly

While some systems and models are designed to be used exclusively by the developer, many are not. This is particularly the case when the system is intended to have extensive application and impact. For such systems to continue to be used, they need to be transferable to other users and managers[5]. This requires both ease of use and ease of learning.

9.2.2.1.1. Easy of Use

Ease-of-use refers to the simplicity and intuitiveness of the system for the experienced users. For a system to be continuously used, it needs to "feel" comfortable. It should have a full range of desired capabilities, activated in a familiar and <u>efficient</u> fashion.

9.2.2.1.2. Easy to Learn

Ease-of-use for the novices is often a very different from ease-of-use by experts and just as important. Since all experienced users are, at some point novices, ease of learning is often considered more important. However, some of the facilities that make a system easy to learn become cumbersome with experience. However, all systems that are successfully require an ease of learning.

9.2.2.1.3. Training Documentation

Training documentation and, particularly, tutorials are often skipped during development for economy. The argument is given that each new set of users will learn from those that

---

[5] One of our longest used programs (CAAR model) was used by Dupont's internal auditing group for 15 years. This involved several changes in users and at least three major changes in administration.

proceeded them. However, for long-standing systems and models, that is false economy. For systems that will endure, well-developed training materials are well worth the time, effort and funds.

9.2.2.2. Economical

Cheap is good! The ability to develop systems inexpensively is the key to their availability. It is not unusual to only discover the power of a model and system after it had been developed. The only way that such systems can be developed on the "hope of use" is if they are not extremely expensive to produce.

9.2.2.2.1. Economical to Develop

The first economic "hit" is during initial development. Many of our decision support systems are developed as part of marketing research programs. It is critical that this development process is sufficiently inexpensive to be included with in the analysis phase without breaking the budget.   In other cases, the systems are developed as part of a planning program. Here too the concentration is on collection of data and the decision making process not on the building of the model.

9.2.2.2.2. Economical to Modify

Rarely are new models and decision support systems sufficiently defined and structured to be effective "out of the box." Most such systems require extensive modification. For management to consider modeling and systems development to be cost effective, it is critical that the costs of these modifications should be only a fraction of the total costs of development.

9.2.2.2.3. System Documentation

We believe that system documentation is very useful and in some cases critical. This is particularly the case when systems survive their developers. However, we have also discovered that it can go too far and be too expensive. In the case of spreadsheets, good design with internal documentation such as variable lists and comments are useful. However, detailed audit tracing of spreadsheets serves little purpose. Similarly, well-documented source code of systems developed using procedural languages is critical. However, detailed flow diagrams and data dictionaries are far less useful.

9.2.2.3. Efficient

Efficiency focuses on the immediacy of results and the size of problems that can be handled. While efficiency was a critical problem in early systems development, today is appears to be far less a problem.   The present generation of personal computers is

approximately 1000 times more powerful than earlier models. They are presently far more powerful than mainframes only a decade ago[6].

9.2.2.3.1. Speed of Computation

It is often desirable to perform decision support in "real" time. That requires computations within a minute. Even relatively complex systems can do this using *Excel* on a modern personal computer. However, some systems using very large databases or large numbers of computations, such as Monte Carlo risk analysis, may take up to an hour. Under these conditions, proper selection of computer tools can greatly reduce this requirement.

9.2.2.3.2. Use of Memory

The vast majority of decision support applications will not push the memory limits of modern personal computers[7]. However, some might. Under these conditions some programming languages are far more effective users of memory and may be required.

9.2.2.4. Ubiquitous

One of the greatest changes to favor the development of business modeling and decision support is the ubiquitously available personal computers and software. Where previously, systems were uniquely developed for specific computer systems and using unique languages and packages, systems and tools are now universally available. The trick is not to loose that advantage.

9.2.2.4.1. Available to the User

The "*IBM*" (*Intel*) Personal Computer is universally available. The *Microsoft Office Suite (Excel, Word,* and *Access)* is fully available to almost everyone. However, there are specific packages and systems that are not universally available even though they run on the personal computer. These packages should be avoid unless specifically necessary to solve the problem.

9.2.2.4.2. Familiar to the User

Not only is "universal availability" a powerful advantage, but its familiarity can also be critical. *Microsoft Windows* operating system provides an almost universal user interface with buttons, screens, and forms. Most general *PC* users are highly familiar with the look and feel of programs that operate within *Windows*. As such, decision support that can maintain that look and feel will be easier for the user to learn and use.

---

[6] An IBM executive had indicated that we have "MIPS" to burn indicating the huge increase in computing power.

[7] The present generation of personal computers involves processor speeds over 1 gigahertz and almost 1 gigabyte of random access memory.

9.2.3. TOOLS OF THE TRADE

Over the past thirty years, we have developed systems using any number of tools and techniques. Each of the methods and tools has unique advantages and disadvantages. As previously noted, there has also be an historical path where various tools become available, dominate the process of decision support development, and then are replaced by other tools which better merge with the computer and operating platforms that become available.

9.2.3.1. Procedural Languages

Procedural languages are the oldest methods of developing systems. These include the traditionally compiled, interpreted, and assembled languages. Modern examples include: *Microsoft QuickBasic*, *Fortran*, "*C*", "*C++.*" These are the most flexible tools but also very difficult and costly. The resulting program is referred to as a source code. Once this source code is converted into native machine code with the appropriate compiler, it can be run on most all computers. However, separate compilers are needed for each type of processor and the code may need to be modified for different computer configurations.

9.2.3.2. CASE Tools and Visual Packages

CASE tools refer to "Computer Aided Software Engineering" and include a number of construction aids useful particularly in the preparation of input and output screens. The "visual" suites of programs are particularly useful for this purpose and are designed specifically to create *Windows* ready applications. Examples of these tools include: *Microsoft VisualBasic*, *VisualC* and *IBM's Visual Age*.

9.2.3.3. "4th Generation Languages"

The term "4th generation language" was popular several years ago to represent database manager packages that included a number of CASE tools for screen generation. These packages were mainly designed for automated database reporting and statistical analysis. Additional modules and add-in packages are available to allow the construction of decision support systems.

9.2.3.3.1. Database Managers

Database managers are widely available that can be used to construct decision support systems but mainly from the data held in the appropriate data files. These tools are particularly useful if internal financial and customer data is being used for the construction of the models. Most of these packages have a programming language and "interpreted" models generators. These require that the database management package be fully installed at the site or in an appropriate server where the model is being used. Compiled versions are also available. This greatly increases the speed of execution. Examples of database managers used for decision support and modeling include: *Information Builders' Focus*, *Microsoft Access*, *Microsoft FoxPro, Oracle, SAP.*

9.2.3.3.2. Statistical Packages

When models use complex statistical and mathematical tools it can be useful to employ a statistical package. Many of the large statistical packages contain special modules and a programming language for these applications. The key advantage in using them is the prior existence of the appropriate data already in the package. Examples of these packages include: *SPSS*, *SAS*, *Systat.*

9.2.3.4. Spreadsheets

Spreadsheets are our preferred tools for business modeling and the construction of interactive decision support systems. These models are developed around a series of flat files. Examples include: *Microsoft Excel and Lotus 1-2-3*. A detailed discussion on using *Microsoft Excel* for these applications is included in these notes.

9.2.3.4.1. Macros

Spreadsheet packages contain both inherent capabilities and those that can be expanded by a programming language. These languages are usually referred to as "macros" and consist of facilities to either record a series of actions or to produce separate programs. While earlier versions of spreadsheet packages (*Lotus* and *Excel*) had only simple macro-language capabilities, recent versions have included versions of "*Visual Basic*"[8]. However, this added capabilities to spreadsheet, truly constitute a series of coded programs with all of the difficulty of procedural language without the CASE tools provided in the *Windows* specific languages.

9.2.3.4.2. Add-in's

Add-in packages are available that expands the capabilities of spreadsheets. These are basically standard prepared macro programs that provide a user interface to do specific functions. These include: linear programming, risk analysis, and organizing flow diagrams. An example of these includes: *@Risk*. While these packages can be useful in preparing a model, they must be available to the user. This greatly limits the availability of the tool.

9.2.3.5. Special Purpose Packages

There are certain types of applications for which special purpose packages have been developed. These include:

- Mathematical and linear programming using packages such as *Lindo* or *Orsys*;

- System simulation packages such as *Powersym* and *IThink;*

---

[8] While "VisualBasic for Applications" has some limitations compared to the *Microsoft VisualBasic*, the limitations are relatively minor.

- Analytical mathematical modeling tools such as *Maple V,*

- Expert systems and neutral nets such as *VPExpert* and others.

In many cases, using these packages or similar spreadsheet add-ins is the most feasible approach when the special technique is required. However, we have found these tools are rarely needed since the most effective models tend to be fairly simple in design.

9.2.3.6. The Internet Specific

The Internet and particularly the World Wide Web offers a potential opportunity to the utilization of business planning models and decision support tools. The availability of systems tools that encourage collaboration are now becoming widely available. While most systems can be distributed over the Internet by e-mail, developing systems that work within the browser is far more difficult. At this time there are no user friendly CASE tools for developing these systems. Development tools such as *Frontpage* and *Dreamweaver* focus on conventional applications and e-commerce sites. Planning tools are more complex to develop and require development in the "native" World Wide Web languages at this time.

9.2.3.6.1. Scripting and Java

There are typically two methods to develop on-line decision support, browser based and server based. Browser based support involves transferring the models and support system to the user for execution on the users personal computer. The second method uses the browser as in input/output device while all computation is done on the server. Browser-based systems have the advantage of increase power through distributed computing, but come at the cost of transmission time and the lack of development tools. It should be noted that the system only needs to be downloaded once and that broadband (high-speed) connections are becoming increasingly available.

The major problem in developing browser based systems is the lack of tools. The decision support systems need to be constructed as a set of dynamic *HTML* (Hyper-Text Markup Language) pages from which the Internet site is built. The languages for these applications include: *JavaScript* for control and *Java* or *VisualJ* as programming languages.

9.2.3.6.2. Server Based

It would appear that for the present, it simpler to develop on-line decision support systems that are server based. This simply requires that input information is transferred to the web site where standard programming languages can be used to perform any computations and the dynamic creation of graphs. Control of the input and output is handle by the *CGI* protocol and is typically written in *Perl* o*r* "*C*" languages.

9.2.3.6.3. Database

Many decision support systems are built as database functions. Relatively simple "expert" systems can be developed total with database lookups. *XML* is a language and protocol system designed to interface between the Internet applications and database systems. As this technology evolves it may change the advantages of using the Internet as a decision support platform.

9.2.3.7. Comparative Measures

In order to compare methods for developing systems, several measures of performance and effectiveness should be used.

9.2.3.7.1. Speed

Not all packages produce programs and systems that execute equally fast. In fact, some packages such as spreadsheets may be 25 times slower than those developed by procedural languages. We propose a qualitative scale with 1 being the slowest and 5 the quickest.

9.2.3.7.2. Memory Efficiency

Various packages store data differently. Some such as statistical packages tend to store data in the most precise form (double or quadruple precision). Procedural languages (particularly *Fortran* and "*C*") allow a broad range of data formats that provide efficient memory use. We have used a qualitative scale here also with 1 being the least efficient use of memory and 5 being the most[9].

9.2.3.7.3. Look & Feel

Each type of method of construction produces a different look and feel to the system. We have identified four standard types:

- "Windows" - Similar to any *Microsoft Windows* compatible application

- "Menu - Open" - Generally menu driven but capable of other interfaces

- "Specific" - Unique to the package

- "WWW" (World Wide Web) - Designed to operate in a HTML browser application

9.2.3.7.4. Flexibility

Most methods impose some constraints and restrictions. Here we use three levels:

---

[9] Statistical packages usually use 8 bytes or 64 bits to hold a number which procedural languages could use a little as 1 bite.

- "Extremely" - allows any type of model or tools as long as it can be programmed.

- "Limited" - generally allows a broad range of applications with some restrictions usually in the form of types of computations

- "Restricted" - limited to only models and tools provided within the package

9.2.3.7.5. Portability

Portability refers to the ability to use the system in different environments. This includes compatibility across different platforms, as well as upward and downward compatibility among versions of the same type of platform such as versions of programs and operating systems (*Microsoft Windows*). This is particularly important, if the systems are intended for extended use. Over a 15 year period, few computer systems will not be modified, upgraded or replaced. We use for levels.

- "Compatible" - allows easy transfer and running of the programs across systems.

- "Source" - allows a single source code to be recompiled for multiple platforms.

- "Limited" - identifies some critical limitations on systems that can be used

- "Restricted" - identifies critical compatibility and portability issues.

9.2.3.7.6. Development Costs

Development costs depend heavily on the nature of the system and the organization and skills of the developers. However, there are some general guidelines based on available development tools with the methods selected. We roughly divide costs into four categories as: (1) "Very High", (2) "High", (3) "Moderate", (4)"Low." Please note that this is not a linear scale, if anything is likely to be geometric.

9.2.3.7.7. Modification Costs

Similarly, the costs of modifying and maintaining the systems depend on its nature, distribution as well as the skills of the developers. However, here we select a simple three point scale: (1) "High", (2)"Moderate", and (3) "Low". In this case, we assume that the developers will also modify and maintain the systems.

9.2.3.7.8. Availability for Development and Use

Availability of tools for development and particularly for use can be critical. If the tools are not available, the systems and models can not be used. Not all tools are equally available. We use a three point scale:

- "Ubiquitous" - means that the supporting software is everywhere. This is almost exclusively a property of *Microsoft Excel* since it is almost universally available on all personal computers.

- "Available" - means that the software can be obtained readily and is a standard within the industry.

- "Limited" - means that the software or a major component is available only directly from the manufacture.

9.2.3.8. Comparison

The following two charts show an estimate rating for the various methods of systems development.

9.2.3.8.1. Functional Factors

	Speed	Memory Efficiency	Look & Feel	Flexibility	Portability
Procedural Languages	5	5	Menu - Open	Extremely	Source
Case Tools and Visual Packages	4	3	Windows	Extremely	Source
Database Managers	2	2	Specific	Restricted	Restricted
Statistical Packages	3	1	Specific	Restricted	Limited
Spreadsheets	3	2	Windows	Limited	Compatible
Macros	4	3	Windows	Extremely	Limited
Add-in's	2	2	Windows	Restricted	Limited
Special Packages	3	2	Specific	Restricted	Restricted
Scripting and Java	3	3	WWW	Limited	Compatible
Server Based	5	3	WWW	Extremely	Compatible
Database (XML)	3	3	WWW	Limited	Limited

9.2.3.8.2. Economic Factors

	Develop Costs	Modify Costs	Availability to Use	Availability to Build
Procedural Languages	High	High	Ubiquitous	Available
Case Tools and Visual Packages	Very High	Moderate	Ubiquitous	Available
Database Managers	Moderate	Moderate	Limited	Limited
Statistical Packages	High	Moderate	Available	Available
Spreadsheets	Low	Low	Ubiquitous	Ubiquitous
Macros	High	Moderate	Ubiquitous	Ubiquitous
Add-in's	Low	Low	Limited	Limited
Special Packages	Moderate	Moderate	Limited	Limited
Scripting and Java	High	High	Ubiquitous	Available
Server Based	High	Moderate	Ubiquitous	Available
Database (XML)	High	Moderate	Limited	Available

9.3. ELEMENTS OF SUCCESSFUL DECISION SUPPORT SYSTEMS

While there are no universal rules that determine when a system will be successful, experience has indicated conditions, which appear to be more favorable. These principles are the same for decision support and for other management information systems.

9.3.1. GET TO THE USER

Without having quality user input into the design and the development process, success is very unlikely.

9.3.1.1. Finding the Real User

A major problem is finding the real user. In most cases, there are several layers of management and organization between the people developing the models and decision support systems and the actual users. This may be due to organizational design or by ignorance. The advocate of the system is often not the intended ultimate user. Unless the advocate has sufficient organizational power to insist on the system's use, it is critical to get to the ultimate user. Even with that power, it is foolish not to collaborate with the ultimate user on the system's development.

9.3.1.2. What's the Value

For any decision support system to be successful, it must help solve a problem. If it does not, it will have no value. Make sure that the system being develop will have more value than it will cost to use. In many cases, the problem that the system is design to solve is non-existent or the form of the problem does not allow decision support to provide guidance.

9.3.1.3. Timing is Everything

Most problems are transitory. For the system to be valuable, it must be available in time to help solve the problem. As such, it is critical to understand the time frame necessary for the system development. A simple tool available in time, is always preferred over a more complete system delivered too late to do any good.

9.3.1.4. Defining the Functional Needs

The trick is understanding the actual functional needs of the user. Not what they "want" or the dream list, but what they need to solve the problem and how they wish to see the

results. Much of the complexity of systems is derived from developers including options that they think the user might wish if the user knew that they were possible[10].

9.3.1.5. Limiting the Expectations

Systems can be expanded and facilities added. It is critical, however, that the expectations of the user focus on what he needs to solve the problem. If it is desired to maintain the system as part of the "permanent" decision process, other facilities may be added later.

9.3.2. KEEP IT SIMPLE

Simplicity is the single greatest correlate on the use and success of decision support systems. I have always been amazed at the success of very simple tools. Complexity serves no inherent purpose; its cost must be balanced by actual increase in desired user value. It is not unusual for systems to evolve from complex to simpler versions.[11]

9.3.3. MAINTAIN GOOD CONTROL

Control of the development and implementation process is critical for success due to economics, timing, and maintenance.

9.3.3.1. Concentration of Control

Most successful decision support projects have few participants in the initial development. The fewer the developers the better; the fewer controlling managers the better! It is not unusual for a highly successful team to consist of only the ultimate user and a developer. For systems that will have wider use, a team is often necessary. However, it is always critical to limit control to a single individual. This is necessary to limit "requirement creep."

9.3.3.2. Building Not Designing

Effective decision support tools are generally not designed, but built. In this regard, the process of development is more of a engineering process than a traditional information management project. Activities usually start with the underlying model with reports, options and entries considered iteratively as the system develops.

---

[10] This is a fundamental Information Systems development problem. Developers wish to assure that the user will have his expectations met by providing a full range of capabilities. Unfortunately, this adds to the complexity of the system, its development-time, and price without provided assured user value.

[11] In one case, we had developed a system involving six interconnected modules as required by the users' specifications. However, after a couple of years work on the system only two of the modules were actually used.

9.3.3.3. Prototyping

Developing prototypes is critical for effective support systems. Rarely are the conditions and specification fully identified before development. The old quote applies here "I don't know what I want, but I'll know it when I see it." In many cases, the project ends with the construction of the last prototype, with the final system never being developed. The reason is usually timing.

9.3.3.4. Document

The long-term success of decision support systems generally requires good documentation both for training and for maintenance.

9.3.4. MODULAR CONSTRUCTION

It is almost a mantra of systems design to build modularly. This was proposed under the theme of "structured programming" during the 1970's and more recently as "reusable code." In any case, it is good practice to construct the systems in a way that each element is self contained.

9.3.4.1. The "Jell-O Effect"

A key problem in all modeling systems is the interconnectivity of parts. This is manifested in the form of the "Jell-O Effect" where a variation in one part of the system produces results in other unexpected parts. It is as if the program vibrates like a bowl of Jell-O. Debugging this type of system becomes a "bear."

9.3.4.2. Modular Independence

The basic element of modular design is independence. Information is transferred into the module and the results are transferred out. No other intermediate effects are allowed. The main purpose of this type of design is to retard and limit the interaction and prevent the "Jell-O Effect." Modular construction is particularly a key design component using procedural languages, databases, and statistical packages. However, it can and should be applied equally with spreadsheets where calculations are constrained to particular sections of the worksheets.

9.3.4.3. Commonality

Using the same basic design and code for multiple applications is both economical and assures a reduction in errors. A practice of reusing modules rests on an investment in good module design and testing.

9.3.5. CONTROL "THE DEVIL IS IN THE DETAILS"

The demons that threatening all decision support are errors and mistakes. These make the systems worse than useless. They provide systems that mislead the organization and generate wrong decisions. Successful systems are based on attention to details.

9.3.5.1. Data Focus

Analytical models are data focused. They are constructed from internal and external databases. In general, much if not most of the effort in systems development is the preparation and "cleaning" of data. Data is usually not available in the appropriate form. It should be noted, that handling of data is usually very labor intensive. Even with automated data preparation, errors are introduced which need to be uncovered and corrected before introducing it into the modeling process[12]. Data analysis and modeling are often undertaken prior to developing the model. Errors in this analysis often can not be detected by subsequent system testing and needs to be verified during the development process.

9.3.5.2. Testing

It is critical to test systems adequately. Every stage in development should be tested. Errors always slip in. We can not rely on luck or fate to uncover them. I have found it useful to embed testing routines and facilities into the models that verify the basic underlying assumptions.

---

[12] Financial auditors use a method of summation of columns and rows (foot and tick) approach to verify that the entries balance. Similar procedures are useful in all model building. While this often appears to be obvious and redundant, the occasion when it reveals an error or imbalance is well worth the additional work.

9.4. <u>BUILDING BUSINESS MODELS AND SIMULATORS</u>

Market simulators are based on aggregating estimates of individual decision-makers choices. While the resulting decision support system tends to be less efficient and larger than those based on market models, they can capture complex decision processes and can be easier to construct for complex situations.

9.4.1. MARKET SIMULATION

Market simulators are based on aggregating estimates of individual decision-makers choices. While the resulting decision support system tends to be less efficient and larger than those based on market models, they can capture complex decision processes and be easier to construct for complex situations.

9.4.1.1. The Number of Respondents

Simulators are based on merging the results of estimated decisions of individuals. These typically are based on their responses to a survey or from some other database. The accuracy of the resulting simulator depends on the quality of the data and the precision on the size of the database. Typically market simulators are developed with as few as a couple of hundred respondents or less. The resulting market simulators tend to be limited to major changes in the market without the ability to look at marginal opportunities. This is a great limitation for the application of these simulators. There are a couple of methods used to improve the precision situation, however, they each have limitations and do not fundamentally change the accuracy or the underlying precision of the simulators.

9.4.1.1.1. Hybrid Simulation

One approach to improve the apparent accuracy is to use market models within the simulator. The market models capture the collective behavior of the market. Those models allow for interpolation of values within the range of the data, but also limited extrapolation beyond the underlying data. This expands the possibilities described by the simulator. However the precision of the resulting hybrid model is still limited by the sample size. Systems built using market and business models are discussed later.

9.4.1.1.2. "Data Enhancement"

Another alternative is to artificially increase the size of the sample. The term "Data Enhancement" is widely used to cover any number of marketing and information systems services. However, in this case we are specifically referring to the process of generating synthetic data, which reflects the same structure as the original data. For example, we may have only a hundred original respondents to build the simulator. This will be too few to look into fine details. However, we can generate 900 additional synthetic sets which by drawing them from a population with the same statistical characteristics as the original data. This gives a thousand respondents and a far finer simulator. However, note that the statistical precision of the estimates is still determined by the original data.

The resulting simulator reflects the world, if the original estimates of the population are maintained with the larger sample.

9.4.1.1.2.1. Building the Data Model

The process of data enhancement starts with understanding the characteristics of the original data. This is referred to as a "data model." It captures:

- The cluster structure reflects the common groups of respondents. These can be thought of as segments of the market. However, with small data sets, usually, it is assumed that there is only one cluster group being considered.

- The intercorrelation among the variables is captured by the "Factor Structure." Factor analysis of the data will generate a number of new "latent" variables called factors that are independent of each other irrespective of the intercorrelation of the original data[13]. For the purposes of data enhancement, a least squares factor analysis is done, specifying as many factors as there are original variables[14]. The values of these latent variables are obtained as the linear combinations of the original variables applying the "factor coefficients" as weights.

- The distribution of each of the latent variables is then identified. Typically it is assumed that these distributions will be normal or Gaussian[15]. This merely involves estimating the average and the standard deviation of the latent variables.

The data structure therefore is represented for each cluster group as the set of factor coefficients and the means and standard deviations of the latent variables.

9.4.1.1.2.2. Generating Synthetic Data

A Monte Carlo approach is then used to generate the synthetic data. Random values of the latent variables are generated randomly[16]. These are then converted into the original data form by applying the inverse of the factor coefficients. This involves obtaining the inverse of the matrix factor coefficients[17]. The final data is obtained by the matrix

---

[13] Factor Analysis is a common multivariate statistical tool available in the standard statistical packages: *SPSS*, *SAS* and *Systat*.

[14] Typically a "Equamax" rotation is used to provide more uniform weights among the factors.

[15] Price-Value data is often log normally distributed and it is therefore, useful to use the logarithm of the original data for data analysis. Similarly, data that is constrained within a total of 100% often are converted to a "normal", Z value before further analysis. If these transformations are used, the resulting synthetic data will need to be transformed back before using them in simulators.

[16] There is any number of random number generating routines. Microsoft Excel provides a standard procedure. More sophisticated approaches such as Markov Chain Monte Carlo (MCMC) are available using *Systat*.

[17] The factor coefficients form a square matrix with as many sets of coefficients as well as the number of coefficients as there were original variables. Square matrices of this type can be readily inverted.

multiplication of the generated latent variable vector by this inverse coefficient matrix. The cluster structure is imposed by sampling each of the cluster groups proportional to the fractions within the original data.

9.4.1.1.2.3. Limitations

The process of data enhancement is based on a number of assumptions that influence the reliability and validity of the resulting simulator. In particular, is the assumption that the data have continuous and infinitely extended distributions. While these are not, necessarily inherent assumptions in the process, they are typically imposed by assuming that the latent variables are normally distributed. These assumptions produce values that are beyond the range of the original data and may not be realistic.

9.4.1.2. Respondent Level Decisions

The key to developing a simulator is estimating the decision process of the respondents. In order to do so, sufficient information and data are needed on the respondent level. We are attempting to estimate how individual decision-makers respond to a set of stimuli whether in a choice of products or a negotiated price.

9.4.1.2.1. Decision Models

Most simulators are based on estimating the utility, or distance from an ideal, for each of a number of choices by the each respondent. These estimates are typically based on either historical behavior or responses to experimental situations as part of a survey. Discussions of the measurement procedures are covered in other parts of these notes[18]. At this point, we will only specify that such measurement is feasible. This provides a numerical value for each choice for the hypothetical consideration set. The question then is which choice the respondent would select based on these values.

9.4.1.2.2. Winner-Takes-All

The simplest rule is "winner-takes-all." With this rule, we assume that the respondent will only select one item with the highest utility. For ties, breaker rules are often. The underlying assumption to this method is that the individual represents a single decision element.

Microsoft Excel will inverse square matrices with up to 54 variables. *Systat* will do matrices with up to 150 variables.

[18] Perceived-value methods include full-profile and compositional conjoint as well as any number of profiling methods such as Simalto. Pricing modeling techniques include choice modeling and concept testing.

9.4.1.2.3. Representing Groups

However, in many cases, we are using the respondent to represent a group of potential customers or number of buying situations. Under these circumstances, we often want a "stochastic" or probabilistic response.

9.4.1.2.3.1. Value Share = Market Share

A simple, but often useful, approach is to consider the value share (or inverse distance from the ideal share) to be equal to the market share for the group of instances represented by the respondent. This simple involves computing a value share from the utilities and assuming that it represents the inclination to purchase.

9.4.1.2.3.2. Equilibrium Share Distribution

A major problem exists regarding the underlying assumption of value share being equal to the resulting market share. Intention to action is probably a very non-linear function of value. "Winner-take-all" can be viewed as an extreme case of this non-linearity. Under this assumption, even a differentially small difference in value exists between two products, the higher one would win. "Value share equaling market share" is the other extreme, where even a small absolute value would command some sales.

An alternative is imposing a share distribution. The relative value shares are used to determine the ranking of the options and an equilibrium (ergodic) distribution[19] is then used to assign appropriate shares. Additional rules can be added to impose threshold levels for choices to participate in the consideration set.

9.4.1.2.4. Multiple Rules

It is not unusual to provide a number of rules in a simulator and provide the user the ability to select the rules or provide multiple results. However, while this is intellectually interesting, it may get in the way of the user. As a general principle, we have found that the "value share equaling market share" is almost always unsatisfactory. The choice between "winner takes all" and equilibrium share tend to depend on expected customer behavior. If it is a single buy situation, "winner-takes-all" appears best. If it is a rebuy situation where there is an inherent value of second sourcing, than the equilibrium share should be considered.

9.4.1.3. Aggregating Results

At this point, we have the estimated choices of the individual respondents. These need to be aggregated to form an overall market or organizational estimate. Several rules can be applied. The choice of the aggregating process depends on the underlying meaning of the

---

[19] There are a number of distributions that have been used. We have found that the "Broken Stick Rule" seems to be very effective. This model is discussed else where in the notes under "Forecasting."

results and how they will be used. We have found at least two uses: (1) market share estimates and (2) collective choice.

9.4.1.3.1. Central Measures

Central measures include averages and median values. In almost all cases when the result is to be used as an estimate of market share, some type of averaged value is usually used to aggregate results. For a collective choice, averages tend to provide values which are between extremes and may represent no individual's opinion. With extremely diverse values, median values or geometric means may be preferred. It should be noted, however, that these other measures of central tendency are inappropriate if a discrete value of choice such as the outcome of "winner-takes-all" is used.

9.4.1.3.2. Weighing Results

Weighing results allows the individual responses to represent a group of customers or respondents. This potentially allows for a better representation of the total population. However, it also reduces the effective sample size. This produces an interesting dilemma since it is best used only with fairly large sample sizes. However, with a large sample size it is generally not necessary to use it. In general, weighting is used on the demand of the client to give an apparent better picture of the world.

9.4.1.3.3. Synthetic Voting

An alternative to using simple averages is to produce a procedure that simulates a voting process. The objective is to reduce the impact of marginal or contrary respondents. A voting process generally discounts the contrary, in essence ignoring them in the computation of value. This is particularly useful for evaluation of risk where the central tendency will combine the values, while a voting process will only include the majority effect.

There are number of different ways of obtaining a vote. Typically, the vote is made on a stratified set of levels or categories. Respondent decision rules are used to evaluate each item to be voted on for each level. Membership would then depend on the opinion of a group (majority generally) of the respondents.

9.4.2. BUSINESS MODELS

Business models represent the behavior of the totality of the business environment. They are based on modeling the aggregation of the business and market data as opposed to the simulator, which aggregates models of the individuals in the market. The business modeling approach usually results in a more efficient decision support system and may better reflect underlying structural assumptions. A complete business model usually consists of several elements including models to represent: (1) the market, (2) competitive behavior, (3) facility and capability development, (4) demand forecasts, and potentially (5) technology and environmental forecasts.

9.4.2.1. Market Models

The key component in most business decision support systems is the market model. The market model relates decision variables (new product attributes, marketing mix expenditures, distribution decisions, and pricing) to the resulting market share.
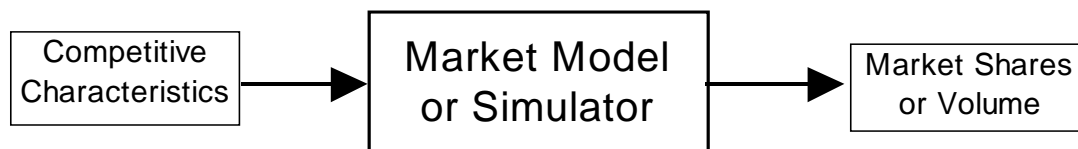
The trick is to develop an adequate market model that allows a broad range of potential actions while capturing the full potential range of responses. There are three types of data that are typically used to develop market models: historical market, experimental and survey data.

9.4.2.1.1. Historical Market Data

Historical data have been used to construct market models. These assume that historical responses to pricing and changes in marketing activities reflect the underlying response function of the aggregation of buyers. Often general principles can be assumed based on this data. For example, the prices and volumes of materials (both specialties and commodities) tend to form a common curve covering a very broad range of materials (diamonds to sand). This relationship (referred to as the "Exclusion Curve") tends toward an elasticity of 2.5 and reflects a dominance of plant investment (6/10th rule). However, it must be noted that such data does not reflect individual buyer decisions nor does it reflect the specifics of the market and business situation. Furthermore, available historical data usually does not cover the range of pricing and design issues that need to be forecasted.

9.4.2.1.2. Market Experimental Data

Market experiments are usually the most theoretically accurate method of developing predictive market models. These experiments, literally attempt to measure the markets response to changes in key characteristics. While this type of data is preferred, it is usually infeasible to collect and very expensive. Only in clearly favorable conditions are

extensive market experiments ever conducted. Furthermore, some variables, particularly competitive behavior usually can not be measured by experiment.

9.4.2.1.3. Opinion Survey Data

The most widely used source of data to build market models is with opinion surveys. In order to capture the needed data, an experimental design is usually required. The potential buyers are given a number of different market scenarios and asked what they intend to do. This intent to purchase data is then aggregated and used to construct models using some type of regression analysis. A number of different procedures can be used and are outlined in other parts of these notes. They are generally referred as concept testing, conjoint, and choice modeling procedures.

9.4.2.1.4. Economic Behavior

Models based solely on economic behavior are theoretical in nature. For example, there are cases with commodity products where location of the production facility dictates costs. As such, a market model based mainly on location can give a reasonable expected description of market behavior assuming that there is an excess of capacity. Linear and quadratic program models have been developed that model this type of market behavior quiet well. However, the situation might radically change with limited capacity where price no longer is dictated by transportation cost alone.

9.4.2.1.5. Sales Management Perceptions

"When all else fails ask the sales management." While this is probably the least satisfactory and defensible approach, the sales management is often the only source of information needed in a timely fashion. Timing is critical! An excellent decision support tool is useless after the decision has been implemented. As such, the only source of information may be the sales-force. And while it is certainly flawed, it often captures the business opinion which has a value of it own. It can be very useful, at least for communications purposes, to capture the internal opinions as well as that of the market. Difference in the resulted predictions could be as valuable as similarities.

9.4.2.1.6. Linear and Non-Linear Forms

Both linear and non-linear relationships are used in constructing market models. As previously noted, if a strictly linear form is used, the results would be the same in a market model as for a corresponding market simulator. Since the resulting market model will be more efficient and less expensive to build than the corresponding market simulator, it is usually preferred.

Non-linear market models include the use of sigmoidal (S-Shaped) and asymmetric demand curves as well as ergotic share distributions. Both linear and non-linear relationships are used in constructing market models. As previously noted, if a strictly linear form is used, the results would be the same in a market model as for a corresponding market simulator. Since the resulting market model will be more efficient

and less expensive to build than the corresponding market simulator, it is usually preferred.

Non-linear market models include the use of sigmoidal (S-Shaped) and asymmetric demand curves as well as ergotic value and share distributions. These are used both in simulators and market models. However, the underlying assumptions are generally only valid for the totality of the market. As such, their use in market models is far more dependable than their use in simulators.

9.4.3. KNOWLEDGE CAPTURING

As was earlier noted, a great deal of the information used in decision support systems is based on the opinions of management, "experts" and the market. This information represents the organizational and market knowledge. While this knowledge is by its nature inaccurate and biased, it is usually the best available. Furthermore, decision support systems are often "political" tools used to obtain consensus. The inclusion of a broad base of meaningful opinions often helps assure acceptance even in factions, which are uncomfortable with the tools or the results.

9.4.3.1. Self Explication

The simplest method of obtaining opinions is simply asking the people their opinion. Several tools are often used to assist in compiling these results and obtaining a consensus with group sessions. Developing these procedure tools in *Excel* is discussed in that section on "Collaboration Tools". Basically, collaborative approach is used to exchange opinions and obtain the consensus. Note, however, that a complete consensus is rarely obtained and but also rarely needed.

9.4.3.2. "Expert" Systems[20]

"Expert Systems" packages consist of methods to solicit decision rules and to build trade-off structures that allow these rules to be accessed within a decision support system. While formal systems are available, we have found that an informal structure to rule setting and the use of lookup tables are sufficient for most applications.

9.4.3.3. "Conjoint" Survey Data

In some cases, the "experts" can not give explicit answers. This is usually due to the explicit form of the knowledge needed rather than any desire to withhold information. Conjoint methods are used to capture decision rules that the respondents may not be cognitive of. For example, introducing strategic benefits into a business model often

---

[20] We consider Neutral Nets to be a type of "Expert" System where the rules are built up from historical data and from experiments but based on a general model framework. It should be noted, however, that the application for Neutral Nets in business decision support applications is likely to be very limited due to both the amount of data needed and the inability to explain the nature of the resulting model.

requires balancing the value of long and short-term gains. Management has historically found it difficult to explicitly provide a balancing model for these gains. However, we have obtained these individual decision rules by use of an exercise requiring the managers to rank order a statistically designed set of alternative projects. This is a "conjoint" experiment. This procedure is discussed in detail in the chapter on Perceived Value Measurement in these notes and in section on Collaborative Methods using *Excel*.

9.4.4. SYSTEMS DYNAMICS

While many business models and decision support systems focus on only the current or near future results, some of the most interesting and useful phenomena are in the future and are dictated by the market dynamics. It is usually infeasible to execute programs and business actions with the short term only. Furthermore, success of programs may rest on the reaction of competitors.

9.4.4.1. Forming a Dynamic Model

Fixed point models are far simpler to design because the model is based on the current information. No provision needs to be made to handle the range of changes inherent in dynamic systems.

9.4.4.1.1. Influence Diagrams

In designing the decision support system, it is useful to determine whether the model will be the basis of a dynamic system or only for fixed points. The key to design dynamic models is using "Influence Diagrams" which lay out the relationships between elements in the model. While Influence Diagrams are always useful in constructing models, they can be critical once dynamics is introduced.
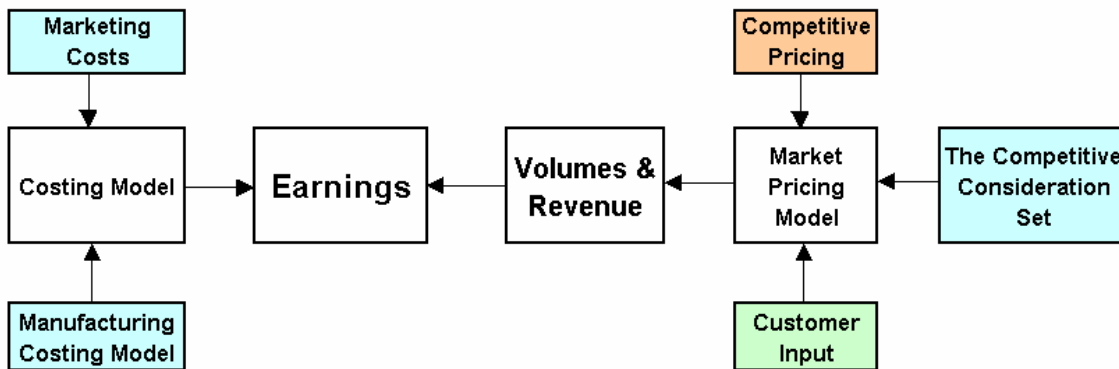
9.4.4.1.2. Forecasts

A key variable in many dynamic business models is the potential for sales to the industry. For most business models these forecasts are viewed as "exogenous," they are imposed on the business dynamics. Introducing the forecast is usually the simplest manner to add

some dynamics into an otherwise static model. Unfortunately, it often results in inflated overall results. However, it is a key element in most dynamic models.

9.4.4.1.3. Interactive Dynamics

The power of dynamic models becomes apparent once a relationship among variables is established. By setting relationships between price, competitive price and share for example, we begin to see effects that may not have been expected. The key is to relate future behavior with current and expected future conditions.

9.4.4.1.4. Discrete vs. Concurrent Decision Processes

Most business models are formed with discrete time periods, months, quarters or years. It is assumed that, for the most part, decisions are made based on previous time period's characteristics. As such, pricing in the next period will depend only on the present characteristics of the business.

While discrete decision making is a good approach for most situations, there are occasions where simultaneous or concurrent decision making is more realistic. For example, if the sales force is permitted to respond to an aggressive counter bid, then some degree of concurrency in decision making may be needed. There are three approaches to introduce concurrency: (1) provide a conditional element in the discrete model, (2) introduce a projective element, and (3) restructure as a differential time model.

Providing conditional or projective elements is the simplest approach but greatly complicates the model. Conditional elements allow changes to take place if certain conditions are met. The projective approach requires recalculation of conditions under a number of possibilities and simulating a more complex decision process. In both cases, it becomes increasingly difficult to trace out what is happening.

Using differential equations to describe the market is a far more elegant solution but introduces a host of other problems. For the most part, business decisions are discrete and are based on current information. A differential model assumes that decision is all concurrent. Introducing delays becomes much more complex. Furthermore, differential forms impose stability that finite difference forms (discrete) do not require. Experience has suggested that such stability is not realistic. Changes in the marketplace can and have been abrupt which would be excluded in the continuous form[21].

9.4.4.2. Model Forms

There are a number of classic forms that dynamic models use. These are either used as the structure of the overall model or as components within it.

---

[21] We have found one exception that is in the model of noise and error where integrating the partial differential equation (Kolmogorov Equation) results in a simple estimate of the distribution of uncertain values. See William Feller, An Introduction to Probability Theory and Its Applications, Vol. 2 (1971)

9.4.4.2.1. Market Model

The market model is usually the core of any business decision support system and represents the action of the market based on competitive offerings. Typically these are relationships describe by some time of linear (or pseudo-linear) function. Typical examples of market models are the pricing[22] and the perceived value[23] models. These models are often based on market data but can be constructed based on management and sales-force opinions.

9.4.4.2.2. Competitive Model

Competitive models focus on the behavior of the competitors against each other. Competitive models are estimates of actions taken given sets of stimuli. For example, a competitor may react with a severe price reduction if his share drops below some critical level.

9.4.4.2.3. Operational or Costing Model

Operational models relate costs to product and business characteristics. Typically, these models capture changes in quality and costs against expenditures and volume. Often for industrial products operational models can be substituted for market models as a value-in-use estimate[24].

9.4.4.2.4. Proforma or Financial Model

"Following the Money"! Business models can be based on a financial structure or "Proforma" table, which describes the overall economics of the business enterprise. An overall model may consist of a number of Proforma tables for each competitor in each of the principal market segments. Each table is a cash balance indicating sources and uses of funds. However, the balance and extent of the expenditure reflect the business strategies. The Proforma table itself is a forecast of future cash flow starting with overall forecasts of sales by segment. Typically the elements of the Proforma include in descending order: (1) overall sales forecast for the industry by segment, (2) market share for this competitor, (3) average product prices, (4) manufacturing costs, (5) marketing costs (including sales force, advertising and promotion), (6) depreciation (which is linked to the permanent investment), (7) working capital charges (linked to estimates of inventories and cash requirements), (8) tied R&D costs (including new product and process development), (9) fixed charges including rent, (10) corporate burden costs (including all other charges and administration), (11) tax charges. From the Proforma table accrued earnings and cash flow can be computed for a given segment (or product line) by competitor for a given year.

---

[22] See the chapter on Pricing for more details

[23] See the chapter on Perceived Value for more details.

[24] Details of value-in-use concept and computation can be found in the chapter on Value.

Typically the Proforma tables are set up as dynamic programs starting with a long term segment forecast. Shares are determined by market models that are based on previous and expected current competitive product quality and price. Competitive reactions are introduced through competitive models, and new capacity estimated based on global reinvestment models.

The classic use of this type of business model was developed by the Federal Group and focused on industry new capacity decisions within the worldwide chemical industries. Models estimating the locations and timing of new capacity were built for titanium dioxide, hydrogen peroxide and others.

9.4.4.3. States of Being

Dynamic models tend to forecast situations that have certain standard characteristics that define business behavior. Understanding the nature of these states helps both in the construction of models and the interpretation of their results.

9.4.4.3.1. Stable Behavior

The simplest behavior of a dynamic model is gradual growth or decline. It is easy to visualize and understandable this dynamic behavior based on underlying driving characteristics.

9.4.4.3.2. Oscillation

Oscillation is an alternative state where shares, prices and capacity may cycle. While this would appear to be counter intuitive, it is a characteristic of commodity industries with large economies of scale. The "world-class scaled" plant is often significantly larger than the present generation. When all competitors enter into the construction of such plants, there is often an over-capacity with a fight for share and a corresponding decline in earnings and new construction. After the excess capacity has been used, prices rise sharply along with earnings leading to the apparent need for new capacity and the cycle repeats.

9.4.4.3.3. Chaos

There is a third state, and thankfully one that I have not seen in a business model, chaotic behavior. The chaotic state is one where prediction is not meaningful even though the model is deterministic. Any small variation will produce unpredictable results. The existence of possible chaotic states is a result of using a finite difference formulation for the business model. While it has not be widely seen in most commercial data, it is a characteristic of financial markets.

9.4.4.3.4. Equilibrium

Equilibrium is the "ergotic" concept that dynamics, if left alone will eventually disappear and the market will go to some steady state condition. The concept of "Equilibrium" is

used both as a test of ultimate stability and working backwards as constraints on the dynamic model. In a backward form, an underlying Equilibrium concept can be used to stabilize an overly reactive model. Some models predict strong oscillations or chaotic behavior that is actually unexpected in the market place. Rarely will competitors radically increase and then decrease prices.

9.4.5. RISK ANALYSIS

All models are "built on the quick-sand of their own assumptions." All models are, therefore, uncertain. A major goal of business modeling and decision support is to capture the nature and extent of these uncertainties. The goal of business and commercial risk analysis is to capture that uncertainty and translate it into measures of likelihood and financial exposure. It has been asserted that the modeling tools for capturing this risk should follow the nature of the uncertainty[25]. Clearly the nature of the modeling process with the assumptions characterizing underlying mechanisms is critically important in structuring the problem. However, we have found that the expectations of the decision-makers who will use the results are even more important.

9.4.5.1. Scenarios

The simplest, most frequently used and traditional risk capturing method is by use of scenarios. In practice a small number of scenarios are selected and analyzed. In the most straightforward mode, high, medium, and low estimates are generated which may be labeled as "optimistic", "expected", and "pessimist" or as "upside, expected or downside potential," or alternatively given a numerical value of 25%, 50%, and 75% likely. However, these scenario results rarely represent probability estimates. They are mainly useful to bound the range of returns that are expected. Unfortunately, rarely do these estimates capture the true exposure of the organization.

From a structural perspective, this approach is usually preferred when the major uncertain issues can be associated with a few key events or assumptions. When that is a reasonable representation of the risk, scenarios are not only easily understood by decision-makers, they are good representations of the totality of the risk environment.

9.4.5.2. Sensitivity Analysis

Less used to capture business risk is sensitivity analysis, which estimates the impact of various assumptions on earnings[26]. Unfortunately, sensitivity analysis is usually considered a tool for analysts rather than decision-makers[27].

---

[25] Hugh Courtney of McKinsey & Company, Business Strategies in Uncertain Times, Presentation to Villanova University (February 22, 2002)

[26] Sensitivity analysis can be done with stochastic models to estimate the impact of strategic variables based on subjective probabilities.

9.4.5.3. Stochastic Modeling

Stochastic or probabilistic modeling captures risk by estimating the probability distribution of potential outcomes of the model. These are based on likelihood estimates around parameters and events used in the model. This is a classic tool of risk analysis in that estimates of likelihood of obtaining returns are generated.

9.4.5.3.1. Subjective Probabilities

All stochastic models rest on estimates of the likelihood of events taking place or parameters being at specific levels. Unfortunately, in the vast majority of cases, these estimates are made of events and conditions that have never existed[28]. There is, therefore, little basis for these estimates. This is a fundamental dilemma of using subjective probabilities[29]. In fact the examination of subjective probability estimates and actual occurrences suggest that the subjective probability estimates tend to measure confidence rather than occurrence. Subjective probability estimates above 90% tend to be too low, while estimates below 10% tend to be too high. Furthermore, these errors tend to be systematic and consistent. Techniques to reduce this problem include:

- Break-up or consolidate events and parameters to keep all probability estimates between 10 and 90%;

- Use visual and decision making aids rather than abstract likelihood estimates; and

- Where feasible, use historical data to test and calibrate subjective estimates.

9.4.5.3.2. Discrete (Decision) Trees

Many decision processes[30] and business situations can be modeled as sequence of uncertain discrete steps[31]. The overall result is either an estimate of the "expected" outcome or the selection of the optimum path. The underlying assumption is that the parameters in the model enter discretely, as single events with single valued parameters. Furthermore, it is difficult in this formulation to allow significant interaction among the parameters and estimates of likelihood. For the most part, the events are considered to be

---

[27] The "Envelop of Opportunity Analysis" uses stochastic, Monte Carlo, analysis to estimate the expected impact of potential events on earnings and sales.

[28] Irv Gross (formerly of Dupont and Penn State University) has argued that this is a fatal flaw of risk analysis and recommends only using Game Theoretic approaches.

[29] A deeper discussion of subjective probability (and on a supportive note) can be found in Peter C. Fishburn, Decision and Value Theory (1964).

[30] The Analytical Hierarchy Process is a general method of structuring decisions in this manner, see Thomas L. Saaty, *Decision making for Leaders* (1982).

[31] Detail description of the process can be found in Howard Raiffa, Decision Analysis, Introductory lectures on Choices under Uncertainty (1968).

"independent." [32]   It should be noted that since only discrete values are used in this analysis procedure, mathematically exact results are obtained.

9.4.5.3.3. Monte Carlo (Continuous Variables)

Monte Carlo analysis or simulation is the most general type of risk estimation procedure. It allows continuous distributed parameters, discrete events, and interdependencies in the model. Monte Carlo simulation involves estimating the distribution of the results from a large number of scenarios whose parameters and the existence of events are randomly selected from prior probability distributions.   These are very general, brute force, procedures. Previously, due to limited computer capabilities, only major problems were tackled using this procedure.   However, with the advent of high speed personal computer[33] systems, Monte Carlo, due to its simplicity in model development, has become the technique of choice. Unlike the discrete tree approach, Monte Carlo analysis only generates estimates of the final results.

9.4.5.4. Undefined "Risk" (Game Theoretic Analysis)

But, what if we can not define the probabilities of events? As noted earlier, there are inherent problems with subjective probability estimates of events that have never previously occurred. What we have is a number of possible scenarios without estimates of their likelihood. Some of these scenarios may result in the death of the firm while others reflect great riches.   Each of these represents results and actions based on decisions. This is a "Game Theoretic Structure"[34]. From a business decision support perspective, game theory provides a number of potential strategies targeted at obtaining acceptable results irrespective of the distribution of events.

9.4.5.4.1. Min-Max/Max-Min

Min-Max and *Max-Min* criteria are strategies designed to reduce the damage from a poor decision. *Min-Max* refers to the desire to *Minimize the Maximum Loss*. Choosing this rule will result in a reduction of risk of disaster. A theoretical result of game theory is that this criterion is equivalent to *Maximize the Minimum Gain* under wide range of assumptions. So if you try to minimize the maximum loss you will also maximize the minimum gain. This can be thought of as "low shooting". We are aiming at a point which should not kill us and will provide satisfactory gains if they are obtainable. *Min-Max* solutions are, therefore, useful with project screening since it highlights the minimum obtainable gain while constraining losses.   However, it also is highly conservative that could strategically be fatal.

---

[32] The ability to make the parameters independent is a key measure of the quality of structuring this type of problem.

[33] The present high end personal computer has speed and memory equivalent of super computers a couple of decade ago.

[34] For a mathematical treatises on Game Theory see Guillermo Owen, Game Theory (1968)

9.4.5.4.2. Minimum Regret

An alternative is to try to minimize the alternative result. This is referred to as *Minimum Regret*. The concept is that we make a choice such that the minimum return from alternative worse case possibilities is acceptable. Minimum Regret is less conservative than Min-Max in that the potential size of the gain is considered. It is also more acceptable by management since it implies greater faith in the outcome of the decision. An application of Minimum Regret was developed with the pricing models to select a price that would be yield satisfactory results irrespective of two competitive pricing scenarios.

9.4.6. OPTIMIZATION

Optimizing strategic issues are a key objective for decision support systems. This includes pricing, attribute selection, distribution locations, advertising and promotional materials and others. Unfortunately, models and the resulting decision support systems always contain uncertainties, imprecision, inaccuracies and errors. This makes estimates of true optima likewise in error. Furthermore, models are limited in their scope. Even if optimum solutions were accurate, they would only be valid within the limited scope of the models. In general, the objective for estimating optimum conditions is to identify an acceptable range rather than the specific points. Depending on the nature of the problem there are a number of techniques used to identify the optimum solutions.

9.4.6.1. Nature of Optima

The nature of optimum solutions depends on what: (1) we choose to optimize, (2) we keep constant and (3) what further assumptions are imposed on the model. All optimizations focus on the objective or goal that we select to optimize. In most cases, we normally choose earnings.

9.4.6.1.1. Global and Sub-Optima and the Nature of Constraints

The idea of a global optimum reflects the existence of some unconstrained best solution. While the concept is interesting, it is rarely achieved. Normally there are constraints that limit the range of solutions. These constrained solutions are referred among mathematicians as "sub-optima." They represent the optimum on a set of constraints. Almost all optimization using practical decision support systems should be consider sub-optimum in that all models have some types of constraints. Often unconstrained optima are outside of the range for which any data exist and reflect the "illogical" extension of the model beyond its scope. Because there is any number of constraints there may be any number of possible optimum solutions. It is useful to view these optimum solutions to be a range of alternative "best" solutions.

9.4.6.1.2. Single Variable Optimum

The simplest optimization focuses on only one varying parameter. This is the typical situation with pricing of a single product. Alternatively, it is used for product or

advertising design with independent features. In this case, the total design is handled as a sequence of single variable optima. While numerical search routines can be used, it is often easier to visualize the optimum using graphs[35].

9.4.6.1.3. Joint Optimum

Joint optimum involves optimizing a number of variables against some collective objective function. Joint price optimization is a classic example of this problem where the decision maker wishes to optimize the earnings from a number of products being offered into the same market.

9.4.6.1.4. Linked Optimum

Linked optimization involves assumed relationships between controlled variables. For example we might seek a joint price optimization but where one product must be priced below another or alternatively where a product must be priced the same in multiple forms and yet we need to optimize constituents.

9.4.6.1.5. Stochastic Optimization (Optimum Control Theory)

Stochastic optimization focuses on maximizing the likelihood of meeting some goal rather than maximizing the goal itself. This is an extension of the general Optimum Control Theory where it is desired to minimize or maximize some functional path or route rather than the end point[36].

9.4.6.2. Methods of Seeking Optima

Procedures to seek optimum solutions have a long and deep mathematical history. In this section we will only review the general techniques as it applies to selection of the tools to be used.

9.4.6.2.1. Constrained Mathematical Programming

The key distinction between optimization methods lay in the importance of constraints. If the optimum is tightly constrained in such a way that the optimum solution will exist only at the constraints, the problem is referred to as one of mathematical programming. With a very large number of constraints and variables, these types of problems can be a "bear" to solve but methods readily exist provided a simple form of objectives. If the objectives and constraints are linear (straight-line additive expressions) it is referred to as Linear Programming for which tools exist to solve even huge problems. If the constraints are linear but the objective is quadratic, the techniques are referred to as Quadratic Programming and once again a number of algorithms exist. Finally, if several objective functions are involved, the procedures are referred to as Goal Programming and Multi-

---

[35] This is discussed in the section with *Applications using Excel*

[36] This is discussed in the section with *Applications of Excel.*

<u>Criteria Decision Making</u>. While techniques also exist here, there are far less well defined.

9.4.6.2.2. "Unconstrained" Numeric Optimum

If solutions are expected to exist away from the constraints, the procedures are referred to as search methods for which there are a large number. For many of our applications we use the **Solver** facility in *Microsoft Excel* to seek out the solution. It should be noted that these techniques will allow solutions to be at the constraints. However, the constraints are imposed rather than built into the search process. This greatly limits the size of the problem that can be handled. A major problem with this type of optimization is that the seeking procedures are "continuous" starting from a specific point. If multiple local solutions exist, it is possible that the optimum solution generated will not be the absolute "best." This is usually not a problem with mathematical programming where the absolute optimum is assured by the linear nature of the constraints.

9.4.6.2.3. Brute Force

The structurally simplest method, but most time consuming, is using random sampling to seek out the solution. This is usually best done with a relatively small number of possible solutions. This allows all possible solutions to be generated. An example of this approach is seeking a solution with modified conjoint perceived value data. For advertising copy development the feature values and interaction of statements are measured. There may be several thousand possibilities but they can be computed. The advantage of Brute Force optimization is the identification of multiple equally valued solutions rather than a single optimum.

9.4.6.2.4. Analytical Procedures

The most elegant approach to optimization is to provide an analytical (mathematical) expression for the optimum. This involves manipulating the equations describing the model in such a way to obtain the highest value of the objective function[37].

9.5. <u>FORMULATING MODELS</u>

Business models in general and market models in particular are usually formulated based on some type of survey information. This can be piece-wise produced, where the information may or may not be complete on the respondent basis. With complete data all relevant modeling information is available for each respondent.

---

[37] This is analytically the point defined by $\partial \textbf{Objective}/\partial \textbf{X} = \textbf{0}$ and where $\partial^2 \textbf{Objective} / \partial \textbf{X}^2 < \textbf{0}$ is a maximum and $\partial^2 \textbf{Objective} / \partial \textbf{X}^2 > \textbf{0}$ is a minimum and where **Objective** is the objective or goal function and **X** is the optimizing variable..

9.5.1. AGENCY MODELS

In agency models we assume that the respondent data represents the total relevant population and thereby we can assume that the aggregation of that information represents the total market. Each of the respondents in this case is thought to be agents representing a similar group of respondents. The market representation is then the aggregation of individual respondent level models. This is the basic marketing research report approach to the market[38]. Distributions and optimizations are computed directly from the respondent level information. Because these models are based on the actual collected data, segmentation analysis and back-tracking for influences can be efficiently and flexibly done. Agency models also have face validity; that is they clearly are derived from market information.

9.5.2. WEIGHTED MODELS

However, sometimes it is necessary with agency models to correct for imbalanced or stratified samples. That is the sample of respondents does not agree with the characteristics of the relevant population. For example, we might have obtained data for a market model with equal numbers of existing customers and non-customers. However, we want a model that describes the total market behavior. As such, we would have to weigh the results using the market share information. Similarly, in consumer market modeling, the underlying survey data may not be balanced by demographics and as such, some type of weighting may need to be applied. Weighing of data produces any number of problems including reduced effective sample size and bias in the segment analysis.

9.5.3. STRUCTURAL MODELS

Market and business models can also be constructed from "first principles" where the distributions of variables and their interdependencies are estimated separately. This is a requirement where complete respondent level data is not available. This may be due to the way the survey data is gathered or from the non-availability of some information from survey sources. These are thought of as fundamental or structural models since they represent the way that the market, industries or business are actually formed. Note, however, that they require explicit assumptions regarding relationships and projections. Relationships and values of agency and weighted models, on the other hand are derived directly from the data. Not so with structural models, they are fundamental assumptions of the models. On the other hand, structural models can include elements that are not well suited by the agency approach. For example, rare events with very low occurrences are usually either excluded or poorly described by agency models since they usually are not included in the collected data.

Structural models are typically "smooth" and continuous while agency and weighted models tend to be discrete. This allows for more efficient optimization, projection, risk analyses using structural forms rather than using agency model. However, they also tend

---

[38] Here the basic error in the analysis is thought to be sampling precision or statistical confidence.

to be more theoretical and therefore, have lower face validity.

Any of these approaches can be used and are often in combination, where particular parts are handled as agency models and other as structural. There are also hybrid forms. For example, split or fragmented sample techniques such as Choice Based Conjoint and Max-Diff measures of perceived feature value, use structural formulations to generate individual respondent utilities which then used in agency models.

9.6. BUILDING DECISION SUPPORT SYSTEMS IN *EXCEL*

The purpose of this section is to discuss methods of developing decision support systems in *Microsoft Excel*. It is assumed that the reader is familiar with *Excel* and can perform routine tasks using the program. General introductory and intermediate level tutorials are widely available covering the use of *Excel* for general business applications. This section will focus on mainly "advanced" methods useful in developing engaging strategic decision support systems that compel action by management.

It is useful to divide management data analysis into two types of activities: (1) ad hoc analysis and (2) formal decision support systems. Ad hoc analysis satisfies the need of management to examine data in multiple ways and to obtain insight into the business function. This is sometimes referred to as Executive Information Systems (EIS) even though business executives rarely use them. Many of the database management programs (i.e. *Microsoft Access* and *Information Builders' Focus*) as well as statistical packages (i.e. *SAS*) have extensive facilities for this type of ad hoc analysis. The objective for this analysis is to view data in a multitude of perspectives to reveal inherent structures and to locate problem areas. *Excel* can be used for similar analysis, but can not handle the general corporate data structures that are often necessary.

Formal decision support systems are designed to assist in the pursuit of specific questions. While the scope of these systems is, by nature, limited compared to a free ad hoc exploration of data, they provide a means of inclusion of additional sources of information. Some of those sources of information typically involve management judgment. It is useful if not necessary to have senior management involved in their use. The trick is to get senior management, who still may be "computer-phoebes," to participate in the use of these tools.

Effective decision support systems that are engaging and compel action should:

- Predict results for a broad range of conditions -- The value of decision support systems are their ability to capture uncertainty regarding key factors in the decision. The broader the range of meaningful factors that can be captured, the more effective the model and the decision support system.

- Produce rapid results -- Users are impatient. Previously, this has limited the use of decision support to relatively simple models when using personal computers. However, with the huge increase in computational power of the modern PC, this is no longer the case.

- Provide multiple dynamic graphic displays -- Users come with different preferences and orientations. For a decision support system to be effective, the output results must be in a form understandable by the users and managers. This means that it is often necessary to have the results in several forms most of which should be graphical.

- Have a familiar look and feel -- Managers do not want to learn new systems and programs for each decision support system. While it may be useful to the vendor to provide proprietary systems, it rarely is to the users. The more similar the system looks to the user; the less resistance can be expected against its use.

- Be relatively simple and inexpensive to produce and modify -- Decision support systems are generally developed iteratively. Most need to be modified to satisfy organization and personal needs of the decision-makers. While it is desirable to incorporate as many options as is anticipated, some changes are almost always needed. For systems to be widely used, the cost and time for building and modifying must be small compared to the potential value and time horizon of the decision.

- Require only ubiquitously available software -- The user should not need to buy new software. Often there are a number of users, some of which the developer does not even know. For effective use, it is necessary; therefore, that all of the software needed to run the decision support system should be widely available if not ubiquitous.

- Reveal all computations and assumptions -- Secrecy leads to mistrust. It is important that the logic of the decision support model be accessible to both the user and other analysts. While black boxes may give the developer a perceived proprietary position, it can only alienate the user.

9.6.1. WHY *EXCEL*?

Clearly, *Microsoft Excel* is ubiquitous; it is everywhere. It is on all desktops and, to some extent, most managers have at least introductory familiarity with it. These characteristics by themselves are not sufficient for its use in developing decision support systems. However, within its limitations, *Excel* appears to meet most of the criteria for developing these systems. In our experience, it allows for an effective development tool.

Excel's major weaknesses are (1) inherent inefficiency and (2) missing functionality. Spreadsheets, by their nature, are inefficient compared to compiled program written in procedural languages (*QuickBasic*, *Fortran*, *C* or even *Visual Basic*). The newer versions of *Excel* are far more computationally and memory efficient than their predecessors. They are still less efficient than conventional programming. However, with high-speed personal computers with large random access memories[39], these limitations are usually minor.

There are a number of capabilities that would improve the functionality of *Excel* for decision support applications. However, most of these are not critical for business

---

[39]   The present generation of personal computers is more than a thousand times quicker and has over a thousand times the memory of comparable machines 15 years ago.

management applications[40], or can be handled with programming and the use Add-in program or by precalculations with other packages. We expect over time, most of these capabilities will be added into *Excel*.

9.6.2. ADD-INS

"Add-in" programs are available to add functionality to *Excel*.   These programs work within *Excel* and focus on specific applications. Add-ins exist for statistical analysis[41] that expands the inherent capabilities of *Excel*, to assist in risk analysis[42], decision modeling[43] and project management[44]. While these add-in programs can be useful for analysts, they are not ubiquitous and require training to use effectively. As such, we have been reluctant to use them as part of management decision support systems. For the most part, we have found them unnecessary.

9.6.3. TO PROGRAM OR NOT TO PROGRAM

Programming capabilities in spreadsheet programs such as *Microsoft Excel* is referred to as "macros." In the case of *Microsoft Excel*, is capability is very extensive. Not only does macro capabilities allow access to all of the functions within *Excel,* it allows for most of the functionality of the *Visual Basic* language. Furthermore with the use of external links within the Macro language, these programs can use any procedural language[45]subroutines.   However, macros hide computation. As such, we have avoided using them.   Only rarely have they been needed mainly for control or to add functionality.

There are certain capabilities in *Excel*, which are difficult to use on an automated spreadsheet. These included the Solver function for optimization and multiple output spreadsheets. In order use these functions, **Macro Buttons** sometimes are needed. This requires the use of a Macro routine and is unavoidable. Similarly, it is sometimes

---

[40]   These include the inability to do: (1) factor analysis (matrix decomposition), (2) optimization by functions, (3) arrow diagrams, and (4) additional distributions.

[41] Statistical Add-in's include *XLSTAT*, *Analyze-It*, and *WinSTAT*

[42] Risk analysis Add-in's are mainly designed to do Monte Carlo calculations and include *@Risk* and *RiskSim*

[43] Add-in's for Decision analysis mainly focuses on structuring models and sensitivity analysis and include *TreePlan* and *SensIt*

[44] *KickStart* is a project management *Excel* Add-in.

[45] *Excel* allows most executable codes to be run within its macros irrespective of the language used to produce them.

convenient to produce new functions that are to be called by the spreadsheet. These can be written as Macro routines and attached to the spreadsheet[46].

9.6.4. AD HOC ANALYSIS TOOLS

The process of building decision support systems normally starts with the identification of the problem and the analysis of available information. In many cases, data has to be obtained from secondary and primary sources. Most of the models that are discussed here rely on marketing research data or sales-force estimates of that information. Typically this data needs to be heavily analyzed using statistical and data base tools. Some of these tools are readily available in *Excel*. We have found it useful to do as much analysis as feasible in *Excel* to allow for easy transfer into the decision support spreadsheets.

9.6.4.1. Limitations of Spreadsheets

Spreadsheets by their nature are based on "flat files." The data in spreadsheets is layered out as a series of untied tables. This is inherent to all spreadsheet operations. While these tables may be interrelated, they do not represent any form of inheritance or hierarchy. This limits the use of *Excel* for ad hoc analysis. However, most business data as well as almost all marketing research data are available as "flat files." Typically, only internal data from the corporate "enterprise data model" is available in the form of complex data structures that require database management packages.

There are several useful sets of tools in *Excel* that facilitates compilation and analysis of data for the preparation of decision support systems. While the uses of these tools are well documented in *Excel* or in published texts, their function tends to be obscure.

9.6.4.2. Data Extractions (Filters)

Often it is useful to extract from a table of data the largest or smallest values. The Filter capability allows for the extraction of records by a cascade of criteria. This capability is obtained from the Menu under Data/Filter. There are two options: (1) AutoFilter selects items based on the fraction of largest values and (2) Advanced that allows for the use of user specified criteria. We will discuss the format of specifying criteria later in this section under data functions. As with other *Excel* functions, the range of data needs first to be selected. Details on the function can be found in the Help function under Filters.

9.6.4.3. Data Tabulation (Pivot Tables)

Some classification variables are discrete and take on only integer value or a name. It is often useful to examine groups of data under these classifications. For example, sales

---

[46] In all cases, we have attached the macro routine to each specific spreadsheet where it is used. Care must be taken when Macros are used to assure that copies are attached to the spreadsheet decision support model.
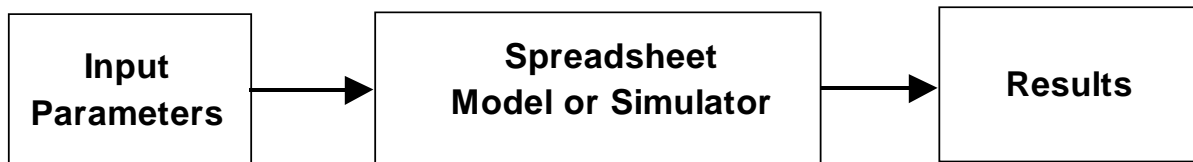
data may be classified by product and region. Before developing the decision support system, it is often useful to examine the model parameters such as sales, or returns by these classifiers. *Excel* provides a means to do this through what is referred to as "Pivot Tables."[47] These are usually two-way[47] tables showing some summary statistic[48] of the group of cells in each category. The Pivot Tables is a standard provided Add-in capability that is activated under the Menu as Data/Pivot Table Reporter.

9.6.4.4. Statistical Analysis (**Analysis Tools**)

Many of the most effective decision support systems rely on statistical or regression models that forecast market or industry behavior based on individual buyer data. These models may be produced outside of the decision support spreadsheet. *Excel* provides a simple to use statistical routines as the Analysis Tools option. This is an Add-in package provided with *Excel* but may or may not have been loaded on installation. Instructions on installing it are available through the Help function. Along with multilinear regression, are various widely used statistical analyses and tests[49].

9.6.5. DECISION SUPPORT TOOLS

As previously mentioned, our objective is to produce an engaging decision support tool that compels action. This requires the spreadsheet system to be dynamic, attractive, and flexible. *Excel* provides a range of tools to allow these capabilities. The following are the description of those tools. We will start with the functional tools. Decision support systems are heuristic in that they translate the users inputted guesses into corresponding estimates of results. The functional tools are used to build the models, compute the changes, and display the results.

```
┌──────────────┐        ┌────────────────────┐        ┌──────────────┐
│    Input     │───────▶│     Spreadsheet    │───────▶│   Results    │
│  Parameters  │        │ Model or Simulator │        │              │
└──────────────┘        └────────────────────┘        └──────────────┘
```

---

[47] Actually, several dimensions can be created using Pivot Tables. This is done by either expanding the sub-divisions of variables or using multiple spreadsheets within a workbook. However, two dimensions is usually preferred for analysis purposes.

[48] *Excel* provides a broad range of summary statistics including count, average, and median. Further, Pivot Tables allows computation of row and column percent as well as comparison with other data fields.

[49] We have found computing Correlation, Regression, and various statistical tests of agreement to be extremely useful, both in designing appropriate marketing research and in preparing data for decision support uses.

9.6.5.1. Computing Results

Excel contains a number of tools that facilitate computation of results. These include special functions, tables, and internal add-in programs.

9.6.5.1.1. Array and Matrix Functions

Even introductory users of *Excel* are usually familiar with the array functions such as **AVERAGE( )**, **COUNT( )** or **SUM( ).** These compute a function of a range of values. However, there are a fairly large number of these that allow rather complex computation in a single cell formula. For example, **SUMPRODUCT( )** allow for the summation of products of two or more arrays while **SUMSQ( )** produces the sum of the square values of the arrays.

In addition to these array functions there a number of matrix functions, which operate on a table of values. These include:

MMULTI( )	Matrix or cross product between to matrices with the same number of rows of one matrix equal to the column of the other.
MINVERSE( )	Inverse of a square matrix.
MDETERM( )	Determinate of a square matrix
TRANSPOSE( )	Transpose of a table or matrix

These functions are particularly powerful methods to compute regression value or to manipulate linear models with new data. These allow single step recomputation of models. The trick in using all matrix and some array functions is to start by selected the appropriate range function and depress the Clrt (control) key with the Enter key when executing it. It should be noted, however, that the matrix functions are limited in size to approximately 52 columns maximum[50].

9.6.5.1.2. Combining Functions

In *Excel,* functions can be used in combination. Simple example would be to compute the geometric mean of a series using a logarithm function: **EXP(AVERAGE(LN(....))).** While this is a complicated way to compute the geometric mean since a function exists to do it **GEOMEAN( ),** it does illustrate how complex operations can be done in a single action. Matrix functions can also be cascaded in this manner. For example, the regression parameters of a linear model can be computed from the "dependent" array of values, Y, and the design matrix (independent variables), X, as:

---

[50] This is true for *Excel97*. Later version may have extended this range.

MMULT(MMULT(MINVERSE(MMULT(TRANSPOSE(X),X)),TRANSPOSE(X)),Y)

While this is a fairly complex computation, it is far simpler than doing the sub-calculations.

9.6.5.1.3. Segmenting Data

Often is desired to look at different groups of respondents in forming market models and simulators. This requires computing statistics based on partial results. *Excel* has a number of "database" functions[51] that allow for computation of statistics for groups of records selected based on some criteria. The format of these functions look-like:

DFunction(Table Location, Column Number, Criteria Location**)**

The first parameter of the function is the table or matrix location or name. This should include a top row containing the column or field names. The next function parameter is the column of data that the function will be applied to and finally the location of the criteria.

DAVERAGE( ) Average of the column data meeting the criteria.

DSUM( ) Sum of the column data meeting the criteria.

DCOUNT( ) The number of entries in the column data that meet the criteria.

DVAR( ) Variance of the column data meeting the criteria.

9.6.5.1.4. Criteria

The criteria are given as a set of spreadsheet cells whose top cells contain the key column names in the database. The cells beneath those titles specify the limits in the selection of data. Any number of criteria elements and fields can be used. For alphanumeric fields the items to be selected need to be listed as in the following example.

Type
A
B

where "Type" is the name of the field and "A" and "B" are the selection values used to select the records or rows. All items with either an "A" or "B" entered in column titled

---

[51] The database functions were developed for Lotus 1-2-3 and carry with them the unusual syntax of the criteria cells.

"Type" will then be selected. Single criterion can also be used. If a blank is placed under this criterion, all rows in the table will be selected for this criterion.

Numerical criteria allow the use of greater than, equal and less than notation. For example:

Location
>=3
<1

These criteria would select items whose "Location" values were less than or equal to 3 or less than 1. Similar to the character criteria, if a blank is used in the criteria, all value corresponding to that column title will be included.

Multiple criteria can be used. In these examples, we can use both the Type and Location column criteria together. However, these then act as filters and both must be satisfied.

9.6.5.1.5. Looking Up Functions

As previously noted, *Excel* works exclusively with "Flat Files". A number functions are available that allows looking up values from these tables. This allows, for example, respondent or product data to be held separately and recalled on demand. Furthermore, lookup functions help in recoding data for use with other database function criteria.   We have found the most commonly used function of this type is the vertical lookup, **VLOOKUP( )**[52].   These are array functions are similar to database functions by requiring a table of data and targeted column. The format for this function is:

VLOOKUP(Value, Table Location or Name, Targeted Column**)**

9.6.5.1.6. Using DataTables

Data-tables are probably the most powerful modeling tool in *Excel*.   These tables allow for the systematic display of the results of varying two parameters in the spreadsheet. The facility is used to compute statistics across databases, to seek optimum values in models and to perform risk analyses.

It is somewhat easier to show how data-tables are used than to explain them. Below are two examples of using them for statistical computation from a database. For these cases we consider product ratings from a market survey that will be used to construct a market

---

[52] Occasionally, it is useful to use the **MATCH( )** function. This function returns the relative position of an item in an array. This is particularly useful to convert rank order data to utility values.

model. The data is presented as a table or matrix titled "Data." Note that this table consists of 6 columns and excludes the identification number. All of the data does not have to be specified in the table. The columns are numbered sequentially on the row above the table. The top row of the table contains the name of each column. In this case the names start with a cluster or segment identification followed by the questions as Q(1) through Q(5).

The data-table below is designed to compute the average value for each question by cluster. The right most cells in the top row of the data-table consists of the formula that will be used to compute the table. In this case, it is a database function for computing the average value based on a criterion and a column number. The criterion is shown on the right and consists of a selection by "cluster" and below it is the location of the column number to be used. The rest of the top row consists of the column numbers corresponding to the questions in the data. In the first column of the subsequent rows is the identity of the clusters. Once specified, the data-table facilities will fill-in the corresponding average values by column number and cluster number. It should be noted that text and characters maybe used instead of the numbers for other problems.

The data-table is then specified from the menu as **Data/Table**. The dialogue box requests the assignment of the **Row input cell** and **the Column input cell**. Unfortunately, the assignment is somewhat intuitively backwards. The numbers in the top row, here specifying column number is understood to be the row input, while the data along the first column is the column input[53].

	1	2	3	4	5	6
			Data			
ID	Cluster	Q(1)	Q(2)	Q(3)	Q(4)	Q(5)
201	1	1	5	2	3	4
202	2	2	4	2	2	3
203	3	3	1	5	5	5
204	3	5	4	1	3	4
205	3	2	4	2	3	4
•	•	•	•	•	•	•
•	•	•	•	•	•	•
530	1	3	5	1	3	3
531	1	4	4	3	5	5
532	1	4	3	2	5	5

Criteria	533	2	3	5	Data Table	4	3
Cluster	534	DAVERAGE(Data,Column #, Criteria)			4	2	3

	1	2	3	4	5	6
1	1					
	2					
Column #	3					

---

53 This syntax was inherited from Lotus 1-2-3.

The data-tables in *Excel* are very flexible. Any function including the location of any cell on the spreadsheet can be used. Furthermore, the row and column inputted data can be assigned to any cells on the spreadsheet. The following modification of the previous problem will illustrate the flexibility. Here we want the number of high and low values for the questions. In this case, the criterion column will change with every column of the data- table. This is accomplished by using a vertical lookup function within the criteria. At each column point the criterion is the name of the column variable. In this way, a cross table analysis of the data can be generated. Furthermore, additional criteria can be added that would allow farther distinction by, for example, cluster.

Criteria	Data Table					
VLOOKUP(column #,Titles, 2)	DCOUNT(Data,Column #, Criteria)	2	3	4	5	6
1	<=2					
	>2					

Column #

Titles	
2	Q(1)
3	Q(2)
4	Q(3)
5	Q(4)
6	Q(5)

More examples of the use of data-table will appear when viewing the specific applications.

9.6.5.1.7. Optimization

Excel contains a facility for optimizing results. The Solver facility seeks values of cells that will adjust a target or objective cell value to either an optimum (maximum or minimum) or to be equal to some value while observing a number of constraints. Solver is a provided add-in tool that needs to be loaded into the system similar to the Data Analysis tools mentioned earlier. Solver is a numerical optimization tool in that it computationally searches for the solution to the problem. Solver first requires the identity of an objective cell, which will be adjusted by varying values in other cells. These varying cells are then identified along with any constraints. The constraints may apply to the cells to be varied or to any other cells on the spreadsheet. This allows for optimizing within specific ranges or within bounds such as keeping all appropriate cells non-negative.

Solver is activated from the menu as Tools/Solver.   The Solver Options allow for selection of method of searching for values[54] and for saving new problems and recalling the previously saved problems. This allows for several optimization problems to be prepared before hand for users. Unfortunately, the only way to automatically evoke the Solver with predesigned problems is by using Macro commands. While this is not

---

[54] We have found that the standard default options are usually adequate for most optimization exercises.

difficult, it does not provide the flexibility and the transparency desired for most decision support system applications as previously noted.

9.6.6. USER INPUT

Most decision support systems are heuristic in that the user is expected to make choices or enter data into the system. It is important to note that it is desirable only that the user enters data in selected cells. It is often highly desirable to "Protect" the spreadsheet and limit user access. This is activated by Tools/Protection/Protect Sheet. However, we have avoided using password protection on the sheets. As such, we leave the Password option blank.

With the spreadsheet protected, the user can not modify any of the cells, which have been locked. Cells which will be used for data entry either directly or indirectly (through a form or graph) must be unlocked. Usually, cells in new spreadsheet are locked automatically To change this status the selected cells should be Format/Cell and the Protection tab selected. The Check Box under Lock should then be blanked and the OK button pressed. Please note that if a Form tool is being used, the Cell linked to the tool needs also to be unlocked.

9.6.6.1. Capturing Discrete Choices

Discrete values, in the form of selection of options or methods, may need to be entered. These may effect the range of data to be considered in the model, the design of competing products, the methods of computing results, and the type of output desired.

9.6.6.1.1. Validated Cells

The simplest way of entering data into the spreadsheet is by typing in values to cells. Data/Validation option allows setting the conditions for which the data can be entered. For example, the range of options may be limited to a specific list or to whole numbers within a range. **Input** and **Error Alert Messages** can be custom designed.

9.6.6.1.2. Forms

Selection buttons and menus are standard entry devices on *Window* applications. *Excel* provides a number of "Forms" to create **Check Boxes**, **Option Buttons and List Boxes** (menus) that can be used to select discrete choices. These tools can be viewed using the **Forms Toolbar** from the View option. Examples of these tools are shown below. All of these "Form" tools allow for **Format Control** by selecting the object. The control assigns a location for the output as well as other properties. The **Check Box** is used to simply select or deselect an option. The output Cell Link identifies the action that has been taken by a "False" it the check box has not been selected and "True" if it has. Once identified, these values need to be converted to a criterion value for inclusion in the decison support process.

Option Buttons are the next form shown below. These buttons work together to form a set of mutually exclusive options.   A **Group Box** is put around the buttons to indicate those that form the mutually exclusive group. Once the **Group Box** assigned all of the **Option Buttons** within it will have the same Cell link. The value in this output cell will depend on which **Option Button** is selected.

The last form is the **List Box**, which provides a menu of options to choose from. The **Format Control** provides a **Cell link** for the output and a location for the menu of options, referred to as the Input range.
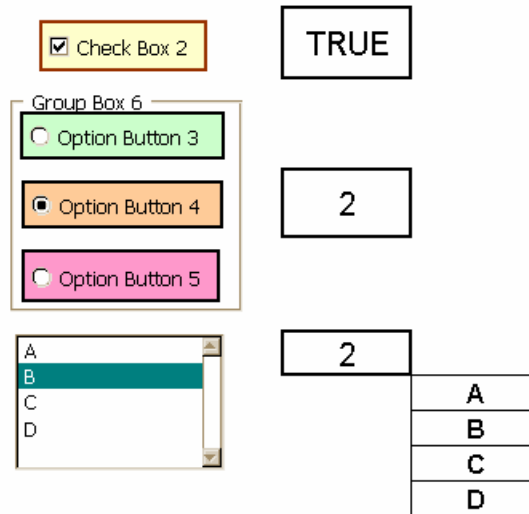
9.6.6.2. Capturing Continuous Values

Many of the more interesting decision support systems require the entry of specific values into the models. These may include competitive prices, costs, goals or expected error ranges. These are continuous variables. *Excel* provides a similar set of techniques to enter these types of data and one exceptional type, graphical.

9.6.6.2.1. Validated Cells

Excel provides a means of cell **Data/Validation** for continuous values as it does for discrete.   Inputted decimal values can be restricted between Minimum and Maximum limits or set to be greater than, less than or equal to a value. Similarly, Input and Error Alert Messages can be selected.

9.6.6.2.2. Scroll Bar

The **Scroll Bar** is to the discrete forms discussed above that allows for continuous values. It is also located on the **Forms Toolbar**. Sliding the slide indicator in either direction changes the corresponding value appearing in the Cell link, identified in the

Format Control option. The Scroll Bars allows the value to jump ranges. The Format Control of this form allows setting ranges and values.

9.6.6.2.3 ◄ ▢ ▶ | 24

Excel allows for continuous values to be inputted by adjustment of charts. This involves moving data points on charts to new positions. The values of these points change to correspond to the new positions. On the example below, the position of the 2002 sales was adjusted up from .8 to 1.0. Notice that the forecast projection also changed. Similarly, any models that depended on that data point would also change.

The data points are moved by selecting the data point in the series. This is sometimes difficult in that the *Excel* normally defaults for the selection of the data series to be formatted. The user often has to insist in the selection of the data point.

Once the point is selected, it can be moved. This works for all types of charts. However, because of this difficulty in using the means of inputting continuous data, it is seldom used. If the data point is computed from another cell, *Excel* will attempt to adjust the connecting cells to produce the desired result.

1998	0.1
1999	0.2
2000	0.35
2001	0.5
2002	**0.8**
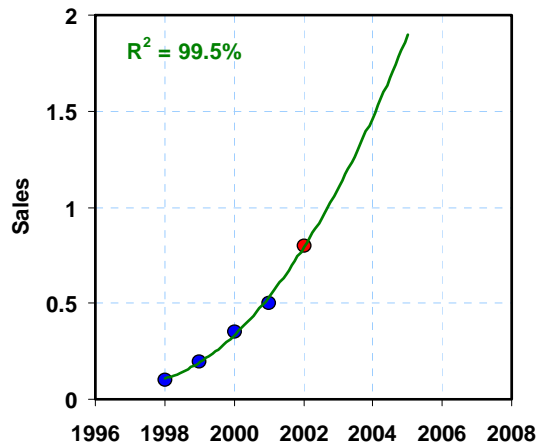
1998	0.1
1999	0.2
2000	0.35
2001	0.5
2002	**1**
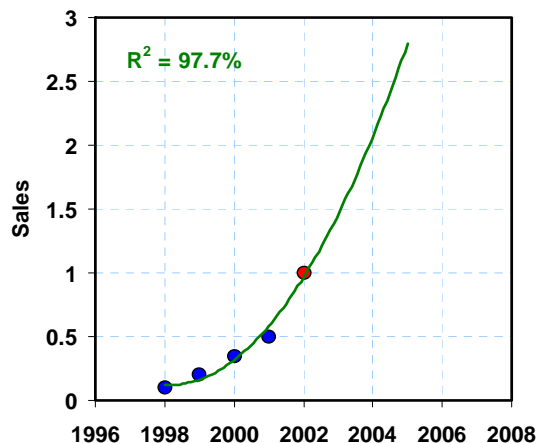
9.6.6.2.4. Selection Criteria

One of the most powerful abilities of Excel based Decision Support systems is to analyze a subset of data. As previously noted there are number of methods to select specific actions. However, in many cases we need to apply a number of possible criteria to select a subset of interest. For example with market models based on respondents we might wish to select those respondents that are already customers and belong to a specific market segment or group. There are two type combining criteria referred to as the "Or" and the "And" condition. For the "And" condition we want all criteria to be met. Note that the example above is a "And" criteria; that is we wanted the two conditions to be met. The form is the "Or" condition where we want any one or more of a set of conditions met. Each of the individual criteria can be selected using of a FORM type tool and then requiring a computed comparison with the data. This forms a table of zero and ones; where the one is a match of each respondent to the criteria.

The trick is then to combine these. For the "And" condition we compute either the PRODUCT or the minimum value, MIN, across the set conditions. For the "Or" condition we compute the maximum value of MAX across the set. Of course these can and are often combined to meet complex criteria.

9.6.7. DYNAMIC RESULTS

The user should be encouraged to change parameters and see their effects. This requires a dynamic response by the spreadsheet to changes in cells. Spreadsheets are specifically designed to facilitate the computation of numerical results in cells based on changes in the values of other cells. Changes in cell values may be interesting but they are neither engaging nor compelling of action. *Excel* provides a number of additional visual aids that can help highlight those changes.

9.6.7.1. Dynamic Charts

Excel has the capability to produce a broad range of two and three dimensional graphs and charts. Later in this section, we will discuss modifying these charts to affect the "look and feel" of the system. These charts are produced from assigned arrays of data. Once the assignment is made, the charts will automatically readjust to changes in values in those arrays producing dynamic graphs[55].

---

[55] It should be noted that the default setting for charts include automatic scaling of axes. This allows changes in values to automatically effect the scale and labeling of these axes. In some cases, fixed scaling is used to produce a more appealing chart. However, this may result in unsatisfactory charts when values are changed.

9.6.7.2. Conditional Cell Formats and Hidden Statements

Recent versions of *Excel* allow for conditional cell formatting that allows cells to change color or font when values of the cells change conditions.   Typically, this is used to highlight extreme values of results. An alternative is to reveal a hidden title under an **If( )** statement that only appears when the output results exceed or fall below some level. Fairly complex results can be highlighted this way.

9.6.8. THE LOOK AND FEEL

The presentation of the spreadsheet provides interface between the model and the user. That presentation can be modified through a host of options within *Excel*.   These are fairly well documented in *Excel* as part of the help facility.   The following items are an overview of what, we have found useful and feasible within *Excel*. There are, however, a number of "tricks" and tools for making modifications in charts, which are of particular interest. These are often overlooked or not widely known or documented. The goal is to produce a decision support system that is engaging to the user, compelling of action, and provides uniqueness that conveys value.

9.6.8.1. Backgrounds and Formats

Changing the format of the spreadsheet is among the easiest and straightforward methods of modifying the look and feel of the decision support tool. Changes in background color, fonts and borders are particularly easy to produce and effective. Unfortunately, I am unaware of producing custom graphic backgrounds in *Excel*. However, the available range is usually sufficient to cover most variations. The only issue is their impact on readability and usefulness. Most spreadsheet systems tend to use a narrow range of background colors and fonts for readability. Varying too far from the standard range produces difficulty for the user. This greatly limits the ability to provide a unique look and feel. This is particularly, the case with input forms. These buttons, slides and menus can not be widely varied in *Excel*.

9.6.8.2. Comments

A simple way of explaining the model is using cell comment embedded in the spreadsheet. These are easy to do using the Insert menu option (Insert/Comment) while on a specific cell. Cells with comments will have a red notice triangle in the upper right corner. The comment appears when the cursor is on the cell.

An alternative approach is using permanent comments. These will appear all the time. These are particularly useful when tutorial spreadsheets are developed to separately describe the workings of the decision support system.
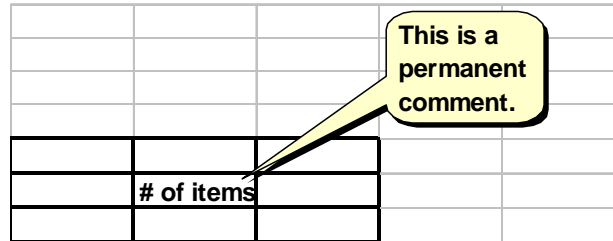
9.6.8.3. Pictures, Sounds and Videos

Pictures such as logos and icons can be added to the spreadsheet. We have found the company logos are very useful to convey client ownership of the decision models[56]. These pictures are inserted using the Insert/Picture options on the menu. *Excel* will accept a fairly large range of picture formats; however, we have found that GIF and JPEG files appear to work well and are reasonably small[57].

In addition to pictures, sounds in the form of narratives or videos can be inserted on the spreadsheet. However, these are much larger files, which may restrict how the system is transferred. It is also necessary to launch these attachments. As such some instruction is needed in the spreadsheet to help the uninitiated user.

9.6.8.4. Modification Charts

As previously mentioned, charts are among the most powerful tools for engaging the user. While *Excel* provides a broad range of options within the standard chart making features, there are some options and tricks that we have found to be particularly useful and not always apparent.

9.6.8.4.1. Log Scales

Logarithmic scales are useful both for modeling and for displaying data covering a wide range of values. These scales are particularly useful for the users who have an engineering or scientific background. They should not be used unless critically necessary, on the other hand, managers without a strong technical background. Logarithmic scales are imposed by formatting the scale. This is done by selecting the axis, selecting the Scale and selecting the Logarithmic option. In order to see the

---

[56] Logos are today readily available in these formats from the company websites or directly from the client.

[57] These are compressed graphic formats, which reduces the size of the file compared to bit maps forms.

logarithmic subdivisions, the "Minor-tick mark type" in the Pattern option needs to be specified (as either Inside, Outside, or Cross).

9.6.8.4.2. Trend Lines

Trendlines can also be added to the chart. These are inserted by selecting the data series and clicking the right button on the mouse. This brings up a number of options including **Add Trendline**. Selecting this option gives a number of possible models including linear, logarithmic, and exponential regression fits. The Options section allows for the inclusion of the regression equation, goodness of fit (R-Square) as well as indicating forecasted values. In should be noted that these trendlines are also dynamic. Changes in the data automatically produce changes in the trendlines and the corresponding equations and goodness of fit.

9.6.8.4.3. 3-D Charts

Excel provides a number of true three dimension charts including the conventional solid and contour maps that convey data on three coordinates. Several of the conventional graphs can also be used to convey three-dimensional information. This is very useful when such information is critical. However, our experience has indicated that this should be avoided if it is not critical to the analysis. Multiple charts are often easier to understand.

Excel also provides "3-D" look to conventional flat charts. These are the notorious 3-D Bar and 3-D Pie charts. Most of the charting tools in *Excel* will generate these effects. We have found that some clients demand it under the impression that they look "professional." Unfortunately, these effects generally distort the charts and can lead to incorrect interpretation of data. This is usually contradictory to the objectives of the decision support system.

9.6.8.4.4. Graphic Modifications

Excel allows for the substitution of standard points and bar with pictures and icons. This allows for a further customization. Below is a **scatter (XY)** plot of hypothetical data with substituted points. The points are substituted by selecting them and then inserting the picture (**Insert/Picture**). In this case, we used some of the standard *Microsoft Clipart*. However, any picture will do as long as it is small enough to be used to specify a point and is large enough to show the indication.
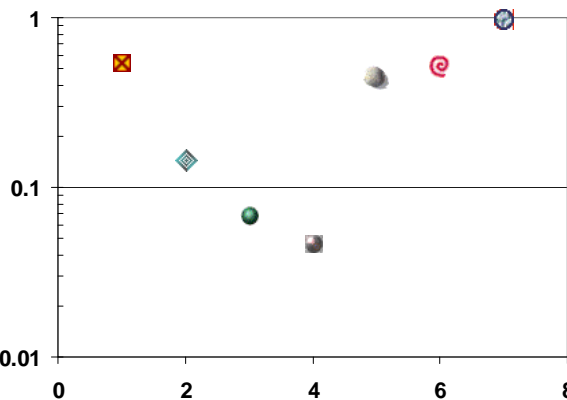
Pictures can also be substituted into bar charts. The figure below shows the substitution of animal icons for the bars. This is done in a similar fashion by selecting the bar and then inserting the icon or picture. *Excel* also allows formatting how the pictures will appear as either staked as shown in the first and third case and stretched in the second. These are edited by selecting the bar to format the data point, selecting Patterns, then pressing the **Fill effects** and selecting the desired option.
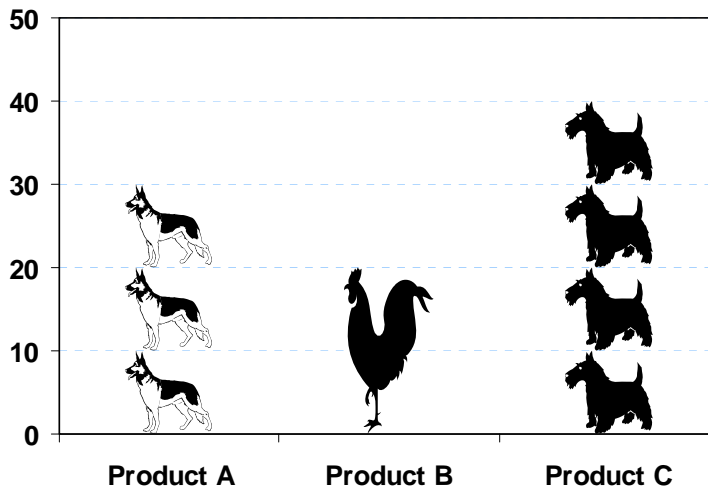
9.6.8.4.5. Merged Charts

Excel allows for charts to be super-imposed. In effect, charts can be over laid. This allows for fairly complex charts to be prepared. It should be noted, however, that this can only be done if the axes will not be rescaled during any subsequent redefinition of the input data. Furthermore, there are some inherent problems, however, in preparing them and it is therefore, not recommended unless necessary.

Below is an example comparing the result of two simulations on a contour map. While *Excel* does not allow for this type of presentation as a single chart, two charts can be combined. All text and as much additional material must be removed from all but one of the charts. The trick is then to super-impose the charts by manually scaling them on top of each other.   This is a difficult and potentially inaccurate process. However, it can produce highly effective charts.
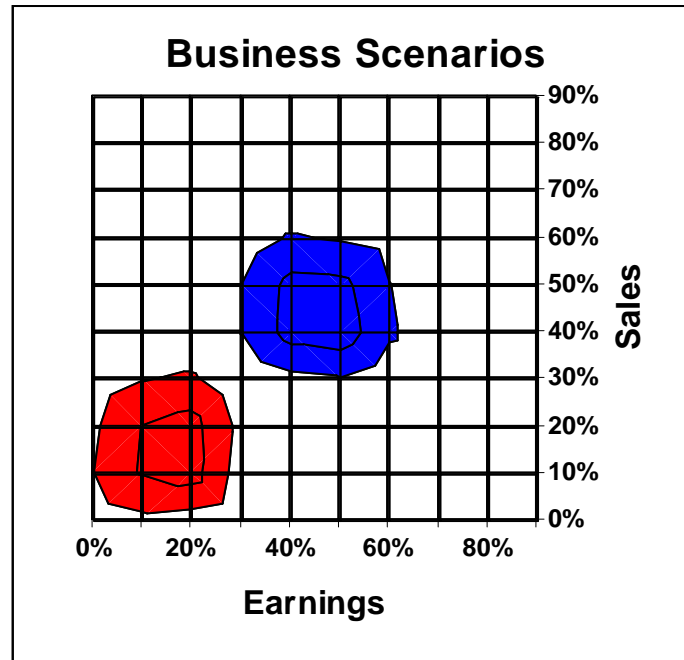
9.6.8.4.6. Data Names[58]

Putting in data names, such as the product names in the following chart, is more difficult in *Excel* than should be expected. There is no native way to doing it using the standard charting tools, even though there was a method to do so in *Lotus 1-2-3* spreadsheet program. However, *Excel* does provide access to the *Lotus 1-2-3* command that will do it. On the other hand, the old *Lotus 1-2-3* commands do not give the full range of options allowed by *Excel*. The trick then is to first use the *Lotus 1-2-3* command to set up the graph and the data names, and then edit the resulting graph using the conventional *Excel* charting tools.

In some forms of *Excel*, the *Lotus 1-2-3* commands are accessible through the Help menu as **Lotus 1-2-3 Help**... Selecting that option will produce the old *Lotus 1-2-3* menu. Choose Graph> and then select the X and identify the data range for the independent variable. Then select A and identify the vertical values. Additional data sets can be selected similarly for data ranges B through F. Select Type> to identify the type of graph. Select XY for scatter diagram.

---

[58] There is an add-in program, *JWalk Charting Tools*, that facilitates direct assignment of dynamic data-names in *Excel* charts. It is preferred approach, if available, since allows for all forms of charts permitted by *Excel*.

We now have to set the options starting with the data names by selecting Options> and then Data-Labels>. Select range A> and identify the range of the data names that correspond to the points. If other ranges of data are being charted, data names for these should also be identified. Quit> after each option. The formats of the point need also be identified. Typically, if the points are only to be identified by names, than neither a symbol nor a line should appear at each point. However, there are other variations of this. To set the formats, select Format> and either the Graph> or a specific range such as A>. As mention above, we typically use Neither symbol nor lines. Finally, you need to Quit> out of this option and then Quit> out of options and Save> the graph by Attach... to the spreadsheet. This results in a graph with the data names located at the charted points. A typical graph would appear in the following form:
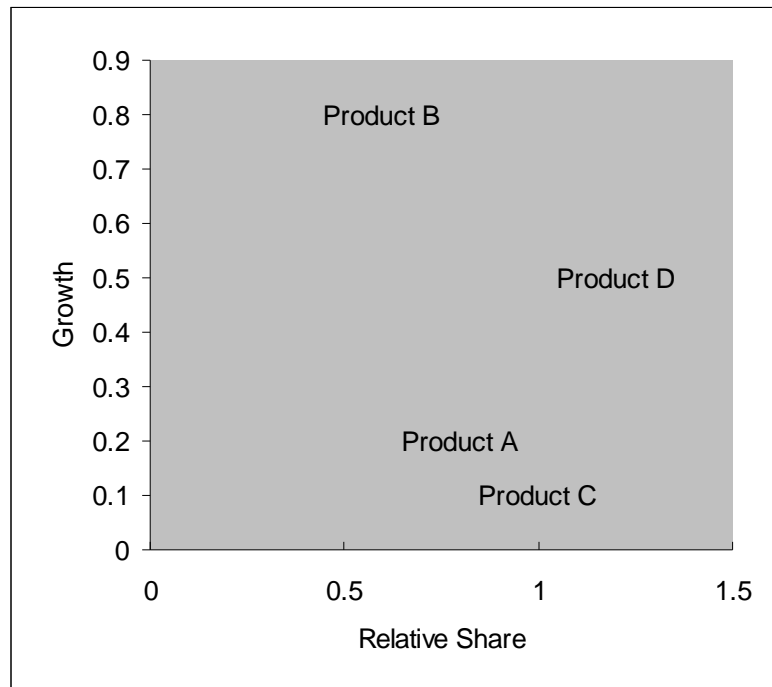
The final graph that we might want would look like the chart below. This is a bubble diagram with the data labels. Most of the editing of the above charts follows standard *Excel* chart formatting procedures to change colors and format the scales. However, there are few additional commands. First is to reposition the data names. *Lotus 1-2-3* automatically puts the names to the right of the point. *Excel* allows realignment of the names as part of the formatting options. This almost always needs to be done. Secondly, the chart type can be changed to any form needed. In this case, we selected using a bubble diagram. However, additional data may be needed and therefore the data ranges need to be changed. Finally, the colors of the bubbles can also be edited. The following chart is an example of the resulting bubble diagram.

Business Modeling and Decision Support Systems   **Page 9-61**
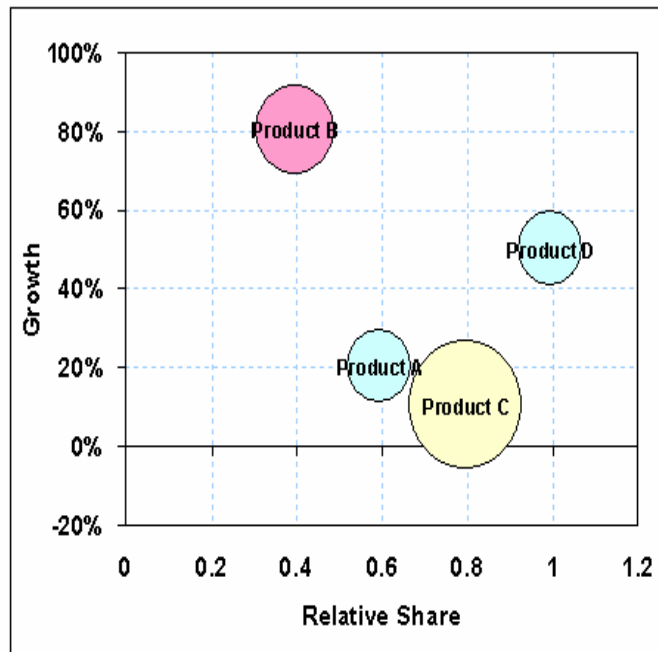
9.7. <u>DECISION SUPPORT APPLICATIONS USING *EXCEL*</u>

The following are examples of decision support applications using *Excel*. The purpose is both to illustrate the uses of the *Excel* tools and to indicate how certain capabilities are implemented in *Excel*. These should not be viewed as the limiting conditions for *Excel* for decision support but only as examples.

9.7.1. COLLABORATIVE PLANNING TOOLS IN *EXCEL*

As previously described, collaborative tools are used to collect opinions from the management team for discussion and decision making purposes. Computer aided tools focus on the compilation and computation processes[59].

9.7.1.1. Positioning

As noted above, the major purpose for positioning planning exercises is to identify the characteristics of key customers and competitors. This is usually done during sessions with the group management team. The trick is to find a simple way of merging the opinions of the group. *Excel* can be used for this function by providing a means of both merging the opinions and provide a visual means of display.

One approach that we have used is to position customers or businesses based on the importance of three criteria: (1) price, (2) product performance, and (3) marketing and service characteristics[60]. For this application, we develop a rating scale for six or nine questions regarding the relative importance of these factors by the customer or segment. Multiple questions are used to expand the scale and to provide a check on the opinions. Often a "halo" effect is observed regarding opinions of customers by the salesforce. By providing a range of questions including negative ones, the "halo" effect is reduced. The chore then is to compile the overall opinions, compute the percent importance and then display the results.

The layout of this decision support system is shown below. In this case, a group meeting was used to estimate the rating on a 0 to 3 scale on six characteristics. The characteristics were then related to the underlying factors of price, brand and product performance.

---

[59] In the chapter on planning methods the procedures of workshops based on these tools is discussed.

[60] Similar tools have been developed to estimate the vulnerability of a firm by customer. In this case, the tools were used to group or segment customers based on their expected loyality and price sensitive.

© **Copyright Custom Decision Support, LLC (2002, 2012)   http://www.lieb.com   08/27/12**

Customer	IMPORTANCE						TOTAL
	Price	Value	Customer Services	Supplier Reliability	In-Use Performance	Product Quality/ Consistency	
A	2	2	2	2	2	2	12
B	3	2	3	1	1	1	11
C	1	2	3	3	2	1	12
D	0	0	1	2	2	3	8
E	3	3	1	1	1	0	9
F	2	2	1	1	2	2	10
G	1	1	0	0	0	0	2
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0

In order to position the customers, first normalized values were computed for the underlying factors and then the positions computed for a triangular graph.

Customer	Price	Brand	Performance			
A	33%	33%	33%	0.500	50%	33%
B	45%	36%	18%	0.333	41%	45%
C	25%	50%	25%	0.333	38%	25%
D	0%	38%	63%	0.625	63%	0%
E	67%	22%	11%	0.333	44%	67%
F	40%	20%	40%	0.667	60%	40%
G	100%	0%	0%	1.000	50%	100%

The graph was constructed, first as a scatter graph using the *Lotus 1-2-3* commands to allow for the data-labels and then converted to a proper Excel graph. Finally, the coordinates of the rectangular graph were removed and a triangle imposed (using the drawing commands). The result is shown below.

Note that changes in the estimated ratings will automatically change the relative positions on the graph. Sometimes the team wants to change the graph directly. This would allow them to physically move a point. This can be accomplished during the session by fixing the last two columns in the computation. This is done by first copying them (Edit/Copy) and then special paste using the value option (Edit/Special Paste/Value) This will make the values out of the formula that was used to compute the point positions. Changes on the graph will then automatically change these values. But note, that by forcing the values to be fixed, they no longer are driven by the importance estimates.

Price

G

E

B

F

A

C

D

Brand   Performance
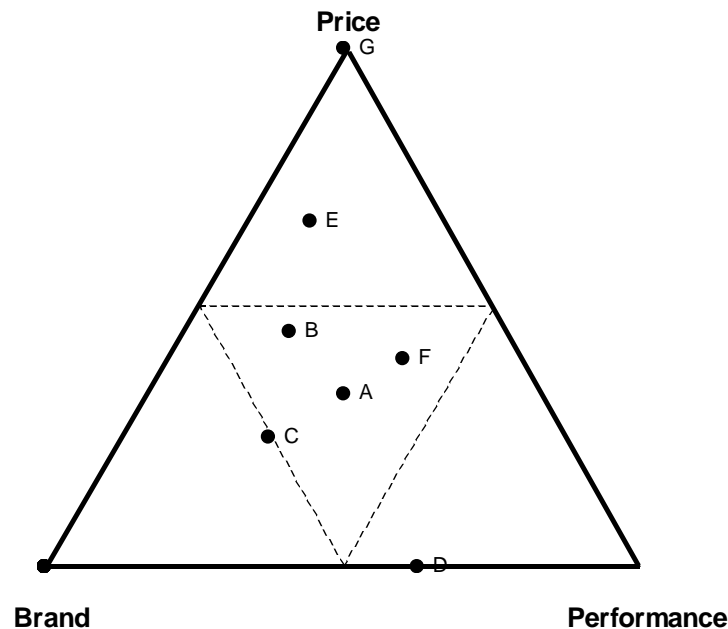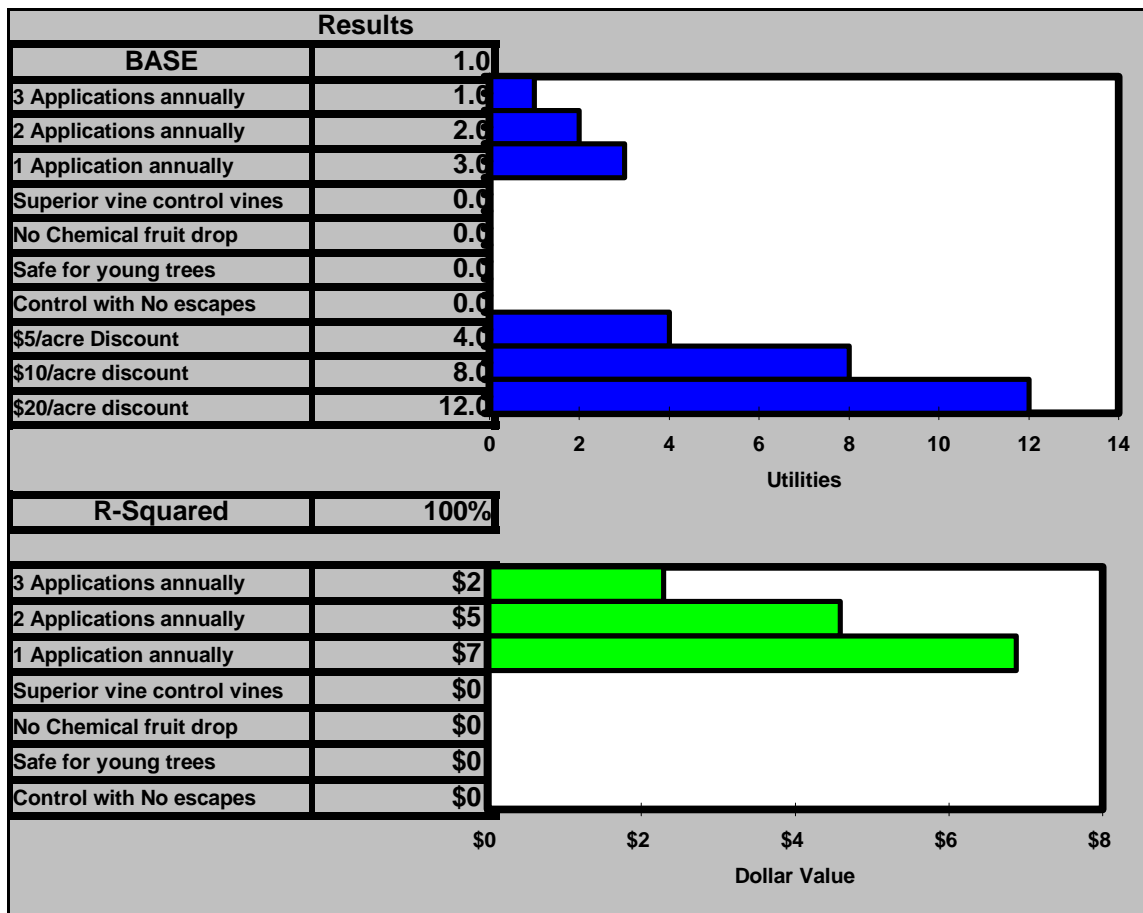
9.7.1.2. Policy Capturing

One of the key collaborative issues is the values or importance of components and attributes. This is sometimes referred to as "weights" when applied to project or business selection. The traditional "stage gate processes" usually require these weights to obtain an overall value of development projects. A number of *Excel* based Decision Support Tools have been developed to capture individual decision policies and to merge them into an overall decision process.

The objective of these policy capturing tools is to facilitate the development of a consensus of policy within the business team. They aid in generating an open discussion of selection policy. In many cases, individuals have not thought out their own rules let alone consider those of other organizations and business units within the firm.

Techniques to estimate individual desired policies have been developed based on perceived value marketing research procedures. In particular, full profile conjoint experiments have been particularly effective. This technique involves providing a set of cards, each card representing a scenario made up of a collection of specific levels of attributes. For example, each card would represent a business concept in terms of expected return on investment, time to commercialization, likelihood of technical success, etc. The individual exercise consists of either rank ordering the cards or rating them in terms of their desirability for the firm. The set of cards is so designed to allow estimation of the levels of each attribute, using regression. This is discussed in more detail in the Chapter on Perceived Value Methods.

An *Excel* decision support system has been developed that allows computation of the values by simply entering the results of the card sort or evaluation. An example of this

type of system is shown below. On the left is the input section where the results of the rank ordered cards are put. The letters correspond to the cards. This data is then converted to a rank order by using a **MATCH** function and a simple table consisting of an alphabetical list. With this, one generates an array with the lettered cards in alphabetical order in the first column and the rank position in column 2. These are then converted into linear utilities by subtracting the ranking from one plus the number of cards in the set. This produces an additional column with the highest valued card equal to the number of cards and the least valued equaling one.

Results	
BASE	**1.0**
3 Applications annually	1.0
2 Applications annually	2.0
1 Application annually	3.0
Superior vine control vines	0.0
No Chemical fruit drop	0.0
Safe for young trees	0.0
Control with No escapes	0.0
$5/acre Discount	4.0
$10/acre discount	8.0
$20/acre discount	12.0

R-Squared	100%
3 Applications annually	$2
2 Applications annually	$5
1 Application annually	$7
Superior vine control vines	$0
No Chemical fruit drop	$0
Safe for young trees	$0
Control with No escapes	$0

The values of the levels of the attributes are then computed using dummy variable multilinear regression. The regression is done using matrix algebra as discussed earlier[61]. Since the same set of cards is used in all cases, the design is constant. As such, most of the computation need only be done once, usually before hand. The final computation is then just a matrix multiplication of the intermediate matrix based on the independent variables in the design and the utility vector we previously discussed. In the above decision support system the results are shown both as a table and a horizontal bar graph[62]. These decision support systems are extremely fast.

9.7.2. BUSINESS MODELS AND SIMULATORS IN *EXCEL*

Market and business models and simulators, as previously noted, are often used for product and advertising design and product pricing. They endeavor to describe the market behavior based usually on the previous year's data and market opinions. As previously discussed business and market models differ from simulators in that the data is aggregated before analysis for modeling and afterwards for simulators.

9.7.2.1. Pricing and Value Models

Models are usually simpler to construct in *Excel* and often require less research data than simulators. The aggregation reduces the affective data and thereby reduces complex computation. Pricing and Attribute Value models are built in a similar fashion as the policy capturing tools discussed above. However, these models but involve aggregated results for the total market and either market segments, geographic areas or parts of the value chain.

For value models some type of conjoint analysis is usually used. For pricing models choice exercise data is preferred (either from a discrete or partial choice approach). Details and variations in methods are covered in details in the Chapters on Pricing and Perceived Value. In most cases, some type of regression analysis is used. In any event, for static models, that is for models based on a given set of data as opposed to dynamically selecting subsets, analysis is done before the decision support system is constructed.

---

[61] The matrix expressions for the regression coefficients , **B**, based on the raw data is:

$$B = [X^T \otimes X]^{-1} \otimes X^T \otimes Y$$

where **X** is the independent variables matrix (with a unity value for the intercept), the superscript **T** is for the transpose of the matrix, the superscript **-1** is for the inverse and $\otimes$ signifies a matrix multiplication. All of these functions can be done in *Excel*.

[62] The goodness of fit is computed as

$$\text{R-Square} = 1 - (\text{SUMSQ}[(B \otimes X) - Y]/([N+1] \bullet \text{VAR}[Y])$$

where **N** is the number of cards

For most models some type of multilinear regression is adequate and can be done in *Excel* either based on the matrix algebra discussed above or using the Data Analysis Tools in the package. In either case, a matrix or array of coefficients is generated. New values are obtained by matrix multiplication of a new input vector and this matrix or array.

Below is a typical pricing decision support system. For attribute design models, rather than changing the price, various options can be selected. Selection of options can be either using a series of forms discussed above or as a check list. In these cases the model will be based on dummy variables and the input design will be a series of zeros and ones.

	New Price	Share		Standard Price
		Estimate	Previous	
Product A	$24.00	6.8%	0.0%	$24.00
Product B	$20.00	1.1%	0.0%	$20.00
Product C	$9.00	39.4%	37.9%	$9.00
Product D	$20.00	0.5%	0.6%	$20.00
Product E	$13.00	9.6%	13.6%	$13.00
Product F	$7.00	28.0%	28.8%	$7.00
Product G	$19.00	14.6%	19.1%	$19.00

	Cost	Earnings
Product A	$6.85	1.16
Product E	$5.00	0.77
Total		1.93

Price Model

Linear	Product A	Product B	Product C	Product D	Product E	Product F	Product G	
R-Square	96%	91%	90%	91%	85%	92%	72%	
Intercept	0.114	0.002	0.405	-0.001	0.116	0.227	0.137	1
Product A	-0.016	0.001	0.005	0.001	0.004	0.002	0.003	24.00
Product B	0.003	-0.002	-0.003	0.001	-0.002	-0.001	0.002	20.00
Product C	0.005	0.001	-0.016	0.001	0.001	0.003	0.005	9.00
Product D	0.001	0.000	0.002	-0.003	-0.001	0.000	0.000	20.00
Product E	0.004	0.000	0.000	0.001	-0.006	0.000	0.002	13.00
Product F	0.004	0.000	-0.002	0.001	0.001	-0.008	0.004	7.00
Product G	0.007	0.000	0.001	0.000	0.000	0.002	-0.010	19.00
	6.8%	1.1%	39.4%	0.5%	9.6%	28.0%	14.6%	
	6.8%	1.1%	39.4%	0.5%	9.6%	28.0%	14.6%	100.0%
	6.8%	1.1%	39.4%	0.5%	9.6%	28.0%	14.6%	

Regarding this decision support system, the new proposed prices for the company's and competitive products are entered in the top space, shown in white.. Next to it is the computed estimates of market share. They are computed directly from the price model. Next is the previous years share which is used as a reality check. A standard price is also usually given as a reference. These are typically, the expected or previous year's prices.

The middle section has the computation of the relative earnings. These are given as dollars per unit of market activity. This is either in terms of customers, patients, plants, etc. This allows changes in the total market to be handled separately if they are

dependent on other factors. The price model is in the bottom matrix in blue, and consists, in this case, of the results from a choice analysis exercise. A tradition linear demand model was used. However, other shaped demand curves or others could be used.

9.7.2.2. Optimization

While estimating of possible values is useful, typically, users want some measure of the "best" price or design. This involves seeking out the highest or lowest of some objective function. Typically, that is maximizing earnings. In reality, we seek a range of prices and attributes that will give a "satisfactory" return, which is not necessary at the highest projected earnings.. This is due to the need to include other strategic factors in the decision process, uncertainty as to external effects as well as admitting to some limitation on the accuracy and validity of the underlying models. As we will see shortly, there are two common methods of seeking out optimum using *Excel*, graphical and using the SOLVER tool.

9.7.2.2.1. Single Price/Attribute Optimization

With a single variable, it is usually easy to graphical display the range of the objective, usually earnings and show the maximum value. For pricing models this is done as continuous variables of share and earnings against price. Below are the typical graphs that are generated. These are generated using the scatter diagram options. Both the share (or demand) and the earnings curves will change automatically with changes in competitive prices and costs.
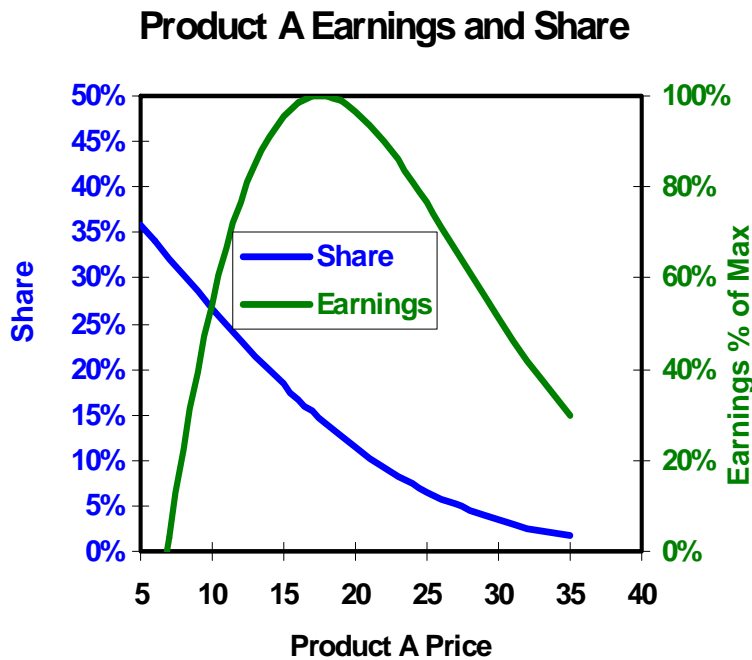
The curves are generated using data-tables to compile the values of share and earnings over the range of prices. Below are the tables used, one for each the share and the

earnings. These are single variable tables with the "**Row Cell**" assigned to any blank space and the "**Column Cell**" assigned to appropriate price cell in the decision support model.   The objective cell for the Data Tables is the corresponding cell locations indicating the appropriate product's share or earnings.   Note that usually this is the earnings from that single product. For convenience, the earnings are also scaled to the maximum. This allows direct comparison between market situations in terms of the "best that can be done.".

1.55	Earnings	15.9%	Share
$5	-0.66	$5	36%
$6	-0.29	$6	34%
$7	0.05	$7	32%
$8	0.35	$8	30%
$9	0.61	$9	28%
$10	0.84	$10	27%
$11	1.03	$11	25%
$12	1.19	$12	23%
$13	1.32	$13	21%
$14	1.42	$14	20%
$15	1.49	$15	18%
$16	1.53	$16	17%
$17	1.56	$17	15%
$18	1.56	$18	14%
$19	1.54	$19	13%
$20	1.51	$20	11%
$21	1.46	$21	10%
$22	1.40	$22	9%
$23	1.34	$23	8%
$24	1.27	$24	7%

9.7.2.2.2. Dual Optimization

In many cases, a firm may offer a number of products into a market. It is then useful to examine the total optimum. With two products this is referred to as the dual or joint optimum and represents the prices of two products that will maximize the total earnings to the firm. This can also be done graphically as shown below.

Earnings from Both Product A and E
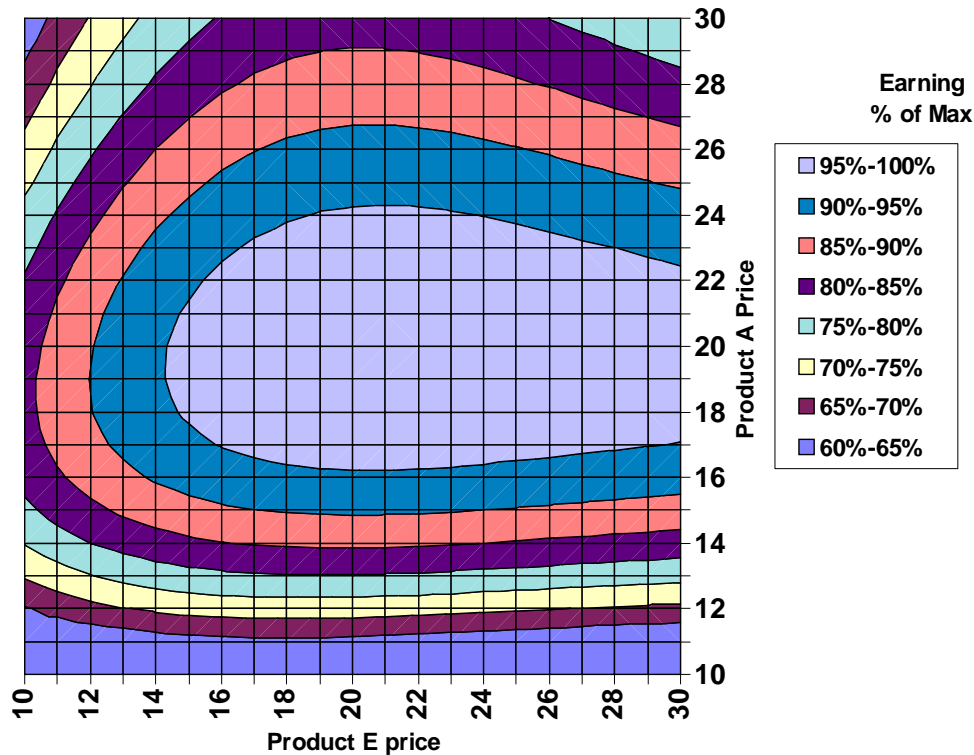
This is a **Contour** map, which is one of the **Surface** Diagram options in *Excel*. The chart is generated using a two dimensional data-table as shown below. In this case the **"Row Cells"** and the "**Column Cells**" are the prices of the two products being optimized. The objective cell contains the total earnings from the spreadsheet. The centered color range corresponds to earnings that exceed 95% of the maximum. In this case the range indicates a very broad range for the product labeled E and far more limited range for the product labeled A.

2.01	10	11	12	13	14	15	16	17	18	19	20
10	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.2
11	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5
12	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7
13	1.6	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
14	1.7	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0
15	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
16	1.9	2.0	2.0	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
17	1.9	2.0	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2
18	1.9	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.3	2.3
19	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3	2.3
20	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3	2.3

9.7.2.2.3. General Optimization using SOLVER

As previously noted, *Excel* contains a solution seeking tool, **Solver**, that can be used to find optimum solutions. Unfortunately, the tools can not be accessed directly through functions and needs to either be handled manually or by using macros. Using macros is straight forward since the facility allows the saving and retrieval of multiple conditions. This allows the developer to assign a number of different situations for using **Solver** on the same spreadsheet. However, we have found that most users prefer to have this type of analysis done by the analyst/developer rather than leaving it to the user.

9.7.2.2.3.1. Under Constraints

Solver allows the imposition of constraints into the problem. For example, we might wish to seek out optimum values but only within the range of the data measured. The underlying model may extend well beyond that range and therefore, optimum values could become unreliable. The constraints may be imposed into other variables as well. For example, we might seek the optimum price given an allowable range in share of competitive products in order to prevent an adverse competitive reaction.

9.7.2.2.3.2. Joint Optimum of More than Two Products

In many cases, firms offer more than two products into a market. This is particularly the case, when the product is offered in multiple package sizes and mixes. In these cases, **Solver** can be used to seek out optimum conditions that would maximize earnings for any number of products. However, it should be noted that if the problem is unconstrained, this optimum may approach infinity.

9.7.2.3. Descriptive Models

Among the widest used decision support tools are based on the relative change in performance that could be expected from changes in attitudes. The underlying models are generated by regression analysis using market survey data. The resulting models represent variation among the respondents and, therefore, only indicate trends rather than actual predicted changes in behavior. The objective of these descriptive models answers the question "Assuming that the trends in the market relate to individual actions what would happen if ...?" This is a very big assumption but often the best we can do with the available data. Predictive models should be based on preference data where respondents indicate their trade-off's between options. Construction of these systems in *Excel* is similar to those used for value models. Changes in specific variables are indicated; a regression model is used to compute the changes; and the results displayed.

9.7.2.4. Live Statistical Models

"Live" models refer to the desire to "slice and dice" the database to produce various models of subgroups or segments. This requires deriving new models based on the users' selection of segmentation criteria. Typically, the criteria are selected on the spreadsheet using various "forms" (drop lists, check boxes and option buttons). Several segments

are often defined for display along with the totals. Examples might be by geographic area and by position in down the distribution channel (such as users, purchasers, resellers, distributors, etc.)

This can be accomplished by extracting selected average values of variables using database functions (**DAVERAGE()**)[63]. This can be done using a data-table. This data often then needs to be rearranged and finally the multilinear regression applied to generate the new models. As previously noted, for many cases, a common design is used and therefore the regression is simply a matrix multiplication.

Live performance models, however, can be more complex in that selection of the independent variables is usually required. Under these conditions the total regression analysis needs to be redone. Unfortunately, with large databases, the use of the normal matrix approach is often limited requiring the inversion of a matrix too large for *Excel*. An alternative is to use the correlation matrix as the basis of the calculation. This reduces the problem significantly[64]. This approach also allows for the use of data-sets with large amounts of missing values and for focusing on key variables. In both cases the regression involves matrix algebraic functions (inversion and multiplications) available in *Excel*[65].

The focusing process is similar to using stepwise and ridge regressions to remove weak and reversed signed parameters. However, for simplicity in *Excel* this is done in as fewer steps as possible. In stepwise regression individual variables are either removed or added to a solution based on their overall impact on model predictability as single steps. To

---

[63] For regression and evaluation of derived importance, correlations need to be computed. Unfortunately, *Excel* does not provide a database function of correlation or covariance. As such, a filter needs to be applied to the data. This gives a blank record for the non-selected respondents. The correlations or covariance are then computed using the standard *Excel* functions.

[64] The matrix expression for the standardized regression coefficient, β:

$$\beta = [\text{Correlation Matrix(X)}]^{-1} \otimes R_{xy}$$

Where the same notation as approve. The term R_{xy}, is the correlation vector of the independent variables X_i's and the dependent variable Y.
The R^2 can also be directly computed as:

$$\text{R-Square} = R_{xy} \otimes \beta$$

Note that sample size is not a parameter in these equations. It neither affects the estimates of the regression coefficients nor the agreement of the model and data.

[65] The major difficulty in providing these regression procedures is that the number of variables required may change. This can be handled in *Excel* by setting the range of matrices using the INDIRECT function. This defines the range location by a text structure which then can be modified depending on the number of variables to be considered. However, this still requires the matrices to be contiguous and therefore needs to be restructured for each calculation.

simplify the process all coefficients that have values statistically indistinguishable from zero are removed[66].

Intercorrelation among the "independent" variables produces indeterminacy in the regression coefficients. An indication of this problem is when the sign of the regression coefficient is reversed from that of the correlation coefficient. This is when the regression coefficient of a variable is negative while its correlation coefficient is positive. If the intercorrelation is moderate, this can be handled by use of ridge regression[67]. That process removes the offending variable by providing selected weights in the correlation matrix. For use in Excel we have simply dropped those variables. In effect, the weights are readjusted to the more predominant intercorrelated variables.

9.7.2.5. Market Simulators in *Excel*

The simulator attempts to first capture the individual decision process and then aggregate them for the total market. As such, the simulators are usually more flexible but also more complicated and difficult to build and interpret. While both static and "live" simulators can be built, typically, these are "live" with the user having control over the definition of the population being considered.

In general, when building simulators, the individual decision models are computed separately and only once. Simulators are particularly useful for combining several different measures within a single survey. For example, a decision support system that combines value exercise information with pricing is often easier to construct as a simulator than as a market model. It should be noted, however, that market modeling is preferred, if not required, when combining the results of multiple sources and where constructing individual decision models are not feasible.

9.7.2.5.1. System Construction

The simulator, itself, is setup in *Excel* as a file of individual decision models with each row containing the information on an individual. The individual may represent a market segment or a potential customer. The components of the individual models are obtained either explicitly for the respondent or implicitly through conjoint or choice modeling

---

[66] An estimate of the standard error of the regression coefficients is needed to provide the criteria for removal. For simplicity we have selected an estimate for a single value for all coefficients as:

$$\text{Standard Error } (\beta) = 1.5 \bullet \sqrt{(1 - \text{R-Square})}/\sqrt{N}$$

Note that the number of responses may differ among the variables the standard error around the coefficient may also vary. However, for analysis purposes we normally assume a constant standard error.

[67] *SAS* and *Systat* both have a ridge regression algorithm available for static modeling.
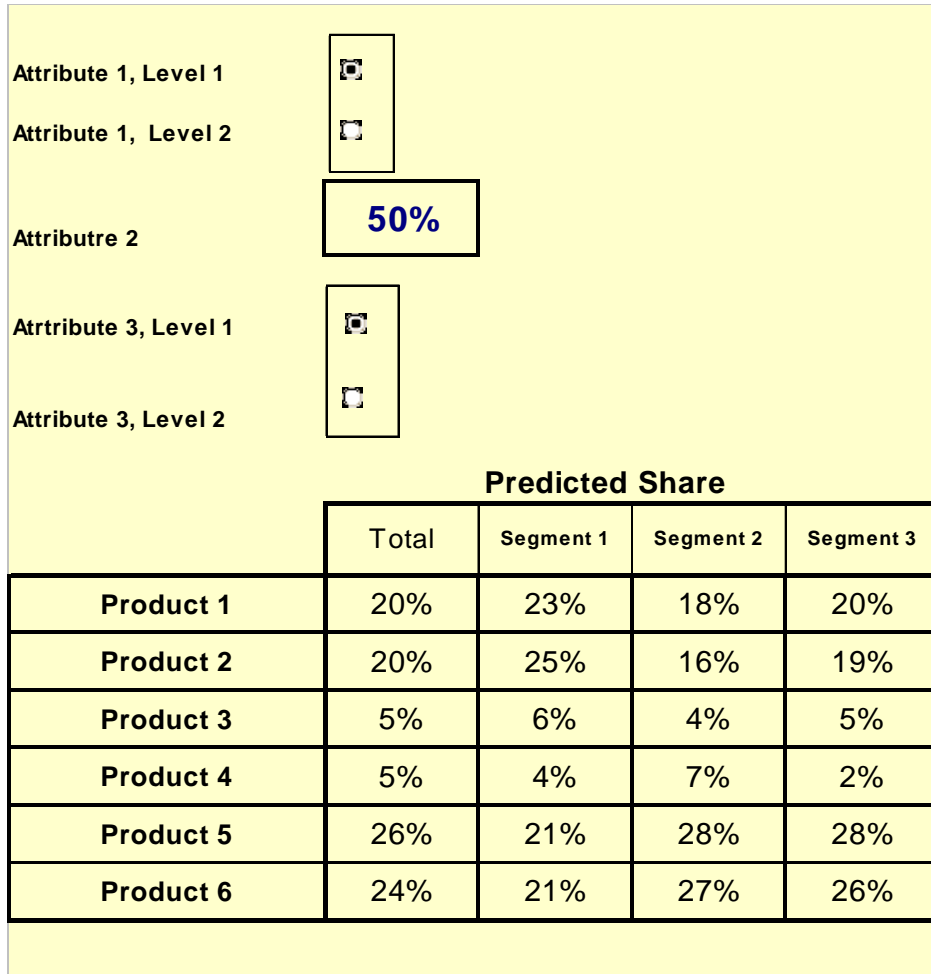
exercises.

Each individual model is then used to predict the selection by the individual of a number of potential options. The input into the simulator is then the choice of these options. The computation is done explicitly in various columns down the file. Typically, a calculation of distance or value is computed for each option. The actual selection is determined by the nature of the purchase and the interpretation of whom the individual represents.

- For cases where only a single item is purchased and each row representing individuals, the "winner takes all" scheme tends to work well. This approach assigns the item with the least distance or greatest value to be the winner and only purchased choice.

- For cases where purchases typically involve multiple items, it is usually important to include the second choice as well as the winner in determining effective market share. In this case we tend to use a distribution of expected purchase share assigned to the ranking of values.

- For single purchased item situations, where rows representing segments of potential customers a distribution of purchases based on the ranking of utilities is usually called for.

While the literature has suggested that value-share (or inverse distance share) can be used for individual market shares, this has tended to produce poor descriptive results and is not recommended.

The results are then aggregated by averaging down the selected individual rows for the segment of the population of interest. Once again, these are controlled by the user as some combination of criteria. Extraction is done similarly to the live market model using tables and database functions. The results are then displayed as a table. Below is a simple simulator for a product competing against a fixed set of competitors. In some cases, the various competitors can also be changed.

Attribute 1, Level 1	⬤
Attribute 1, Level 2	☐

Attributre 2   **50%**

Atrtribute 3, Level 1	⬤
Attribute 3, Level 2	☐

Predicted Share

	Total	Segment 1	Segment 2	Segment 3
Product 1	20%	23%	18%	20%
Product 2	20%	25%	16%	19%
Product 3	5%	6%	4%	5%
Product 4	5%	4%	7%	2%
Product 5	26%	21%	28%	28%
Product 6	24%	21%	27%	26%

9.7.2.5.2. Distributions and Graphics

Unlike market models, distributions of results are available using simulators, at least, in terms of utilities, values and inverse distances. This allows the computed displays of values. Typically it is desirable to show the distributions in terms of the subpopulations involved. In order to do this graphically, the values need to be separated into columns representing each of the groups. This is usually done with an "**IF**" function in new column cells.   Note that while there is no requirement that the groups to be exclusive, their identification on the resulting charts will be set in order of their display by *Excel*. A typical chart is shown below:

% Respondents

Share Distribution
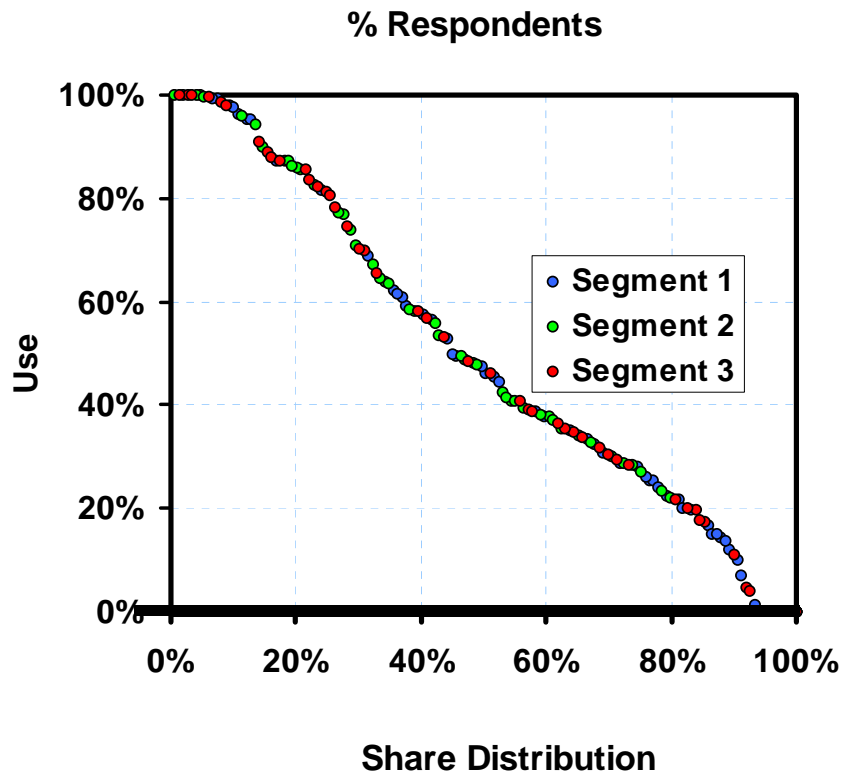
The charting feature in *Excel* tends to assign a zero value to alphanumeric table entries. These will appear as zero values for the non-selected entries in the table created to separate the segment data. However, these can be either blocked as in this case by using a broad line reinforcing the origin or by assigning a large negative value to the missing data in the selection and then only including positive values on the graph.

9.7.3. DYNAMIC BUSINESS MODELS IN *EXCEL*

The models and simulators that we have discussed to this point are static in time. They refer to data only meaningful at a particular point in time. However, one the greatest use of *Excel* spreadsheet decision support systems is forecasting the impact of future events. These are dynamic models. The key in developing dynamic models in *Excel* is to be able to predict the future time period results from the present values. Traditionally this is set up as a "finite difference" relationship where the future values depend on past values. This is in the form:

$$X_{j,i+1} = \text{Function } (X_{j,i}, X_{j,i-1}, ...)$$

where $X_{j,i}$ are the variables of the model and i is the time period. Eventually all dynamic models must be in this explicit form. However, in formulating the problem, the parameters may enter implicitly, where some future parameters depend on the concurrent value of other parameters. However, the order of computation must be such that the values of the variables are well defined at the time of computation. Simultaneous forms

can be used as long as the computation procedure allows them to be solved within the time period.

It should be noted that several of the variables may be entered manually as forecasts or events. Other parameters are totally defined by other internal parameters for example in the Proforma model discussed below some of the inventory values are computed directly from sales. Though it is feasible, optimization between time periods is rarely used within these models because of complexity.

While there is no specific constraint on the nature of the time periods, in general they are taken at a constant interval, usually as monthly, quarterly or annual results. Usually shorter time periods are not used to allow some degree of averaging over accounting and transaction discrepancies.

9.7.3.1. Proforma Models

The most classic dynamic business models are the "Proforma" financial tables, which is the traditional, "spreadsheet" model. Below is a partial sample of this type of dynamic model in *Excel*. These are usually constructed based on standard rules for computing the financial components and is driven off of a set of assumptions regarding the long-term physical sales and price.

Years	1	2	3	4
Physical Sales	0.057	0.143	0.293	0.519
Price	$2.00	$2.06	$2.12	$2.19
Revenue	$0.115	$0.294	$0.622	$1.135
Yield	62.2%	73.1%	81.8%	88.1%
Production	0.09	0.20	0.36	0.59
Material/Pw Cost	$0.018	$0.039	$0.072	$0.118
Direct Labor Cost	0.107	0.114	0.122	0.133
Mill Cost	$0.126	$0.153	$0.194	$0.251
Sales Support	0.103	0.109	0.119	0.134
• • •	• • •	• • •	• • •	• • •
Equipment	$0.677	$0.677	$0.677	$0.677
Permanent	$1.854	$1.854	$1.854	$1.854
Investment				
Depreciation	$0.155	$0.155	$0.155	$0.155
Rent	$0.000	$0.000	$0.000	$0.000
Adjustments	$0.000	$0.000	$0.000	$0.000
Cost of Sales	**$0.807**	**$0.873**	**$0.986**	**$1.156**
Before Tax Earnings	**($0.692)**	**($0.579)**	**($0.364)**	**($0.021)**
Tax	(0.304)	(0.255)	(0.160)	(0.009)
After Tax Earnings	**($0.387)**	**($0.324)**	**($0.204)**	**($0.012)**
• • •	• • •	• • •	• • •	• • •
Cash Flow	($2.54)	($0.45)	($0.26)	$0.06
Discounted Cash Flow	($2.54)	($0.40)	($0.20)	$0.04

This type of manual model is turned into a decision support system by introducing parameters that adjust the financial elements: In this case, these are rules of operations as well as assumptions regarding costs and investment as well as sales.   These are summarized as values for the model parameters. Below is a partial list of the parameters for this proforma model. A typical decision support system will include a user friendly interface to allow changes in these parameters and the initial sales forecasts.

Potential	2
Ref Time	0
1st Year	2
Inflation	5%
Correction	2%
Ref Time	1
Ult. Yield	100%
● ● ●	● ● ●
M Base Costs	0.20
Labor Rate	0.05
Base Labor	$0.10
● ● ●	● ● ●
Base S&CS	$0.10
Base A&P	$0.000
Base D&T	$0.000
● ● ●	● ● ●
Inflation	5%
Tax Rate	44%
Cost of Capital	12%

9.7.4. RISK (MONTE CARLO) ANALYSIS IN *EXCEL*

Uncertainty in the results of models is derived from the variation expected in the input variables.   Monte Carlo analysis consists of capturing the variation in results by combining the simulation of randomly sampled input variables.   Monte Carlo risk analysis can be used as part of business models and simulators and as collaborative tools. An example of its use as a collaborative planning tool is in the estimates of the "Envelope of Opportunity" analysis where the sensitivity in the variation of revenue and earnings is estimated.

Monte Carlo is a "brute force" approach. Each input variable is assumed to vary by some known distribution. These input distributions maybe dependent or independent of each other. The process of Monte Carlo risk analysis on an existing business model consists of: (1) setting up the distributions of variables, (2) randomly sampling those distributions, (3) collecting the results, and (4) analyzing the results.

There exist a number of commercially available "Add-In" programs designed to assist in performing Monte Carlo analysis in *Excel*[68].   While these programs are useful, they are not necessary and since, as was previously noted, like other "Add-In" programs, they are not universally available and require special training to use. And furthermore, they may have some limitations that restrict application.   Mainly because there are not universally available on all systems where the decision support system may be needed, it is preferred to use only the capabilities within *Excel*.

9.7.4.1. Generating Random Values

Excel has the capability of generating random numbers from uniform or flat distributions[69]. In particular, **RAND( )** will generate a random number uniformly from zero to one. Every time the spreadsheet is recalculated, these functions generate new values. A data-table is used to generate the recalculation and compile the results.

The trick is to generate the random values based on other than a uniform distribution. This can be done for many standard types of distributions using *Excel's* statistical functions.   The inverse distribution functions map values from 0% to 100% into corresponding distributed values. These functions are:

BETAINV( )	Beta and Binomial Distributions
CHIINV( )	Chi^2 Distribution
GAMMAINV( )	Gamma and Log Gamma Distributions
LOGINV( )	Log Normal Distribution
NORMINV( )	Normal (Gaussian) Distribution

These are fairly common distributions that describe a broad range of varying processes. Note that these are the cumulative inverse distributions whose input values are from zero to one. The output, however, may vary over any range of values depending on the function and its parameters. An alternative approach is using discrete distributions. This is easily programmed using nested **IF** statements or **LOOKUP** functions. Similarly, a broken linear model can be constructed which interpolates values between these points. In all these cases, the output values may also be rescaled or shifted using additional model parameters.

---

[68] The program *@Risk*[68] is the oldest version and originally designed for Lotus 1-2-3 and provides a number of tools that help guide the development process and execution. *Risk Solver Pro* and *ModelRisk*, *RiskAMP*, are more recent add-in's and claim faster operations using higher precision distributions. Several Monte Carlo add-ins are free and developed by Universities as part of their courses, these include *MCSim.xla*,, *MonteCarlito 1.10*, *SIMTOOLS*, and others.

[69] The **RAND( ) and RANDOM( )** functions sample from a uniform distribution between zero and one while the **RANDBETWEEN( )** function gives a uniform distribution between two values.

In most stochastic models, however, the underlying distributions are usually not well understood.   Typically, Uniform, Normal, and discrete (triangular) distributions adequately describe the phenomena within understood limits.

9.7.4.2. Generating Results

As previously indicated, a data-table is used to drive the recalculation and the compile. The typical set-up of this table is shown below:

The Result table, in the figure above, contains the values transferred from the model for each computed iteration. Any of the variables can be captured here. Typically the key

output variable is captured, such as the earnings. However, often it is useful to capture a number of variables. These can include share, revenue, total costs, earnings or components of them. Note that each cell of the table would require a separate recalculation. If multiple columns are used, each cell of the column and row would have a separate recalculation. As such, in order to capture multiple outputs they are combined into a single output result. An easy way of doing that is using a text variable that combines the variables and then decomposed it to compute the values of the components. For example if there were three resulting components to be recorded for each iteration, the output would be a text of:

Output =

  =TEXT(Result 1, "0000.00")&TEXT(Result 2,"0000.00)&TEXT(Result 3,"0000.00)

This is basically the concatenation of three text descriptions of the results in a fixed format. The individual results are then decomposed as:

$$\textbf{Result 1 = VALUE(MID(Output,1,7))}$$

$$\textbf{Result 2 = VALUE(MID(Output,8,7))}$$

$$\textbf{Result 3 = VALUE(MID(Output,15,7))}$$

These would be computed in the three columns to the right in the table. However, any number of variables may be used. The results appear in the column labeled Result 1, Result 2, and Result 3. Notice that in this data-table has no values below the function to be recorded. If you wish an ID code can be used here. When specifying the data-table, the "**Column Input Cell**" is given as any blank cell while the "**Row Input Cell**" is given as the cell named as "N" specifying the recorded variables from the results section.

There are at least three general ways of viewing these results: (1) as a distribution of the variables within a market or group, (2) probability distributions of variables for a set of simulations for a given condition, and (3) a plot of the likelihood to meet a goal over a range of inputted variables. In the first case, we capture the distribution of results, in the second, the uncertainty of a specific action. While in the third, we endeavor to compute the optimum action to be taken under uncertainty.

9.7.4.3. Displaying Distributed Variables

The results of market models are often displayed as distributions. Here the distribution indicates the range of value or target price that would be expected for each of the members of the market computed in the analysis. The resulting distribution is obtained by ranking and displaying the results from lowest to highest and performing what ever necessary calculations are needed. For example, the optimum target price estimated by computed values of earnings based on the distributed economic value, is shown below.
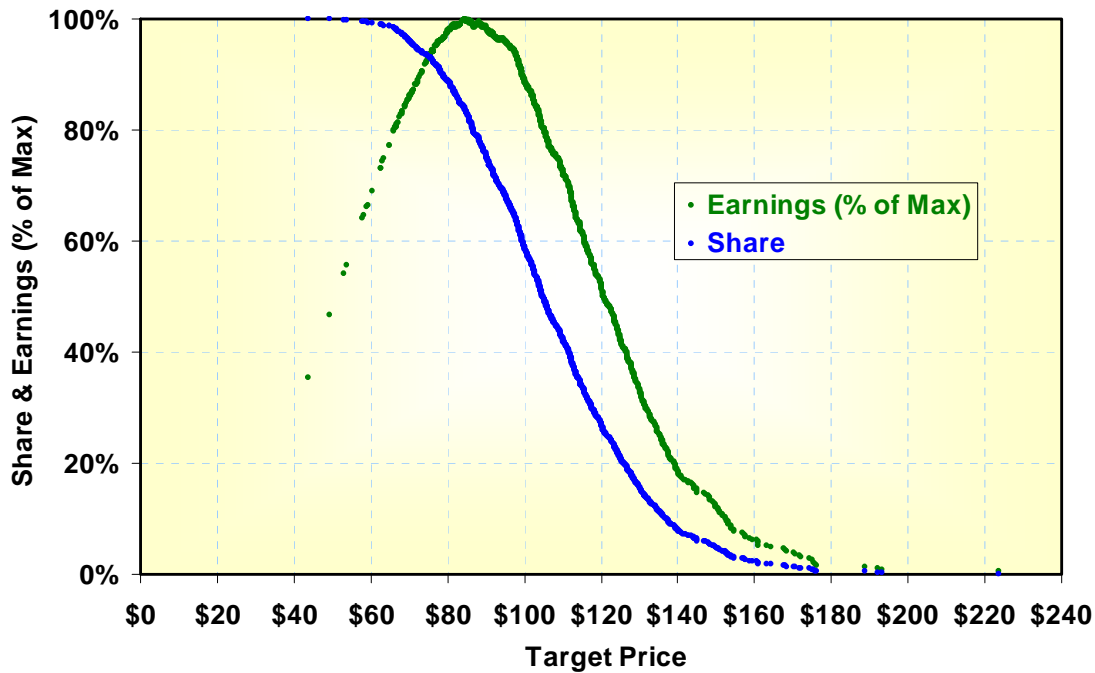
9.7.4.4. Displaying Probability Distributions

It is often useful to display the uncertainty of a decision. Typically, there are two key variables to be investigated. For investment decisions, these are usually invested costs and net earnings. For marketing decisions, these are usually some measure of sales (revenue or share) and earnings. This type of analysis can be critical for complex business models. However, with simpler models few managers wish to delve into this level of detail.

Single variable distributions can be computed using a simple data-table. This consists of grouping the variables into categories and then applying a data-table to determine the count in each category using a database count function (**DCOUNT**). The categories are set over the range of the data (**MAX - MIN**) based on some number of intervals such as 50. The counts are normalized and the cumulative values computed and charted[70]. Once set-up, the chart would be automatically recomputed each time the simulation is run. Note that there is only one variable that will change in the data-table.

Computing the two variables or bivariate distributions[71] of these results is a little more complicated but basically using the same approach. The results appear as a contour map of probability values with each color range indicating a different likelihood. This is

---

[70] We have found useful for our clients to smooth these distributions. This can be done either by using the internal chart data trend capability for exponential and linear distribution or to use mean and standard error estimates with the standard distribution functions (i.e. **NORMDIS**).

[71] @Risk does not provide a means of producing bivariate distributions.

shown below along with marginal distributions. In this case, the data-table is two dimensional with both the column and the rows having categories listed. Here the two variables have to be categorized as in the single variable case. The resulting table will have the counts for both variable categories. These results have to be normalized. The bivariate matrix is typically computed as a density distribution not as a cumulative as in the case of the single variables. The marginal distributions are computed from the bivariate matrix by summing across categories of the opposing variable.

The bivariate plot is obtaining using the "Surface" option in the standard charts, similar to the dual optimum analysis shown above. We have found it useful to modify the colors and ranges using these charting options to give a more compelling presentation. The charts indicating the marginal values are produced separately, using the bar and column chart options. They have been put onto the same chart manually by eliminating the backgrounds and adjusting size to fit.
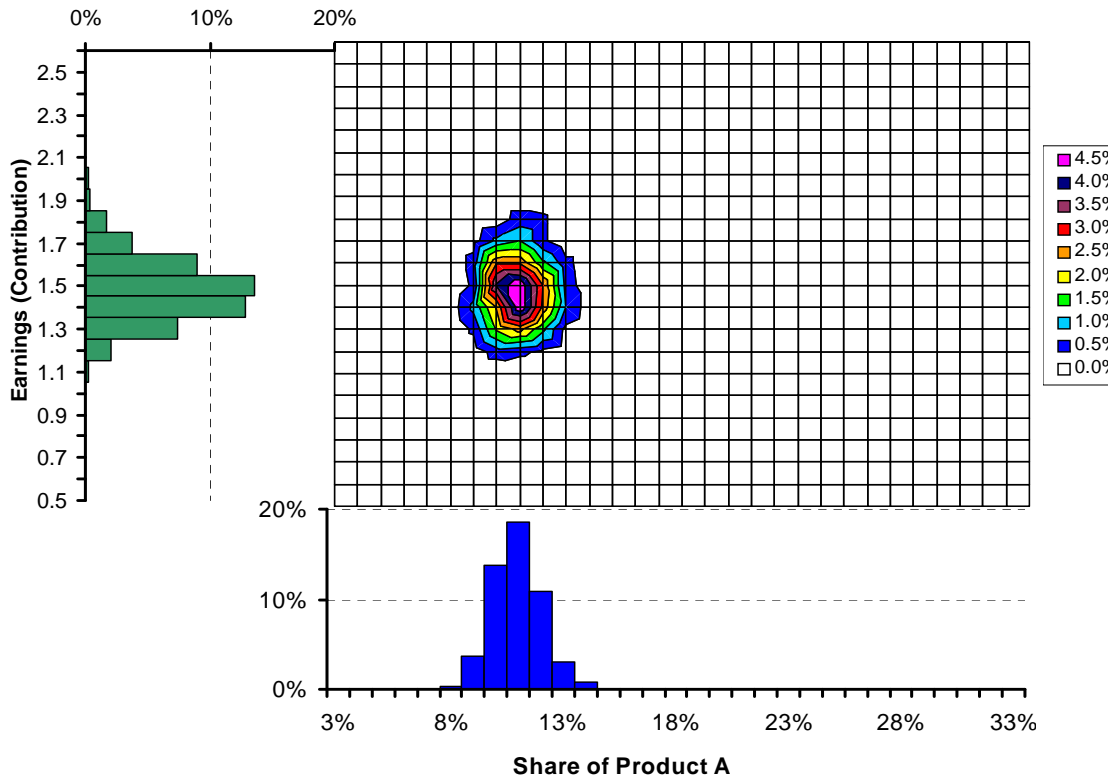

### 9.7.4.5. Optimization under Uncertainty

Identifying a desirable approach in an uncertain world focuses on the likelihood of meeting some objective. In this case, the optimum is based on the likelihood of meeting a goal or objective. Monte Carlo analysis is used to determine the likelihood of success. The process is similar to graphically identifying the optimum value for the deterministic case, however, here we use the likelihood of success to select the optimum rather than the

earnings. Monte Carlo analysis generates distributions of earnings at each price point. From these distributions, the likelihood that an earnings value is above or below a certain level is computed. For example, if the goal is to meet some earnings level, only the earnings from the Monte Carlo analysis is computed. This is done on a data-table with no values for the Column Cell but with the changes in the key decision variable into the Row Cells. The final results can be shown as a bar or line chart as shown below.

Likelihood to Meet Earnings Goal
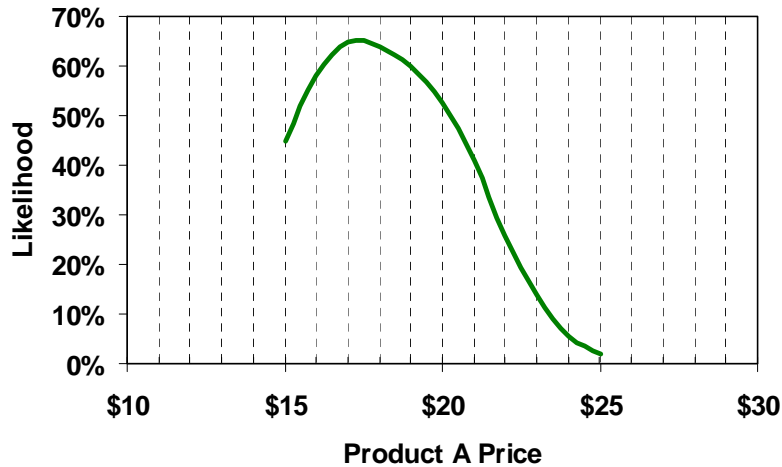
Likelihood to Meet Earnings Goal
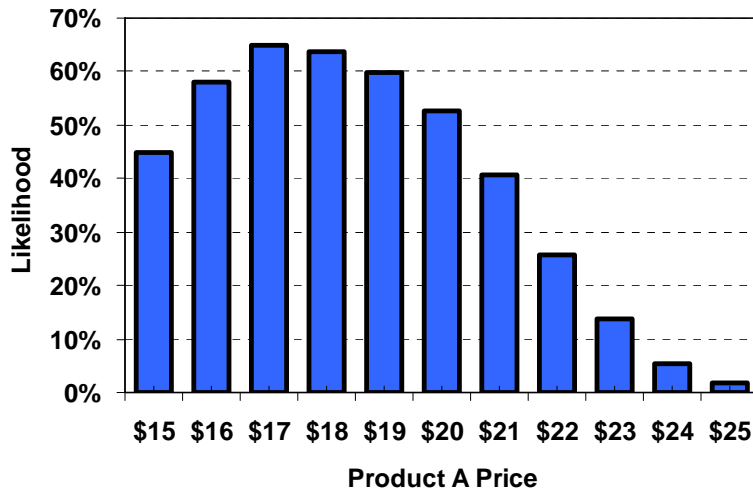
9.7.4.6. Sample Size and Computing Power

As should be expected Monte Carlo can be computationally intensive. The sample size will depend both on the need and to some extent on the available computation power of the computer or alternatively on the patience of the user. With modern personal computers fairly large sample size of the order of tens of thousands can be run.

However, we have found that for relatively simple models (with uniform or Gaussian distributed input variables[72]) a few thousand is adequate. This is important for optimization exercises where that computation will be done ten or fifteen times. Here we rarely use more than a few thousand simulations per case.

---

[72] This is probably true for all relatively small models with smooth symmetric distributed input variables.

9.8. <u>APPENDIX - BUSINESS AND MARKETING APPLICATIONS AND USES</u>

Business decision support systems have been developed to assist in a broad range of applications. The following consist of systems developed by Custom Decision Support, Inc. from the late 1970's to the present. By no means, does this list cover the full range of systems that have been developed or are being used. However, they are a sample of what is feasible and our experience in their development. In recent years, many of the systems have been developed using *Microsoft Excel*. A discussion of developing systems in this platform is covered in the next section.

9.8.1. PLANNING ANALYSES DECISION SUPPORT

The most classic form of business decision support is in the generation of financial analyses. During the advent of the personal computer, in the early 1980's decision support systems were exclusively associated with financial decisions.

Objectives: Assist in the establishment of financial control by forecasting expected returns from existing and new investments and compile necessary budgetary information. These systems often involved the construction of some form of "proforma" model that allows for the computations of multiple measures of financial return (ROI, Present Value, Internal Rate of Return, etc.) Alternatively, decision support tools were also developed to help in the balancing of budgets and organizing inventories.

Specifications and Components: These types of tools are usually handled by financial analysts, managers and accountants. However, systems were also developed to help in project development with the technical staff.

Success Comments: Recently, corporate financial and operations data has tended to be maintained through a common "Enterprise Data System", such as *SAP*.   Adopting these systems represent major investments. As such, there has been a trend to develop analysis tools within them. This trend, we believe will continue, however, it should not limit the development of such systems for use on the personal computer.

9.8.1.1. Budgeting Systems

Objective: To compile, adjust, and balance a multifunctional marketing activity at a Fortune 50 industrial company. The major issue was to compile budget established by interdependent but separately managed groups.

Date: 1983 - 1987

System/Language: *IBM PC/Lotus 1-2-3*

Success/Use: Various forms of the system were used over a five year period. The system expanded finally involving over 300 spreadsheets. The system was finally replaced by a simpler centrally controlled budget approach.

Description: The underlying constraint on this system was the compilation of budgets from approximately 50 sites and functions worldwide within a tight annual planning cycle. It was the automation of a manual process to compile spreadsheets obtain mainly by "snail mail" but with oversea data obtained with the recently introduced electronic mail.

9.8.1.2. Venture Financial Analysis

Objective: To develop new venture proforma tables and measures of expected financial performance for new and existing businesses.

Date: 1981 - 1994

System/Language: *IBM PC/Lotus 1-2-3, Excel*

Success/Use: These spreadsheets were developed as teaching tools illustrating financial modeling. Though its intended use has been limited to education and training, some have been used for projects.

Description: The analysis model consists of a traditional spreadsheet model, however, the relationships and parameters have been imposed. The parameters reflect ratios estimating working capital elements as well as other operating factors. The organizational goal of these models is to establish a common basis for comparison by imposing standard assumptions.

9.8.1.3. Early R&D Venture Analysis

Objective: To provide guidance to research and development personnel in setting goals based on financial objectives.

Date: 1979 - 1981

System/Language: *IBM PC (8088) and Apple II/BASIC*

Success/Use: Though two fully functional support systems were developed, the research and development organizations did not show interest. This was a "good" example of a technically successful tool that did not seem to have a market. We suspect, that financial analysis was considered to R&D to be a "political hot potato" best left to management and analysis to finesse.

Description: Several models were developed to estimate the return for ventures based on a few general parameters, including cost, price, and new plant investment. An extensive financial model was used to estimate inventories, working capital, etc. The purpose was to give the researchers some insight into setting goals. Extensive help and explanatory tutorial were included for the technical researchers.

9.8.1.4. Dynamic Industry Model

Objective: To model the dynamic behavior of a commodity industry and forecast the need for new capacity and potentially location..

Date: 1990

System/Language: *IBM Personal Computer/Microsoft QuickBasic*

Success/Use: By the 1990's the original Federal Group models were becoming less reliable and valid. Basic industry structures had changed with the formation of international cartels, some consolidation and some increased localization of production. As such, continuation of this effort was not done. The "hay-day" of this work was the late 1970's. The demise of the Federal Group was recognition of this fact.

Description:. The *Federal Group* had pioneered the use of dynamic modeling of industries following the lead of the "Club of Rome" work on global dynamics in the 1960's. The models focused on the behavior of commodity products for example titanium dioxide (white pigment) and hydrogen peroxide (oxidizing and bleaching agent). The *Federal Group* went out of business in the early 1990, and *Custom Decision Support, Inc.* was asked by its customers to help maintain those models. That activity focused on the re-establishment of the parameters inherent in its forecasts and migration to the personal computer.

9.8.1.5. Dynamic Industry Risk Model

Objective: To estimate the risk of various potential actions taken in response to the entry of a new competitor.

Date: 1991

System/Language: *IBM Personal Computer/Microsoft QuickBasic*

Success/Use: The decision support system was built to examine a particular situation, the entry of the first significant competitor in a market. The problem centered on responsive pricing options. It provided a visual support for an unpleasant option of non-response. The model was developed for this purpose only and was designed to be used only by the analyst/developer.

Description:. The entry of the first significant competitor into a market is always an uncomfortable situation to the established firm. In this case, there was a great deal of uncertainty. This Monte Carlo simulation decision support systems is able to display the possible outcomes of actions under various policies.

9.8.1.6. Audit Portfolios

Prior to the development of this system, Dupont's internal auditing organization had used a fixed scheduling process for selecting audit-sites. This was a standard procedure for

corporate auditing before the 1980's. At that time, the national governing organization had issued a new requirement for audit site selection should be based on "risk" associated with the potential sites. This new requirement came at the same time of the acquisition by Dupont of Conoco. This acquisition doubled the size of the Internal Auditing function. It was felt that a shift to a "risk" oriented audit portfolio selection process would reduce the staffing requirement of joint company and provide greater coverage of the potential exposure. A program, "CAAR," was undertaken to both shift selection to a "Risk" basis and provide a rational means of determining the required staff.

Objective: To select a portfolio of sites for internal auditing in a Fortune 50 firm based on the "risk" associated with not auditing the site.

Date: 1985 - 2000

System/Language: Mainframe, *IBM AT/SAS, IBM BASIC, QuickBasic, Lotus 1-2-3, LP-88*

Success/Use: This was probably our most successful system and was operated for almost 15 years in various forms. Documented cost saving partially attributable to the application of this system exceeded $30 million.

Description: "Risk," for the purposes of this system, is a subjective estimate based on the exposure that an item or site might represent in the experience of the evaluator. The Auditing group had a group of 9 criteria for the evaluation. The problem was capturing the relative importance of these criteria. It should be noted that initial development of this system was under a tight time constraint of 90 days. As such, solutions were sought that did not require consensus of the management teams or senior corporate management. In order to capture the group opinion a technique combining policy capturing and synthetic voting was developed. The synthetic voting approach was based on individual decision models obtained by a process of policy capturing[73].

All potential items (up to 10,000) were assigned into a "risk strata" or level by simulating a voting process based on the individual decision models. A system was provided to develop a selection policy based on the risk strata and the classification of the item. Finally, a selection of the portfolio was made based on the selection policy.[74]

Two systems were developed: (1) a prototype using the mainframe system in SAS and (2) personal computer system using *IBM Basic, QuickBasic, Lotus 1,2,3* and *LP-88*. The first prototype system was used to test the underlying logic and to assist in the reorganization of the Internal Audit Function in Dupont. The second system, which was fully documented, was design for routine operations. This latter system was a "tour de

---

[73]A discussion of conjoint analysis is covered in the Chapter on *Perceived Value Measurement*. The construction of policy capturing system is given in the section on *Applications in Excel*.

[74] A more detailed discussion of the process can be found in: E. B. Lieb & J. B. Gillease, *"Du Pont Uses a Decision Support System to Select Its Audit Portfolio"*, Interfaces, Vol. 26, Number 3, May-June 1996

force" for use of the personal computer in this size operation. The personal computer systems provide economic, control, security, and performance advantage. Especially designed algorithms allowed faster operations than on the mainframe for a fraction of the cost. The stand-alone system provide unsurpassed security and control. It should be noted, that the cost of data compilation, as would be expected, was far greater than the system development cost.

9.8.1.7. Personnel Evaluation

This was an attempt to expand the potential use of the Audit Portfolio selection system to help in the evaluation of personnel. While the system did not set the criteria for personnel evaluation it assured an objective and consistent evaluation of results.

Objective: To obtain an objective unbiased compilation of personnel evaluations.

Date: 1989

System/Language: *IBM PC (80386)/IBM BASIC, QuickBasic*

Success/Use: We found little interest in the system among industrial human resource personnel and development was dropped. After our experience with the Territory Assignment System, we felt that successful exploitation of this technology without a strong interested client would not be feasible.

Description: The tools developed for the Audit Portfolio Selection system provide a foundation for handling very large evaluation problems on personal computers. With the continued increase in computing power (Moore's Law) the size of problems that can be handled has likewise increased greatly. At this point, it is feasible to handle tens of thousands in a similar type of evaluation. As envisioned for personnel evaluation, both management and those being evaluated would be considered in the group of evaluators. Comparisons of management's view, an organizational voted appraisal, and the personal self view would be the end result.

9.8.2. COLLABORATIVE PLANNING

Collaboration activities are undertaken both to share information and opinion and to get buy-in and consensus to decisions. Decision support systems can be highly useful for making collaboration processes engaging and the results compelling. Time is always a critical factor but for collaborative processes they can be the determining factor in "buy-in" to the results. On-line decision support systems can help the concurrency of the analysis to the sharing activities.

Objectives: To provide analysis concurrent with the sharing of information and opinion in collaboration activities.

Specifications and Components: At the present time, these systems are designed for use with personal computers (laptop or notebook size). On-line systems, over the Internet are

likely to be more useful in the future with teleconferences. But at this time, few tools exist for the development.

Success Comments: More so that with most other systems, decision support of collaboration has to be integral with the process. They must be user friendly. But most importantly they must be concurrent with the collaboration activity. They should encourage the forward momentum of the sessions rather than an inhibitor.

9.8.2.1. Product/Market Positioning

The major purpose for positioning exercises is to identify the characteristics of key customers and competitors. The goal is to determine what should be done to provide the firm increased share or price. In general, the knowledge and familiarity of specific customers and competitors are not universally held by all members of the management team. Usually, specific customers are known by individuals on the team, or information about them will be the responsibility of specific individuals. For example, for a large industrial products business, it is typical that major "national" accounts be handled by a different sales-force than the routine "smaller" accounts. Similarly, the parts of the customers' organization will be known to different parts of the firm. The sales-force will be very familiar with the purchasing agents while the technical field service may know the engineering staff. The purpose of the positioning process is to collect the diversity of knowledge of the market.

Objective: To merge information regarding the market influencing factors including price, product performance/quality and brand/services.

Date: 1999

System/Language: Personal Computer *(Windows & Macintosh)/Excel*

Success/Use: These tools have been used several times within both a closed group session and on a more open basis in which participants may submit asynchronously their input. They have been used for both the evaluation of opportunities and for seeking to understand vulnerability.

Description: These systems are discussed in detail in the section on *Excel* applications.

9.8.2.2. Policy Capturing

Policy capturing involves the use of psychometric tools to reveal latent or implied decision rules that participants am not be able to articulate or that may be masked by culturally normative behavior. For example, issues such as safety and community activities tend to be overly valued when discussed explicitly. However, when investigated implicitly using these tools, they tend to have far less importance then performance or cash value.

Objective: To capture the opinions of the management team regarding the relative importance of project and business criteria.

Date: 1998

System/Language: Personal Computer *(Windows & Macintosh)/Excel*

Success/Use: There has been increased use of these methods as user friendly analytical design and analysis tools become available. The major problem in there use is the "active disinterest" among senior management who believes that these decisions are theirs alone.

Description: The same analytical procedures are used for these applications as used with perceived value analysis. Construction of these system in *Excel* are discussed in detail in the section on *Excel* applications.

9.8.2.3. Risk Sensitivity (Envelope of Opportunity)

The business risk sensitivity analyses are based on Monte Carlo analysis of estimates of the impact of events on the existing business forecast. These techniques were promoted by a number of "high end" business consulting firms including Braxton Associates. However, the procedure was viewed as too expensive for routine application without the use of a personal computer system to perform the computations.

Objective: To estimate the impact on forecasts of possible uncertain events.

Date: 1979, 1982

System/Language: *IBM PC, Apple II/Basic*

Success/Use: These programs were used several times and were successful in providing risk analysis insight. Systems developed in *Excel* would provide far better graphics and should be more compelling than these early versions.

Description: Calculations were done using a simple Monte Carlo algorithm. Sensitivity was estimated by the impact of removing individual events. This process was automated to deliver both a contour map of events (referred to as the "Envelope of Opportunity") and the relative impact of each event. Due to the speed of machines of that day, the process was done off-line or during a major break in the sessions. Today it could be done concurrently with on-going sessions.

9.8.2.4. Merging Opinions, Boardroom Voting

Boardroom voting tools have been available for a number of years. They allow the compiling and manipulation of votes during a meeting or session. Availability of on-line systems should accelerate their use in combination with teleconferencing.

Objective: To display the opinions of individual within a group as a means of generating a consensus.

Date: 1978, 1989, 2001

System/Language: *Atari, IBM PC/Basic, QuickBasic, Excel*

Success/Use: These decision support tools have been used occasionally but mainly for demonstrations.

Description: Initial commercial boardroom voting systems were very expensive (>$40,000). A far cheaper but limited system was developed using an *Atari* home computer in the mid-1970's. This system allowed real time Delphi method data processing. Later systems were developed with manual data input using the *IBM PC*. Below is a sample of the display where participants identified themselves in regards to familiarity with the subject.
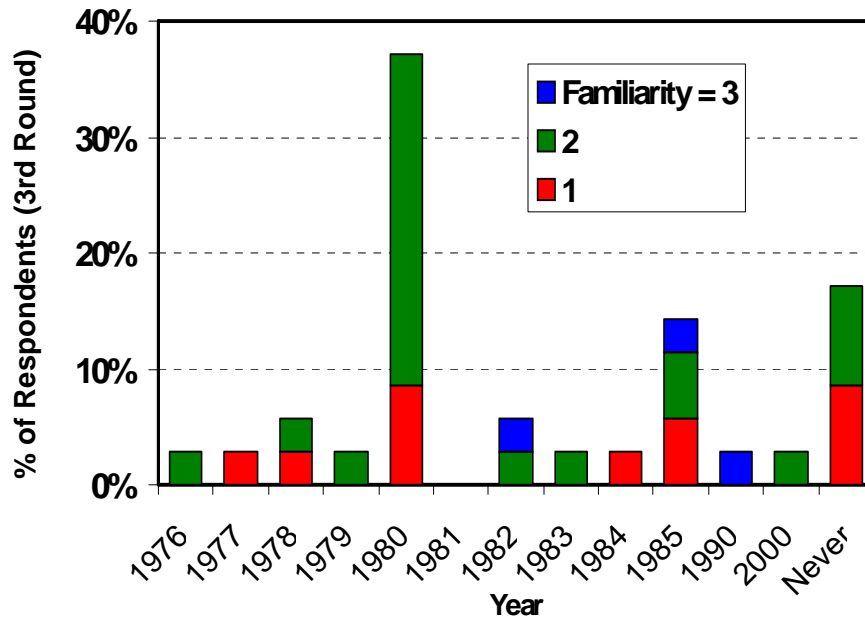
9.8.3. OPTIMIZING THE OFFERING

Marketing research studies tend to provide measures of the perceived and potential value of product attributes. While this information can provide insight, it does not and should not respond to the underlying question of what actions should be taken. Other factors need to be included in order to get to "best" actions. The purpose of this group of decision support systems was to bridge the gap between market data and the actions that should be taken. Typically these systems tend to merge costs with the marketing research data and display the results of scenarios based on alternative underlying assumptions.

Objectives and Goals: To provide assistance in the design of products, promotional campaigns and sales tools**.**

Specifications and Components: Early decision support systems of this type were used almost exclusively by the analyst/developer and were of limited use. However, as the personal computer and *Windows/Excel* have become ubiquitous their use by business teams has likewise increased. This has required more attention to the user interface.

Success Comments: In general, these systems are built for specific problems and rest on the results of particular market research studies. As such, success is limited to the use of those systems.

9.8.3.1. Price Modeling (Economic Value)

Objective: To identify the optimum price for an industrial product (printing aid) based on economic value-in-use models and market distributions..

Date: 1989

System/Language: *Personal Computer /Microsoft QuickBasic*

Success/Use: This was a single use decision support system. While the capability for modification and alternative scenarios were built in, they were not required or used.

Description: This system used Monte Carlo (risk analysis) tools to capture the market variation within the value model. It was designed for analyst use and therefore, was not designed to be user friendly.

9.8.3.2. Price Modeling (Perceived Value)

Objective: To identify a satisfactory range of prices for potential offerings that would yield the acceptable earnings.

Date: 1996 - Present

System/Language: *Personal Computer (Windows and Macintosh) /Microsoft Excel*

Success/Use: The use of a particular decision support spreadsheet is usually limited to an applicability of the underlying data and the longevity of the problem. Typically this is within a year. However, business units tend to have these model rebuilt annually. We have constructed several hundred of these systems.

Description: The development of these systems is discussed as an example in the next main section covering the development of systems in *Microsoft Excel*. However, it should be noted that there is a wide range of situations and needs that must be reflected in these models. As such, they are custom designed.

9.8.3.3. Product Design (Mainframe)

Objective: To identify a potential "optimum" designed product to meet the market desires.

Date: 1977 - Present

System/Language: Mainframe and PC/*SPSS,* and Custom Programs

Success/Use: While decision support systems were developed for use by the management, they were almost exclusively used by analyst/developers and only summaries presented to the business teams. These were mainly single use tools.

Description: Modeling tools are available through the *SPSS* and others to simulate new product concept value and shares based on "conjoint" marketing research data. The goal of these systems is to identify the most attractive product. Typical of all of these design tools is the focus on the market and the exclusion of cost factors.

9.8.3.4. Offering Design (BASIC)

Objective: To develop the sets of optimum profiles for offerings and outlets..

Date: 1990 - 1994

System/Language: *IBM Personal Computers/QuickBASIC*

Success/Use: These systems were designed to help utilize specific marketing research data. As such, they were limited to the specific problems and time. However, several such systems were developed over a five year time period.

Description: These systems were designed to optimize products and outlet (boutique) design based on perceived value measurement. Data from both profiling (Simalto) and conjoint methods[75] were used for input. Both tabular and graphical results were displayed for competitive offerings. The key issue is the ability to meet the needs of a diverse set of potential customers with a limited number of offerings. Construction of these systems in compiled *Microsoft QuickBasic* allowed for efficient execution even with relatively weak computers.

9.8.3.5. Product Design (Windows)

Objective: To identify optimum designs to meet market desires.

Date: 1995 - Present

---

[75] The development of this type of decision support system is discussed in the Chapter on Perceived Value Measurement

System/Language: *Personal Computer (Windows and Macintosh)/Microsoft Excel*

Success/Use: These models are now customarily included with most perceived value studies. They are, in fact, expected by clients on a routine basis.

Description: The development of these systems is discussed in the next main section covering the development of systems in *Microsoft Excel*. Like all such models, they are highly customized. However, the use of *Excel* as made customization fairly simple.

9.8.3.6. Promotional (Claims and Position Statements) Design

Objective: Product and organization position statements can be considered to be made up of claims that relate to those products and organizations. Marketing research tools are able to measure the relative preference in the market of those claims. The purpose of these decision support system is to identify effective and "optimum" statements based on the preference and value of customers to claims.

Date: 1992 - 1998

System/Language: *IBM PC/QuickBasic*

Success/Use: Several models were developed based on a generalize approach to identify the best combination of claims to form position statements. These were based on proprietary measurement procedures of our clients and were therefore limited to their use.

Description: Special full profile conjoint methods were used to obtain relative value of claim statements both in terms of importance and in relevance to the product or organization. In addition, measures of interaction were estimated. The key then was to seek out the optimum combination of claims based on these three evaluations.

9.8.3.7. Stochastic Technology Assessment

This model was developed as an academic exercise but provide planning input to a program targeted at early development of Laser Ignited Nuclear Fusion. Its intention was to help provide "logical" expectations based on the opinions of the technical staff doing the research.

Objective: To provide a broad view of the likelihood of Laser Ignited Nuclear Fusion as a major source of power in the United States.

Date: 1971, 1973

System/Language: *IBM 360/Fortran 66*

Success/Use: While time may have proven the results correct, the organization was not particularly happy to hear them. As such, with the exception of a review due to changes

in parameters (all of which were highly favorable to the concept and associated with high run up in the cost of oil during the early 1970's) the activity was terminated.

Description: The procedure merge a modified "Delphi" method to obtain expected technical performance of the process as envisioned at that point with economic value analysis. Competitive estimates for fission and fossil fuel were based on traditional extrapolation of available data. Possible environmental and structural risks were estimated but not included in the economic analysis. All key inputs were estimated stochastically as probability distributions and the results obtained by Monte Carlo analysis.

9.8.4. OPERATIONAL SUPPORT

Operations provide any number of opportunities for decision support. The following are operational support systems that were developed to handle marketing or business problems.

Excluded from these are engineering and R&D issues. While we had developed a fairly large number of these, they focused on technical problems and process development that are beyond the scope of these notes. These models included process design and performance prediction. They were all developed for specific technical problems.

Objectives: To facilitate the functional operations and to focus on sales and marketing management issues.

Specifications and Components: There has been a long history of the development of these systems most focusing on the migration to the Personal Computer from the Main Frame. At present, the capabilities of systems have made no distinction between these types of systems other than in terms of support.

Success Comments: The major concern, from our experience, is that the problem being solved is real. It is far too easy to develop decision support systems that do not meet the needs or desires of the final users. Similarly, it is highly desirable that the systems operate on multiple occurrences. Systems designed for single applications are useful, but expensive. Multiple uses become even more critical with the high cost of training.

9.8.4.1. Territory Assignment System

The Territory Assignment System was designed as a "tour de force" for use of *the IBM Personal Computer*. The system was designed to provide a color graphic system for assigning agricultural protective chemicals sales-forces to groups of counties in such a way that the assignments have equal sales potential. The trick was to produce a system that would fit and operate effectively on the Personal Computer of that generation (8088). These machines did not have hard disk capacity and the floppy disks only had a capacity of 360 Kilobytes.

Objective: To assign county sales territories that was of equal value.

Date: 1986

System/Language: *IBM PC (8088, without hard disks)/QuickBasic*

Success/Use: This was almost a classic story of a technological success but an application failure.   The project was initiated without end-user (field managers) participation.   The final system was designed for independent allocation of sales territories.   As it turned out, sales managers rarely, if ever, totally reorganize their territories.   Usually, only small modifications are made to handle new or transferred personnel. As such, there was little need for the system. However, the system was used as a demonstration of what was possible using the *IBM PC* platform and was considered highly effective compared to the monochromic *Macintosh* platform available at the time.

Description:

As is typical of all systems of this type, setting-up the data involved at least as much development effort as the system itself. In this case, this was significant since the maps that were used for both assuring continuity of the assignments and for displaying assignments had to be produced manually from state maps. This was due to the fact that sales regions involved a number of states and parts of states. Commercial mapping packages were available for this manual process but we were unable to automate it. Business data were unevenly available across counties reflecting different markets and applications. These included sales of protection chemicals and production of agricultural products. As such, a broad basis of measures of potential had to be considered. In this case over 20 different series were available in different sets. A facility was provided to allow the user to define potential as a combination of these variables.

There were four elements to the Territory Assignment System: (1) identifying starting points for the assignments, (2) assigning the counties and continuously balancing the portfolios, (3) a manual approach to supplement to finish the assignment, and (4) storage of the data.   The general process of assigning the counties was based on a statistical clustering approach, "hill-climbing algorithm."   However, that required initial starting points. We contracted with Prof. David Bellamy who provided a means of estimating farthest points that were used in the system. A key problem was storage of the system on the very small floppy disks. The result was use of on-line compression. This was an early use of the technique. It should be noted that the size of the disks were in flux. Initially, we were considering only 160 Kilobyte disks. The eventual space increased in the last stages to 1.2 Megabytes which became standard during the 1980's and early 1990's.   This latter size allowed the total US data base including all of the regions to be included on one disk.

9.8.4.2. Distribution Simulation

An effort was undertaken during the late 1980's to explore the feasibility of optimizing and managing the distribution channel based on analytical models.   The goal of this process was to extend the concept of supply chain management forward to the customer.

This was mainly an exploratory effort to see of it was feasible to model such a complex process for a major business on the personal computer.

Objective: To determine the feasibility of modeling the distribution and storage of protection chemicals throughout the United States using the personal computer. This was a risk analysis process under a great deal of uncertainty.

Date: 1987

System/Language: *IBM PC, Cray/QuickBasic, Fortran*

Success/Use: It was found that the process was far to complex for simulation on the personal computer of that time. Sample programs took up to eight hours on the personal computer (80286) to do simple parts of the overall simulation. However, the algorithms were ported to the *Cray II*, which completed the same calculations in less than 8 seconds. This indicated that such simulations were feasible on the supercomputer and probably on today's far more capable workstations.

Description: To be effective, Monte Carlo analysis tends to be built on small elements. This was true for this model. Furthermore, there were a large number of variations of these elements which needed to be considered. The major design variables included: the location of stored materials, ease of getting to market, changing economics, pest pressure, and weather. These all had investment and cost issues. Since prices tended to be fixed during the season, pricing was not considered a variable in the model.

For demonstration purposes only a small distribution network was considered with only one product and in one region. Even with these simplifications, the computation took over eight hours on the personal computer. In order to test the program on the *CRAY*, it had to be ported into *FORTRAN 77* for which there was a "vectorizing compiler". The programs specifically written in a simple form allowed easy rewriting into *FORTRAN 77* and smooth compiling. The resulting program ran in less than 8 seconds.

9.8.4.3. Optimum Warehouse Removal Selection

The client for this and the next decision support system had an extensive set of warehouses and distribution centers. Over 500 distribution centers held product and were serviced by 15 regional warehouses serving the continental United States. The value of reducing the site would be a reduction of the excess inventory necessary to maintain them on a contingency basis. On the other hand, the marketing cost would be the increased distance from either the distribution center or the customer. This would translate into delay time and lost sales. The goal for both of these systems would focus around the estimation of the increased average and maximum distance that would be incurred with the reduction of sites.

Objective: To select the optimum warehouse reduction scheme.

Date: 1988

System/Language: *IBM PC/QuickBasic*

Success/Use: This was a single application system developed for use by the analyst. As such, it performed its function. However, no further application arose again.

Description: The warehouse reduction problem was fairly simple due to the lack of additional constraints and the relatively small number of warehouses involved (15). As such, "complete enumeration" could be used where the maximum distance between warehouses is computed and the one producing the smallest effect removed from the portfolio. The process is continued until none remain. The plot of the number of warehouses versus the maximum distances between them reflects the value of an additional warehouse. In this case the order of which warehouses should be considered for reduction was identified.

9.8.4.4. Optimum Distribution Center Selection

Objective: To determine the impact of reducing the number of distributors.

Date: 1988

System/Language: *IBM PC/QuickBasic, Eastern Software LP-88 (ORSYS)*[76]

Success/Use: This was also a single application system developed for use by the analyst. As such, it performed its function. However, other applications were discussed but never acted upon..

Description: The selection of distribution centers was far more complex than that of the warehouses. The distributors who own the centers are customers not employees. Contracts exist between these distributors and the firm. Furthermore, each distributor may have any number of centers. In many cases, the distributors take ownership of the products and therefore, the firm has little control over placement. This situation generates a fairly large number of constraints on the problem. These include:

- The minimum size of the total for the distributor;

- The maximum size for each distribution center;

- The minimum coverage of materials within a geographic area;

- The requirements of the existence of some centers; and

- Possibly the distance from the nearest second source.

The system was set up as a linear programming problem. With the objective function set at maximizing the sum of the product of the old and new product quantities at the

---

[76] I'm uncertain if *ORSYS* or *LP88* are presently available. They appear not to run in a *DOS* window within *Windows NT* or *XP*. Lindo may be a adequate substitute. However, the prices are significantly higher than these were.

distribution centers. This would drive the solution to the minimum number of distribution centers with a concentration on the largest centers. The problem consisted of over 1800 constraints (if second sourcing were included this rises to 2300 constraints) and over 500 non-slack variables. *Eastern Software LPX-88* and later *ORSYS* are Linear Program solvers.[77] These packages solve the problem based on an initial tableau and the objective function. The decision support system set up the initial tableau based on geographic positions of the distribution centers, desired levels and distances. Each line of the initial tableau represented a constraint, which was computed based on a *BASIC* program. The resulting tableau was then acted upon by the LP solver to generate the solution. It should be noted that the solution of the first problem of a set took up to 8 hours on an IBM AT (80286) personal computer. However, follow-up problems were solved much quicker using the previous solutions as starting points.

It should be noted, however, that the final solution may not be unique. Other solutions could give a comparable result. What the specific centers chosen to be closed was not critical in the analysis. What was of concern was the number of centers. The final report then consisted of the impact of changes in conditions, i.e. maximum distance between centers, minimum level of business to each distributor (group), maximum percentage increase in the size of a center, etc. against changes in the number of centers.

9.8.5. CUSTOMER DECISION SUPPORT (SALES AIDS)

Objectives: To provide tools for use either by the customer/end-user or by the sales-force to encourage the use of a firm's products.

Specifications and Components: These systems usually consist of two elements: (1) product specification (expert system) based on requirements of use, and (2) promotional and advertising materials.

Success Comments: The key success factors for the continued use of these systems include: (1) providing value to all users, (2) simplicity in design for easy modification, and (3) maintaining novelty. Our experience was that providing real value is difficult, novelty wears off quickly and unless value can be maintained, these systems have a very short life span. It should be noted, however, that the advent of the Internet and the World Wide Web has expanded the potential applications of these tools. We have recently seen an expansion of purchase aids in the direct sales arena and process aids for consumer products on the Internet.

9.8.5.1. Costing Models

Tailored products and service businesses require detailed cost estimates in order to price products and make deals. Costing models are design to help the sales force in estimating price. These are usually based on standard cost elements. Typically the results of these tools are a range of prices centered on a target or expected price as well as lower limits.

---

[77] The Simplex methods is used either in primal or dual forms.

Objective: To help the sales-force in estimating price for custom services and tailored services for weed and pest control businesses.

Date: 1988

System/Language: *IBM PC/Lotus 1-2-3*

Success/Use: This was an initial prototype system designed as much to explore the issues of standardized costing as to develop the functional sales aid. This initial system was used for researching the feasibility of the business concept. However, a more advanced on-line system was developed shortly thereafter and was used in operations.

Description: Prototyping is a key tool for developing operational decision support systems. *Lotus 1-2-3* and *Excel* are excellent tools for this type of prototyping effort. In this case, developing the prototype was a separate exercise from the final system.

9.8.5.2. Customer Product Selection Support

Objective: To get customer to specify the firm's products.

Date: 1985

System/Language: *IBM PC/BASIC*

Success/Use: This system was designed primarily as part of a corporate initiative on "Expert Systems". Two systems were developed, one using a suite of "Expert System" Development Tools for the mainframe (*DEC-10*) and a PC version using lookup tables. Custom Decision Support was responsible for the PC version. This system was far more effective partially due to the ineffectiveness state of computer data communications at the time. Several follow-up systems were developed for different crop markets. However, extensive use of these systems after its introduction were curtailed due to the perception that it was "not worth the effort" once the novelty had passed.

Description: These systems were specified by the client both as a sales tool and as a means of demonstrating the effective use of the recently obtained lap-top computers. The development of these systems was somewhat haphazard as was common during the introduction of personal computers into business. Due to the complexity of this program and lack of effective documentation, modification for use in its full form was difficult.

9.8.5.3. Product Use Assistance

Objective: To promote a new practice in the use of an agricultural protective product.

Date: 1986

System/Language: *IBM PC/BASIC*

Success/Use: These systems were a simplification of the previously discussed Product Selection Systems. There were used over a 2 year period for several applications. As in the more complex versions, they were dropped after the novelty wore off and more sophisticated commercial programs became available.

Description: These were greatly slimmed down version of the Product Specification Model; consisting mainly of information on the use of a key product for which there was little competition and some promotional and advertising "Gee Whiz." The effective part of these models was often the promotional "Gee Whiz" based on simple animation graphics. Ease of construction and maintenance coupled with the novelty of the lap-top computers gave these systems longer life than the more sophisticated systems.

9.8.5.4. New Product & Market Development (Marketing Toolkit)

Objective: To identify and develop effective marketing strategies with new products or where market conditions have changed. The focus is on product development, effective pricing, appropriate promotion (product messaging), and distribution development.

Date: 1992 - present

System/Language: *Microsoft EXCEL (Statistical Analysis by SYSTAT, others)*

Success/Use: Dozens of these systems have been developed covering a broad range of industries including, earth-moving equipment, computer peripherals, agricultural protective chemicals, specialty chemicals, engineering materials, consumer products, and pharmaceuticals. While these have been developed mainly for industrial products, some consumer and service products have also been explored. These have all been used to develop new products, design product launches, and reposition existing products under threat.

Description: The Marketing Toolkit consists of a number of modeling and data analysis visualization tools based on marketing analytical (survey) data. The structure is designed to allow for examining market segments and customer groups to test strategies. Specific research tools are deployed to allow for product and price optimization. Data is used to identify market segments and to provide quality (Six Sigma) view of the marketing process.