# Some Contribution to Practical Management Science Problems

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## ABSTRACT

The Subject of practical management science has evolved for over 50 years and is now a mature field within the broad category of applied mathematics and statistics. A mathematical model or a statistical model is a quantitative representation of a real problem and every management science application is a mathematical model or a statistical model. The main purpose of this research article is to expose a variety of problems that can be solved with management science methods and to give experience in modeling these problems. In this article, we would like to explain why the study of management science problems is a valuable experience using the concept of a mathematical model and describe a seven-steps models'-building process.

***Index Terms***—*Mathematical model, Statistical model, Management Science problem, Seven-steps models building process, descriptive model, Optimization model.*

## INTRODUCTION (IMPORTANCE OF STUDY MANAGEMENT SCIENCE PROBLEMS)

The management science is an important area and that highly trained analysts are need to solve the large and complex problems faced by the business world. However, unless you are one of the relatively few students who intends to become a management science professional, you are probably wondering why you need to study management science. This is a legitimate concern. The following are some of the reasons that is why we study management science.

I.1. **Development of Quantitative Skills:** Management science is admittedly built around quantitative skills – it deals primarily with numbers and relationships between number. As we work through the many models our quantitative skills will be sharpened immensely. In a business word driven increasingly by numbers, quantitative skills are an oblivious asset.

I.2. **Development of Logical Modelling Skills:** The modelling approach is an important and valuable way to think about problems in general, not just specific problems. This modelling approach directs us to think logically. We must discover that how given data can be used (or, as in some of the "modelling" problems, which data are necessary), we must determine the elements of the problem that we can control (the decision variable), and we must determine how the elements of the problem are logically related. We realized that these logical thinking skills will be valuable and helpful in our careers.

I.3. **Development of Spreadsheet Skills :** When we enter this course, our spreadsheet abilities might not be very good, but by studying many models and examining their solutions, we will be a proficient spreadsheet use. We will undoubtedly pick up a few useful tricks along the way. We chose the spreadsheet package Excel, which is the most widely used package (other than word-processing packages) in the business word today. The facilities we gained in Excel is worth. Not only has that but Excel given us complete control over our model. We can apply spreadsheets to an endless variety of problems. Spreadsheets give us the flexibility to work in a way that suits our style best and spreadsheets present results almost immediately. As we succeed with relatively easy problems, our confidence will build and we will be able o tackle more difficult problems successfully. In short, spreadsheets enable everyone, not just technical people, to develop and use their quantitative skills.

I. 4. **Development of Intuition :** Management science modelling helps us to develop our intuition, and it also indicates where intuition alone sometimes fails. When we confront a problem, we often make an educated guess at the solution. By studying many models and examining their solutions, we can sharpen our intuition considerably experienced management scientists tend to have excellent intuition – that is, the ability to see through to the essence of a problem almost immediately.

Now in next two subsequent we discuss the concepts of mathematical modelling and seven-step modelling process with it's application.

## BRIEF DISCUSSION OF THE SEVEN-STEPS MODELS BUILDING PROCESS

We now discuss the seven modeling steps in more detail.

- **Step:1 Problem Definition :**

Typically, a management science model is commissioned when an organization believes it has a problem. Perhaps the company is losing money, perhaps its market share is declining, perhaps its customers are waiting too long for service – any number of problems might be evident. The organization (Which we will refer to as the client) calls in a management scientist (the analyst) to help solve this problem. In such cases the problem has probably already been defined by the client, and the client hires the analyst to solve this particular problem.

As Miser (1993) and Volkema (1995) point out, however, the analyst should do some investigating before accepting the client's claim that the problem is already well defined. Failure to do so could mean solving the wrong problem and wasting valuable time and energy.

For example, Miser cites the experience of an analyst who was hired by the military to investigate overly long turnaround times between fighter planes landing and taking off again to rejoin the battle. The military was convinced that the problem was caused by inefficient ground crew – if they were sped up, turnaround times would presumably decrease. The analyst nearly accepted this statement of the problem and was about to do classical time-and-motion studies on the ground crew to pinpoint the source of their inefficiency. However, by snooping around, he found that the problem lay elsewhere. It seems that the trucks that refueled the planes were frequently late, which in turn was due to the inefficient way they were refilled from storage tanks at another location. Once this latter problem was solved – and it solution was embarrassingly simple – the turnaround times decreased to an acceptable level without any charges on the part of the ground crews. It the analyst had accepted the client's statement of the problem; the real problem might never have been located or solved.

The moral of this example is clear : If an analyst defines a problem incorrectly or too narrowly, the best solution to the real problem might never emerge. In his article, Volkema (1995) advocates spending as much time thinking about the problem and defining it properly as modeling and solving it. This is undoubtedly good advice, especially in real-world applications where problem boundaries are often difficult to define.

- **Step:2 Data Collection :**

This crucial step in the modeling process is often the most tedious. All organizations keep track of various data on their operations, but these data are often not in the form the analyst requires. In addition, data are often stored in different places throughout the organization and in all kinds of formats. Therefore, one of the analyst's first jobs is to gather exactly the right data and put the data into the appropriate form required by the model. This typically requires asking questions of key people (such as the accountants) throughout the organization, studying existing organizational databases, and performing time-consuming observational studies of the organization's processes. In short, it often entails a lot of leg work.

- **Step:3 Model Development :**

This step is where the analyst brings his or her special skills into play. After defining the client's problem and gather the necessary data, the analyst must develop a model of the problem. Several properties are desirable for a good model. First, it should represent the client's real problem accurately. If it uses a linear function for costs when the real cost function is highly nonlinear, the recommendations of the model could be very misleading. Similarly, if it ignores an important constraint such as an upper bound on capacity, it recommendations might not be possible to implement.

On the other hand, the model should be as simple as possible. Most good models capture the essence of the problem without getting bogged down in minor details. They should be approximations of the real world, not mirror images in every last detail. Overly complex models are often of little practical use. First, overly complex models are sometimes too difficult to solve with the solution algorithms available. Second, complex models tend to be incomprehensible to clients. After all, if a client cannot understand a thing about a model, the chances are not too good that the model's recommendations will ever be implemented. Therefore, a good model should achieve the right balance being too simplistic and too complex.

- **Step:4 Model Verification :**

This step is particularly important in real management science applications. A client is much more likely to accept an analyst's model if the analyst can provide some type of verification. This verification might take several forms. For example the analyst could use the model with the company's current values of the input parameters. If the model's outputs are then in line with the outputs currently observed by the client, the analyst has at least shown that the model can duplicate the current situation.

A second way to verify a model is to enter a number of sets of input parameters and see whether the outputs from the model are reasonable. One common approach is to use extreme values of the inputs to see whether the outputs behave as they should.

What if we enter certain inputs in the model, and the model's outputs are not as expected ? There could be two causes. First, the model could simply be a poor representation of the actual situation. In this case it is up to the analyst to refine the model until it lines up more accurately with reality. Second, It is possible that the model is fine but our intuition is not very good. That is, when asked what we think would happen if the inputs were set equal to certain values, we might provide totally wrong predictions. In this case the fault lies with us, not the model. Sometimes, good models prove that people's ability to predict outcomes in complex environments is lacking. In such cases, the verification step becomes harder because of "political" reasons.

- **Step:5 Optimization and Decision Making**

Once the problem has been defined, the data have been collected, and the model has been formulated and verified, it is time to use the model to recommend decisions or strategies. In the majority of management science models, this requires the optimization of an objective, such as maximizing profit or minimizing cost.

The optimization phase is typically the most difficult phase from a mathematical standpoint. Indeed, much of the management science literature (mostly from academics) has focused on complex solution algorithms for various of models. Fortunately for us, this research has led to a number of solution algorithms – and computer packages that implement these algorithms – that can be used to solve real problems. The most famous of these is the simplex algorithm. This algorithm, which has been implemented by many commercial software packages, is used on a daily basis to solve linear programming optimization models for many companies.

Not all solution procedures find the optimal solution to a problem. Many models are too large or too complex to be solved exactly. Therefore, many complex problems use heuristic methods to locate "good" solutions. A heuristic is a solution method that is guided by common sense, intuition, and trial and error to achieve a good, but probably not optimal, solution. Some heuristics are "quick and dirty", whereas others are quite sophisticated. As methods become larger and more complex, good heuristics are sometimes the best that can be achieved – and frequently they are perfectly adequate.

- **Step:6 Model Communication to Management :**

Sooner or later, an analyst must communicate a model and its recommendations to be client. To appreciate this step, you must appreciate the large gap that typically exists between the technical analyst and the manager of organizations. Managers know their business, but they often do not understand much about mathematics and mathematical models – even spreadsheet implementations of these models. The burden is therefore on the analyst to present the model in terms that non-mathematical people can understand ; otherwise, a perfectly good model might never see the light of day.

The best strategy for successful presentation is to involve key people in the organization, including top executives, in the project form the beginning. If these people have been working with the analyst, helping the analyst to understand the way the organization really works, they are much more likely to accept the eventual model. Step 6 therefore, should really occur throughout the modeling process, not just toward the end.

The analyst should also try to make the model as intuitive and as user-friendly as possible. Clients appreciate menu-driven systems with plenty of graphics. They also appreciate the ability to ask what-if questions and obtain answers quickly, in a form that is easy to understand. This is one reason for developing spreadsheet models. Although not all models can be developed on spreadsheets, due to size and/or complexity, we believe the spreadsheet approach in this book is an excellent choice whenever possible because most business people are comfortable with spreadsheets. Spreadsheet packages support the use of graphics, customized menus and toolbars, data tables and other tools for what-if analyses, and even macros for running complex programs.

- **Step:7 Model Implementation**

A real management science application is not complete until it has been implemented. A successful implementation can occur only when step 6 has been accomplished. That is, the analyst must demonstrate the model to the client, and the client must be convinced that the model adds real value and can be used by the people who will have to use it. For this reason, the analyst's job is not really complete until the system is up and running on a daily basis. To achieve a successful implementation, it is not just sufficient for upper management to accept the model; the people who will run it every day must also be thoroughly trained in its use. At the very least, they should understand how to enter appropriate inputs, run what-if analyses, and interpret the model's outputs correctly. If they conclude that the model is more trouble than it's worth, they might simply refuse to use it, and the whole exercise will have been a waste of time.

It is interesting to observe how many successful management science applications take a life of their own after the initial implementation. Once an organization sees the benefits of a useful model–and of management science in general – it is likely to expand the model or create new models for uses beyond those originally intended. Knowing that this is often the case, the best analysts design models that can be expanded. They try to anticipate problems the organization might face besides the current problem. Also, they stay in contact with the organization after the initial implementation, just in case the organization needs guidance in expanding the scope of the model.

This discussion of the seven-step modeling process has taken an optimistic point of view. We have assumed that a successful study will employ these seven steps, in approximately this chronological order, and everything will go smoothly. It does not always work out this way. Numerous potential applications are never implemented even though the technical aspects of the models are perfectly correct. The most frequent cause is probably a failure to communicate. The analyst builds a complex mathematical model, but the people in the organization don't understand how it works and hence are reluctant to use it. Also, company politics can be a model's downfall, especially if the model recommends a course of action that top management simply does not want to follow – for whatever reasons.

Even for applications that are eventually implemented, the analyst might not proceed through the seven steps exactly described in this section. He or she might backtrack considerably throughout the process. For example, based on a tentative definition of the problem, a model is built and demonstrated to management. Management says that the model is impressive, but it doesn't really solve the company's problem. Therefore, the analyst goes back to step 1, redefines the problem, and builds a new model (or modifies the original model). In this way, the analyst might generate several iterations of some or all of the seven steps before the project are considered complete.

## A SUCCESSFUL APPLICATION OF THE SEVEN-STEPS MODELLING PROCESS

In this section we discuss one particular successful management science application at GE Capital. We provide a detailed description of this application, and we tie our discussion of this application to the seven-step model-building process discussed in the previous section.

### GE Capital

GE Capital, a subsidiary of the General Company's financial services business, provides credit card service to 50 million accounts. The average total outstanding balance exceeds $12 billion. GE Capital, led by Makuch et al. (1992), developed the PAYMENT system to reduce delinquent accounts and the cost of collecting from delinquent accounts.

- **Step:1 Problem Definition :**

At any time, GE Capital has over $ 1 billion in delinquent accounts. The company spends $100 million annually processing these accounts. Each day employees contact over 200,000 delinquent credit cardholders with letters, taped phone messages, or live phone calls. However, prior to the study, there was no real scientific basis for the methods used to collect on various types of accounts. For example, GE Capital has no idea whether an account 2 months overdue should receive a taped phone message, a live phone call, some combination of these or no contact at all. The company's goal was to reduce delinquent accounts and the cost of processing these accounts, but it was not sure how to accomplish this goal. Therefore, GE Capital's retail financial services component, together with management scientists and statisticians from GE's corporate research and development group, analyzed the problem and eventually developed a model called PAYMENT. The purpose of this model was to assign the most cost-effective collection methods to delinquent accounts.

- **Step:2 Data Collection :**

They key data requirements for modelling delinquent accounts are delinquency movement matrices (DMMs). A DMM shows how the probability of the payment on a delinquent account depends on the collection action taken the size of the unpaid balance, and the account's performance score. For example, if a @ 250 account is 2 months delinquent, has a high performance score, and is contacted with a phone message, then certain events might occur with certain probabilities. The events and the probabilities for each possible collection action and each type of account.

Table 1.1 Sample DMM Entries

| Event | Probability |
|---|---|
| Account completely paid off | 0.33 |
| One month is paid off | 0.40 |
| Nothing is paid off | 0.30 |

Fortunately, because GE Capital had millions of delinquent accounts, plenty of data as available to estimate the DMMs accurately. To illustrate, suppose there are 1000 2-month delinquent accounts, each with balances under $300 and a high performance score. Also, suppose that each of these is contacted with a phone message. If 300 of these accounts are completely paid off by the next month, then an estimate of the probability of an account being completely paid off by next month is 0.30. By collecting the necessary data to estimate similar probabilities for all account types and collection actions, GE Capital finally had the basis for seeing which collection strategies were most cost-effective.

- **Step: 3 Model Development :**

After collecting the required data and expressing it in the form of DMMs, the company needed to discover which collections worked best in which situations. Specifically, the analysts wanted to maximize the expected delinquent accounts collected during the following 6 months. However, they realized that this is a dynamic decision problem.

For example, one strategy is called "creaming". In this strategy, most collection resources are concentrated on live phone calls to the delinquent accounts classified as most likely to pay up – the best customers. This creaming strategy is attractive because it is likely to generate short-term cash flows from these customers. However, it has two negative aspects. First, it is likely to cause a loss of goodwill among the best customers. Second, it gains nothing in the long run from the customers who are most likely to default on their payments. Therefore, the analysts developed the PAYMENT model to find the best decision strategy, a contingency plan for each type of customer that specifies which collection strategy to use at each stage of the account's delinquency. There are also constraints in the PAYMENT model to ensure that available resources are not overused.

- **Step: 4 Model Verification :**

A key aspect of GE Capital's problem is uncertainty. When the PAYMENT model specifies the collection method to use for a certain type of account, it implies that the probability of collecting on this account with this collection method is relatively high. However, there is still a chance that the collection method will fail. With this high degree of uncertainty, it is difficult to convince skeptics that the model will work as advertised until it has been demonstrated in an actual environment.

This is exactly what GE Capital did. It piloted the PAYMENT model on a $62 million portfolio for a single department store chain. To see the real effect of PAYMENT's recommended strategies, the pilot study used manager-recommended strategies for some accounts and PAYMENT- recommended strategies for others. They referred to this as the "champion" versus the "challenger". The challenger (PAYMENT) strategies were the clear winners, with an average monthly improvement of $185,000 over the champion strategies during 5-month period. In addition, because the PAYMENT strategies included more "no contact" actions – don't bother the customer this month – they led to lower collection costs and greater customer goodwill. This demonstration was very convincing. In no time, other account managers wanted to take advantage of PAYMENT.

- **Step: 5 Optimization and Decision Making:**

As described in step 3, the output from the PAYMENT model is a contingency plan. The model uses a very complex optimization scheme, along with the DMMs from step 2, to decide what collection strategy to use for each type of delinquent account at each month of its delinquency. At the end of each month, after the appropriate collection methods have been used and the results have been observed, the model then uses the status of each account to recommend the collection method for the next month. In this way, the model is used dynamically through time.

- **Step: 6 Model Communication to Management:**

In general, the analyst communicates the model to the client in step 6. In this application, however, the management science team members were GE's own people – they came from GE Capital and the GE corporate research and development group. Throughout the model-building process, the team of analysts strived to understand the requirements of the collection managers and staff – the end users – and tried to involve them in shaping the final system. This early and continual involvement, plus the impressive performance of PAYMENT in the pilot study, made it each to "sell" the model to the people who would have to use it.

- **Step: 7 Model Implementation:**

After the pilot study, PAYMENT was applied to the $4.6 billion Montgomery Ward department store portfolio with 18 million accounts. Compared to the collection results from a year earlier, PAYMENT increased collections by $1.6 million per month, or over $19 million per year. Since then, PAYMENT has been applied to virtually all of GE Capital's accounts, with similar success. Overall, GE Capital estimates that PAYMENT has increased collections by $37 million per year and uses less resource than previous strategies. Since the original study, the model has been expanded in several directions. For example, the original model assumed that collection resources, such as the amount available for live phone calls, were fixed. The model has since been expanded to treat these resource levels as decision variables in a more encompassing optimization model..

## CONCLUSION

Our world is fast changing. New developments are taking place in the field of management science and technology everyday. Sophisticated and complex equipments are being researched designed, developed and implemented in every walk of life.

In this research article, we have introduced the field of management science and discussed why the study of management science is a valuable experience, even if you don't intend to pursue a professional career in this field. To prove more concrete understanding of these concepts, we described a seven-steps models building process that begins with problem definition and proceeds though final implementation. Finally, a successful application of seven-steps modeling process is also discussed.

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