Chapter 3
Perfect Partners of Mathematical Modeling with Technology in Risk Assessment

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ABSTRACT

This chapter discusses the use of mathematical modeling with technology in risk assessment in the broad area of operations research. The authors provide modeling as a process and illustrate suggested steps in the process. This chapter reviews some of the main modeling texts and provide a brief discussion of their processes. Many illustrative examples are provided to show the breadth of mathematical modeling. These examples cover such topics as discrete dynamical systems, game theory, multi-attribute decision making, data envelopment analysis with linear programming, and integer programming. The authors discuss the important of sensitivity analysis, as applicable. Several scenarios are used as illustrative examples of the process.

INTRODUCTION

Consider the importance of modeling for decision making in business (B), industry (I), and government (G). BIG decision making is essential to success at all levels. We do not encourage "shooting from the hip". We recommend good analysis for the decision maker to examine and question in order to find the best alternative to choose or decision to make. This book explains the modeling process and provides examples of decision making throughout.

Let's describe a mathematical model as a mathematical description of a system using the language of mathematics. The process of developing such a mathematical model is termed mathematical modeling. Mathematical models are used in the natural sciences (such as physics, biology, earth science, meteorology), engineering disciplines (e.g. computer science, systems engineering, operations research, and in the social sciences (such as business, economics, psychology, sociology, political science, and social

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networks). The professional is these areas use mathematical models all the time. A mathematical model may be used to help explain a system, to study the effects of different components, or to make *predictions* about behavior (Giordano, Fox, & Horton, 2013).

Mathematical models can take many forms, including but not limited to dynamical systems, statistical models, regression models, differential equations, optimization models, or game theoretic models. These and other types of models can overlap, or one output becomes the input for another similar or different model form. In many cases, the quality of a scientific field depends on how well the mathematical models developed on the theoretical side agree with results of repeatable experiments (Giordano, et al, 2013). Any lack of agreement between theoretical mathematical models and experimental measurements could lead to model refinements and better, more useful, models. We do not plan to cover all the mathematical modeling processes here. We only provide an overview to the decision makers. Our goal is to offer *competent, confident problem solver*s for the 21st century. We suggest the references listed at the end of this chapter in order to get more familiar with the many techniques in mathematical modeling.

BACKGROUND

Overview and the Process of Mathematical Modeling

Bender (1978) first introduced a process for modeling. He highlighted: formulate the model, outline the model, ask is it useful, and test the model. Others have expanded on this simple outlined process. Giordano et al. (2013) presented a six step process: identify the problem to be solved, make assumptions, solve the model, verify the model, implement the model, and maintain the model. Myer (1984) suggested some guidelines for modeling including formulation, mathematical manipulation, and evaluation. Meerschaert (1993) developed a five step process: ask the question, select the modeling approach, formulate the model, solve the model, and answer the question. Albright (2010) subscribes mostly to concepts and process described in previous editions of Giordano. Fox (2012) suggested an eight-step approach: understand the problem or question, make simplifying assumptions, define all variables, construct the model, solve and interpret the model, verify the model, consider the model's strengths and weaknesses, and implement the model.

Most of these pioneers in modeling have suggested similar starts in understanding the problem or question to be answered and making key assumptions to help enable the model to be built. We add here the need for sensitivity analysis or model testing to help insure we have a model that is performing correctly to answer the appropriate questions.

Someplace between the defining of the variables and the assumptions, we begin to consider the model's form and technique that might be used to solve the model. The list of techniques is boundless in mathematics and we will not list them here. Suffice, it to say it might be good to initially decide among the mathematical forms: deterministic or stochastic for the model, linear or nonlinear for the relationship of the variables, and continuous or discrete.

In this chapter we will illustrate some application of models to problems in decision making in business, industry, and government. We will discuss briefly the formulation of the model emphasis various aspects of importance to modeling. We will also provide a solution using the most common technique to solve that class of modeling problems.

For example, consider the following:

Integrating the Information Systems Success Model With Project Success Management Process: Position Paper
Ali Varshosaz, João Varajãoand Nilton Takagi (2021). *International Journal of Applied Management Theory and Research (pp. 1-13).*
www.irma-international.org/article/integrating-the-information-systems-success-model-with-project-success-management-process/279651