# THE ROLE OF QUANTITATIVE METHODS IN MANAGEMENT

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When we look at the current global financial meltdown, it is hard to resist asking ourselves the simple and obvious question, "Where have we gone wrong?" I don't think there are simple answers to this simple question. In any case, hindsight will not help us get out of the present mess brought about by the demise of a 158-year-old institution called Lehman Brothers and the collapse of financial giants such as Merrill Lynch and AIG which had to be rescued by Bank of America and the US government with a staggering price tag of $700 billion or more. To quote Santosh Desai, these were all solid corporations staffed by the brightest people from business schools across the world. It is reasonable to assume that these business school professionals had enough exposure to quantitative methods, modeling, and forecasting, to be able to apply these tools toward optimizing their business decisions. Yet, the outcomes we have seen recently must make us wonder about the effectiveness of such tools in today's complex financial world, or the skill set of the decision makers, or both.

It is clear that quantitative techniques have their limitations. They are typically based on assumptions that, in some situations, may not be consistent with reality. Quoting Santosh Desai again, "The headiness of wealth in the short term blinds us to the cantankerous nature of money in the long run. Money exaggerates natural cycles; so when the going is good or particularly bad, it is easy to forget that it can be any other way. When the sensex touched 21,000, most experts believed that it would reach 25,000, and when oil prices approached $150 per barrel, most agreed that they would cross the $175/barrel mark. If one thing is clear from the current crisis, it is that there are no experts when it comes to money, only people with varying degrees of greed." This sentiment is echoed by Chidanand Rajghatta who has come up with credible terms for the usual acronyms, such as Chief Embezzlement Officer for CEO and Corporate Fraud Officer for CFO, and jokes such as "What is the difference between an investment banker and a pigeon? A pigeon can still make a deposit on a Ferrari." The point is that we need new quantitative models which factor in such attributes as greed and fraud, to be able to predict financial meltdowns such as the one we are presently facing.

From a brighter perspective, quantitative tools can be immensely helpful in making optimal decisions in almost any field of human endeavor ranging from pharmaceutical research and development to market research and financial services. Quantitative techniques can be viewed as forming the basis for decision theory, which is about making optimal decisions in the face of uncertainty.

Typically, decision theory tends to be normative or prescriptive in that it focuses on identifying the best decision to be taken, assuming an ideal decision maker who is well informed and rational in his or her approach. The common terminology for this prescriptive approach (how people should make decisions) is called decision analysis, which is aimed at organizing tools, methodologies and software to help people make better decisions. The most systematic and comprehensive software tools developed in this way are called decision support systems. As the label suggests, these decision support systems are just aids for decision making, and are not to be viewed as completely automated decision systems into which you can feed your questions and expect valid answers.

Several statistical tools and methods are available to organize evidence, evaluate risks, and aid in decision making. Hypothesis testing is one such tool. The following example shows a structure for deciding guilt in a criminal trial:

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Actual State of Affairs</td></tr>
<tr><td>Guilty</td><td>Not guilty</td></tr>
<tr><td rowspan="2">Decision</td><td>Verdict of 'guilty'</td><td>True Positive</td><td>False Positive<br>(i.e. guilt reported unfairly)<br>Type I error</td></tr>
<tr><td>Verdict of 'not guilty'</td><td>False Negative<br>(i.e. guilt not detected)<br>Type II error</td><td>True Negative</td></tr>
</table>

Of the two types of errors denoted in the table above, it is clear that Type I error, namely that of rendering the 'guilty' verdict when the defendant is actually not guilty, is a more serious error than Type II error, namely that of rendering the 'not guilty' verdict when the defendant is actually guilty. The judicial system usually requires strong and compelling evidence beyond reasonable doubt, before pronouncing a defendant guilty. In this case, the hypothesis to be tested, typically referred to as the null hypothesis, is that the defendant is not guilty so that the null hypothesis is presumed sufficient to explain the data unless there is overwhelming evidence to indicate that the data does not support the null hypothesis, in which case the null hypothesis is rejected in favor of the alternative hypothesis, namely, that the defendant is guilty.

The probability of Type I error, namely, an erroneous conclusion resulting from the rejection of the null hypothesis when it is really true, called the significance level of the test, is controlled by setting it at a small predetermined value such as 0.05. This means that there is only a 5% chance of rejecting a true null hypothesis. While it is important to first control the probability of Type I error, it is necessary to address the probability of Type II error as well. In general, there is an inverse relationship between the probabilities of the two types of errors for a given set of sample data or level of evidence. The only way to simultaneously decrease both types of errors would be to increase the extent of data or evidence by expending more resources. The power of a test is defined as the probability of a correct decision resulting from rejecting the null hypothesis when it is not true, which is equivalent to 1-the probability of Type II error.

For a clinical study designed to demonstrate the superiority of a test drug to placebo, the probability of Type I error is typically set at the 5% significance level, while the number of patients to be enrolled in the study, referred to as the sample size, is determined with the aim of achieving a power of at least 80% for demonstrating the superiority of the test drug.

In order to test any hypothesis, it is necessary to collect appropriate data. Consider a clinical trial designed to test the null hypothesis that the administration of a certain drug does not cause a change in alkaline phosphatase levels. A very simple clinical trial can be conducted to gather data from 100 patients on alkaline phosphatase levels after administration of the drug. A suitable probability model is used to describe the data and an appropriate test is done to test the hypothesis.

Once you have clearly defined the random variable (such as the alkaline phosphatase level whose values occur randomly, but follow a probability distribution) you are interested in, the next step is to measure the values your random variable generates. Ultimately you want to use this empirical information to construct the observed probability distribution for your random variable. The graph of the observed probability distribution may immediately suggest a theoretical probability distribution (such as, a normal distribution). You can use a theoretical distribution, in lieu of the observed probability distribution, to derive inferences about the probability of observing various types of outcomes. In the model-fitting stage, your goal is to replace the observed probability distribution with a better understood theoretical probability distribution. This substitution enables you to more easily make probability statements about your random variable. Based on this probability model, it is possible to decide whether the observed values of the random variable are consistent with the null hypothesis. If so, the null hypothesis is not rejected and one can conclude that there is no change in alkaline phosphatase levels or that there is insufficient evidence to indicate a change.

If the null hypothesis is rejected, and the conclusion is that there is a significant increase in alkaline phosphatase levels, the logical next step is to estimate the magnitude of the increase. Estimation theory is a branch of statistics that deals with estimating the values of parameters based on measured or empirical data. Estimators attempt to approximate the unknown parameters using the observed measurements. For example, consider estimating the proportion of a population of voters who will vote for a particular candidate. That proportion is the unobservable parameter, and the estimate can be based on a small random sample of voters. The estimation process also involves quantifying the extent of uncertainty about each estimated value by providing a confidence interval (with a high level of confidence such as 95%) with lower and upper limits for each estimate.

Forecasting is another major statistical tool used in making decisions. Planning for the future is essential for any business. Commodities industry needs forecasts of supply and demand for production planning, sales, marketing, and financial decisions. Financial institutions face the need to forecast volatility in stock prices. There are macro economic factors that have to be predicted for policy-making decisions by governments. The list is endless and forecasting is a key 'decision-making' practice in most organizations.

It is a good idea for managers to keep themselves abreast of forecasting methods. There are plenty of forecasting models available. However, choosing the right one is not an easy task. A common, but erroneous perception is that complex forecasting models always give better results than simple ones. It is important to validate any model using available data.

Forecasting techniques that are frequently used can be subsumed under regression analysis, a collective name for techniques for the modeling and analysis of numerical data consisting of values of a dependent variable (response variable) and of one or more independent variables (explanatory variables). The dependent variable in the regression equation is modeled as a function of the independent variables, corresponding parameters, and an error term. The error term is treated as a random variable. It represents unexplained variation in the dependent variable. The parameters are estimated so as to give a "best fit" of the data. Most commonly the best fit is evaluated by using the least squares method.

Regression can be used for prediction (including forecasting of time-series data), inference, hypothesis testing, and modeling of relationships between variables. These uses of regression rely heavily on the underlying assumptions being satisfied. Once a regression model has been constructed, it is important to confirm the goodness of fit of the model.

Regression models are used to help us predict the value of one variable from one or more other variables whose values are known. Regression analysis can be used for predicting the outcome of a given business indicator (dependent variable) based on other related business drivers (explanatory variables). For example you could predict sales volume based on the amount spent on advertising and the number of sales people employed. In practice, a more complex model with more variables would be required.

The growing complexity and volatility of the business environment has made decision making very difficult. Decision-makers can no longer afford to make decisions that are based solely on their experience and observation. Decisions need to be based on data that show relationships, indicate trends, and show rates of change in the relevant variables. The merit of Quantitative methods is that they provide an analytical and objective approach to decision making and help managers tackle the intricate and complex problems of business and industry. These methods can be used to deploy resources efficiently, project long-term capital requirements, forecast demand, and identify customer preferences.

Quantitative methods are especially helpful in marketing research. The environment for marketing has become extremely dynamic. Without adequate preparation, it is difficult for organizations to survive in such an environment. Marketing research is one of the most effective tools that help organizations excel in the marketplace. Obtaining necessary information about customers' tastes and preferences is the key to business success.

Marketing research provides information about consumers and their reactions to various products, prices, distribution, and promotion strategies. Marketers who collect accurate and relevant information quickly and design their strategies accordingly are more likely to be successful in the marketplace.

Marketing research helps in effective planning and implementation of business decisions by providing accurate, relevant, and timely information. The process of marketing research involves a series of steps for systematically investigating a problem or an opportunity.

This investigation starts with problem or opportunity recognition and definition, development of objectives for the research, development of hypotheses, planning the research design, selecting a research method, analyzing the research designs, selecting a sampling procedure, data collection, evaluating and analyzing the data, and finally preparing a research report. The research process provides a scientific platform, contrary to the traditional intuitive approach of decision making by managers which used to put large amounts of resources of the organization at risk.

Quantitative techniques such as estimation, hypothesis testing, regression analysis, and cluster analysis play a key role in marketing research, which is used for new product development, segmenting markets, identifying the needs of the customers, sales forecasting, estimating the market potential of products and services, and analyzing the satisfaction levels of customers.

Various constrained optimization techniques such as linear programming are also helpful in making business decisions. Linear programming (LP) is a technique for optimization of a linear objective function subject to linear equality and linear inequality constraints. Informally, linear programming determines the way to achieve the best outcome (such as maximum profit or lowest cost) in a given mathematical model, given a list of requirements represented as linear equations.

Linear programming can be applied to various fields of study. Most extensively it is used in business and economic situations, but it can also be utilized for some engineering problems. Some industries that use linear programming models include transportation, energy, telecommunications, and manufacturing. It has proved useful in modeling diverse types of problems in planning, routing, scheduling, assignment, and design.

Linear programming is heavily used in business management, either to maximize the income or minimize the cost of a production scheme. Some examples are food blending, inventory management, portfolio and finance management, resource allocation for human and machine resources, and planning advertisement campaigns.

In conclusion, there is every incentive to use quantitative techniques, along with qualitative analysis and sound judgment, to enhance the efficiency of any business process.

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