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[QUANTITATIVE TECHNIQUES]

Complete Quantitative Techniques notes of CPSP-K II (Certified Procurement and Supply Professional of Kenya) by www.masomomsingi.co.ke

TABLE OF CONTENTS

CONTENTS

OVERVIEW

Quantitative techniques are those statistical and programming techniques, which help decision makers solve many problems, especially those concerning business and industry and industry.

Quantitative techniques can also be described as those techniques that provide the decision makers with systematic and powerful means of analysis, based on quantitative data, for achieving predetermined goals.

These techniques involve the use of numbers, symbols, mathematical expressions, other elements of quantities and serve as supplements to the judgment and intuitions of the decision makers.

Classification

They can broadly be put under two groups.

1. Statistical Techniques: Which are used in conducting the statistical inquiry concerning a certain phenomenon.

It includes all the statistical methods beginning from the collection of data till the task of interpretation of the collected data. Collection, Classification, Summarizing, Analyzing , Interpretation of the data.

First designed to tackle defense and military problems and are now being used to solve business problems.

2. Programming Techniques: Used by many decision makers in modern times.

First designed to tackle defense and military problems and are now being used to solve business problems.

It includes variety of techniques like linear programming, games theory, simulation, network analysis, queuing theory, and so on.

Applications of Programming Techniques:

-System under consideration are defined in mathematical language: Variable (Factors which are Controlled), Coefficients (Factors which are not controlled)

-Appropriate mathematical expressions are formulated which describes inter-relations of all variables and coefficients. This is known as the formulation of the mathematical model. It describes the technology and the economics of a business through a set of simultaneous equations and inequalities

-An optimum solutions is determined (Maximizing profit and Minimizing cost)

Role of Quantitative Techniques in Business and Industry

Quantitative techniques specially operation research techniques have gained increasing importance since world war II in the technology of business administration. These techniques greatly help in tackling the intricate and complex problems of modern business and industry.

Role of Quantitative Techniques in Business and Industry

- Role can be well understood under the following heads
- They provide a tool for scientific analysis
- They provide solutions for various business problems
- They enable proper deployment of resources
- They help in minimizing waiting and servicing costs
- They enable the management to decide when to buy and how much to buy
- They assist in choosing an optimum strategy
- They render great help in optimum resource allocation
- They facilitate the process of decision making
- Through various quantitative techniques management can know the reaction of integrated business systems

Quantitative Techniques and Business Management

1. It helps the directing authority in optimum allocation of various limited resources viz., men, machines, money, material, time etc.
2. It useful to the production management: selecting the building site for a plant, scheduling and controlling , locating, scheduling and calculating the optimum product-mix
3. It useful to the personnel management: optimum manpower planning, the number of persons to be maintained on the permanent or full time role, kept in a work pool intended for meeting the absenteeism.
4. It equally help the marketing management to determine – distribution points, warehousing should be located, their size, quantity to be stocked choice of customer, optimum allocation of sales budget to direct selling and promotion expenses with consumer preferences

5. It is very useful to the financial management – finding long range capital, determining optimum replacement polices, workout profit plan, estimating credit and investment risk.

Limitations

1. The inherent limitation concerning mathematical expressions
2. High costs are involved in the use of quantitative techniques
3. Quantitative techniques do not take into consideration the intangible factors i.e. non-measurable human factors.
4. Quantitative techniques are just the tools of analysis and not the complete decision making process

Need for Quantitative techniques

Mathematics is logical and precise as applied to measurable phenomena. Measurable quantities include:

-Output
-Revenue
-Commissions
-Costs
-Profits etc.

Rationale: Management needs to be able to influence factors which can be manipulated or controlled to achieve objectives e.g. sales level is determined by a sales function which has determinants such as level of advertising, price, income etc.

Optimization theory i.e. maximising or minimising some measure of revenue or costs calls for the use of mathematical analysis.

Maximise: Revenue, profits, productivity, and motivation

Minimise: Costs, risks, lateness, fatigue

Mathematical analysis also helps in marginal analysis i.e. the conversion of marginal function to a total function.

Drawback: It is not applicable to non-measurable phenomena even if such a factor is crucial to the success of an organization.

Development of quantitative techniques

Frederick Winslow Taylor is credited with the initial development of scientific management techniques. The scientific management principle developed by him during the early nineteen hundreds, laid the basis to the study of managerial problems. He developed his theory emphasizing the new philosophy of management responsibility for planning and supervision and formulating of rules, formulae, etc. in connection with labor and machine techniques, which would result in lower cost to the employer and a higher return to labor.

Taylor's chief contribution to the development of management theory was an application of scientific method to problems of management. His emphasis on the study of management from the point of view of shop management led to the overlooking of "the more general aspects of management, particularly in the United States and Great Britain."

In addition, several management science techniques were further developed during World War II.

World War II posed many military, strategic, logistic, and tactical problems. Operations research teams of engineers, mathematicians, and statisticians were developed to use the scientific method to find solutions for many of these problems. The usefulness of the Quantitative Technique was evidenced by a steep growth in the application of scientific management in decision-making in various fields of engineering and management. At present, in any organization, whether a manufacturing concern or service industry, Quantitative Techniques and analysis are used by managers in making decisions scientifically.

Types of Quantitative Techniques

Differentiation

A popular type of quantitative technique is differentiation. Differentiation is a mathematical process involving calculus and it is useful for seeing change over time within a given system.

Differentiation is generally used to figure out the changes in a system when a variable in the system changes, measuring how the end result changes by altering a variable. This could be used in many ways: in cooking, chemistry, and many physical sciences, yet it is less useful in a social science. Differentiation also has an opposite, integration, which works in the opposite way. Integration is used to see the changes to a variable when the system changes.

Regression Analysis

Regression analysis is incredibly useful and a whole host of people use this technique every single day in their business life. Generally, economists are interested in the concept of regression analysis, which is based around finding a causal link or correlation between two independent variables in any given system. A common example for regression analysis is that of measuring the salary of an employee and their level of education, to see if there is a correlation between the two factors. You could also use this in cooking and many other fields, as you can see. Regression analysis is useable in many fields and will save you time if you learn how to use it and integrate in to your business.
Regression analysis uses two sets of data, predictors and independent variables. These values can be anything, from total revenue to tax rate to advertisement budgets and so on. Comparing the two is the basis of regression analysis.

Simulation

Simulation is a great way to get pseudo real world data on anything that can be simulated effectively in a controlled environment. If you can simulate a scenario effectively, you can then see how test subjects respond to stressors and often this information is very valuable. It’s not just used for living things however, a wind tunnel is a widely used simulator to test the aerodynamics of cars and other objects. This data allows the manufacturer to make tweaks in design and concept and can show data which may lead to the product being discontinued before production starts. This is obviously a good thing as recalling product lines is costly and should be avoided at all costs. Simulation allows these kind of usability tests, even in unlikely scenarios.

Factor Analysis

Factor analysis is another often used data technique used for quantitative data analysis. This type of analysis tries to thin down the amount of data that is available to be used by exploring the similarities between multiple sets of data. This way, you can analyze the overall trends that are hiding in the data without having to figure these out yourself. Market researchers and economists are very avid users of Factor Analysis as it makes trawling through large sets of data received from surveys easy and quick.

Indexes

Another one for the economists, indexes are a fantastic way to use quantitative research to simplify and share data with the general public in an efficient and easy manner. Indexes are all over the finance world, with each of the major stock exchanges (NASDAQ etc.) having an index as a representation of how the financial market is doing. Analyzing indexes is useful as they are a useful way to see how the overall trend of a given environment is behaving. People base decisions worth hundreds of thousands of dollars on the existence of stock market indexes every day and without quantitative analysis and research this wouldn't be possible.

Game and Probability Theory

Game Theory is a class of thought that aims to find the most optimal strategy in any given scenario. It achieves this by using quantitative methods and thought experiments and always finds the optimal course of action in a competitive situation. This type of quantitative technique is slightly less applicable to business, yet very useful if you find yourself in a situation where you are unsure of the options.

The "Prisoner's Dilemma" is a very common instance of game theory, showing why two people may not cooperate with each other, even if cooperation is the best move, statistically. In the canon of the Prisoner's Dilemma, two prisoners are offered one of three options to remedy their current situation. They are offered the chance to testify about the other person, getting released from prison at the expense of the other prisoner spending times in the jail. The other option is to be quiet, not telling the officer anything. If both parties stay silent, both parties are in jail for a year, whereas in the other scenario, the jail time served is greater. This shows that the correct thing to do is stay silent. Of course, in that situation, you would probably try to get out of jail by offering evidence against the others. The dilemma occurs as

both parties are given these options, meaning if both parties try to get no jail time, they both end up in jail for longer. Quantitative thinking techniques like these allow people to make more logical and useful real world decisions and are a cornerstone of advanced logical reasoning.

Probability theory is useful to use in conjunction with statistics allowing someone to semi-accurately predict how someone or something will act in a given situation, assuming you have access to all of the necessary data. Probability theory is useable to see patterns in apparent randomness. This is how we know that the probability of getting a heads or tails on any given coin flip is equal. The coin flip itself is random, yet over time it averages out to a 50% chance of heads or tails.

Quantitative Data Collection

As mentioned above, the best way to collect non-biased and useful quantitative data is choosing to conduct double or triple blind experiments which allow more accurate results for a given portion size. Quantitative data can also be collected in many other ways, depending on the situation you are trying to gather data upon. For data from inanimate objects, you can use sensors and electronic surveying tools to gather numerical data. When you are trying to get quantitative data from people, it is a little more difficult to get accurate data. Surveys and questionnaires will get you some useable data but the data from these may be inaccurate. Many people will answer untruthfully on a questionnaire for lots of different reasons. If you need to find data on objects or the general population, city records and other standardized records will be of a great help to you. For products, most manufacturers will keep records of their product specifications, for the general public to browse. This is helpful for techniques, which need complete information to use, such as testing audio or visual equipment and tests of this sort.

Areas where Quantitative techniques are applicable

Finances

One area where quantitative techniques are applied in business is in the area of finances. Some of the models that financial managers and analysts use are return on investment, decision trees and net present value. Financial analysts determine how much profit a particular product brings in versus the costs of producing that product. They run regressions

and analyses to note trends over time and determine how much to invest in a particular business line. Financial analysts also use quantitative methods to determine productivity and whether or not to hire, retain or lay off workers. They use quantitative data to manage risk and create investment vehicles.

Advertising

Advertisers use quantitative data to determine how many viewers or readers will see a particular advertisement in a particular medium. They use data from rating services to find out how many people click on a certain website or watch a particular television show at any time. Advertisers also use quantitative data to do pre- and post-testing of advertisements. Advertisers use surveys to test ad recall in viewers, and attitudes about proposed advertisements, among other things.

Marketing

Companies make heavy use of statistics to determine how to market their products, which markets their products and services will do best in and which consumers will buy their products. There are thousands of companies in the United States that gather and analyze data about consumer interests, desires, likes, dislikes, motivations and concerns. Marketers use this data to focus sponsorships, direct mail campaigns and position their companies in the general culture. Marketers also use data from UPC codes at stores (often in combination with shopper discount cards) to determine who is buying their products, how often and where. This also gives them important information to use in making decisions about stocking, delivery and promotions.

Insurance

Insurance companies have a multitude of applications for quantitative data. Although many of these applications could transfer to other businesses, insurance companies have dozens of statisticians or actuaries on staff. Therefore, they have the manpower and know-how to analyze mountains of data. For example, insurance companies gather data about each salesperson in each line of business. They then analyze the data to see if there are similarities in the top salespeople so they can recommend improvements to those not doing so well. They also see which lines of business produce profit and which should be closed down because

they are unprofitable. Insurance company actuaries also analyze data on accidents, fires, floods and other mishaps that require them to pay out money and use these analyses to set insurance rates for their customers.

EQUATIONS AND FUNCTIONS

1. Linear Equations

They are equations with one unknown and the index of the unknown is one. It is of the form ax + b =0. Where *a* and *b* are constants and the solution is obtained by writing ax= -b

And getting a = $\frac{b}{X}$ provided that a ≠ 0

Example

Solve for x in the following equation.

$x - 4 = 10$

Solution

Add 4 to both sides of the equation:

$x = 14$

The answer is $x = 14$

Check the solution by substituting **14** in the original equation for x. If the left side of the equation equals the right side of the equation after the substitution, you have found the correct answer.

2. Simultaneous equations

i. The Elimination Method

This method for solving a pair of simultaneous linear equations reduces one equation to one that has only a single variable. Once this has been done, the solution is the same as that for when one line was vertical or parallel. This method is known as the ***Gaussian elimination method***.

Example

Solve the following pair of simultaneous linear equations:

Equation 1: $2x + 3y = 8$
Equation 2: $3x + 2y = 7$

Step 1: Multiply each equation by a suitable number so that the two equations have the same leading coefficient. An easy choice is to multiply Equation 1 by 3, the coefficient of x in Equation 2, and multiply Equation 2 by 2, the x coefficient in Equation 1:

3 * (Eqn 1) ---> 3* ($2x + 3y = 8$)---> $6x + 9y = 24$

2 * (Eqn 2) ---> 2 * ($3x + 2y = 7$)---> $6x + 4y = 14$

Both equations now have the same leading coefficient = 6

Step 2: Subtract the second equation from the first.

$$\begin{array}{r} 6x + 9y = 24 \\ -(6x + 4y = 14) \\ \hline 5y = 10 \end{array}$$

Step 3: Solve this new equation for y.

$$y = 10/5 = 2$$

Step 4: Substitute $y = 2$ into either Equation 1 or Equation 2 above and solve for x. We'll use Equation 1.

$$\begin{array}{ll} 2x + 3(2) = 8 & \\ 2x + 6 = 8 & \text{Subtract 6 from both sides} \\ 2x = 2 & \text{Divide both sides by 2} \\ x = 1 & \end{array}$$

Solution: $x = 1$, $y = 2$ or (1,2).

ii. Substitution Method

If two (or more) equations have the same variables and the same solutions then they are simultaneous equations. For example, these equations are simultaneous equations:

$$x + y = 3 \text{ and}$$

$$2x + 3y = 8$$

because both have the **same variables**: 'x' and 'y', and the **same solutions**: $x = 1$, $y = 2$

Substituting $x = 1$ and $y = 2$ into both equations, they BOTH give correct answers:

$$1 + 2 = 3 \text{ and}$$

$$2\acute{}1 + 3\acute{}2 = 8$$

Thus: $x = 1$ and $y = 2$ are the solutions to both equations.

'Solving' simultaneous equations means finding the values of 'x' and 'y' that make them true. The following steps will demonstrate how to solve simultaneous equations by the **substitution method**.

Example

(1) Isolate one of the variables ('*x*') on one side of one of the equations:

$$x + y = 3$$

Isolating '*x*':

$$x = 3 - y$$

(2) Substitute for the isolated variable in the other equation:

$$2x + 3y = 8$$

Substituting 3 - y for '*x*':

$$2(3 - y) + 3y = 8$$

This equation has only one variable, so we can solve it.

(3) Solve this equation for the other variable, '*y*':

$$2(3 - y) + 3y = 8$$

Expanding the brackets:

$$6 - 2y + 3y = 8$$

Simplifying:

$$6 + y = 8$$

Subtracting 6 from both sides:

$$y = 2$$

(4) Substitute the known value of '*y*' into the equation for '*x*' derived in step 1:

$$x = 3 - y$$

Substituting 2 for **'*y*'**:

$$x = 3 - 2$$

Therefore:

$$x = 1$$

The 'Method' section below shows you how to use Algematics to solve simultaneous equations by substitution.

3. Quadratic functions

General formula: y =a + b1x + b2x2

Where x = independent variable

y = dependent variable

a, b1, b2 = constants

Note b2 ≠ 0

Properties of quadratic functions

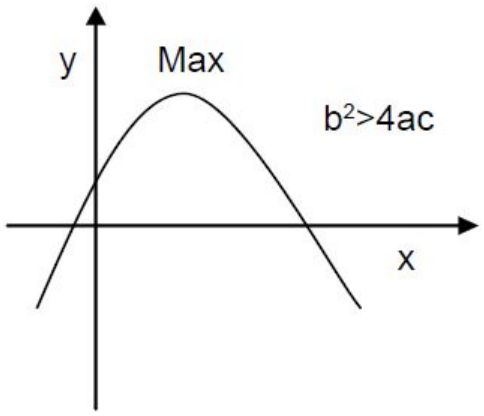
1). N umber of solutions (roots) is 2, i.e. it can cross the x-axis twice.

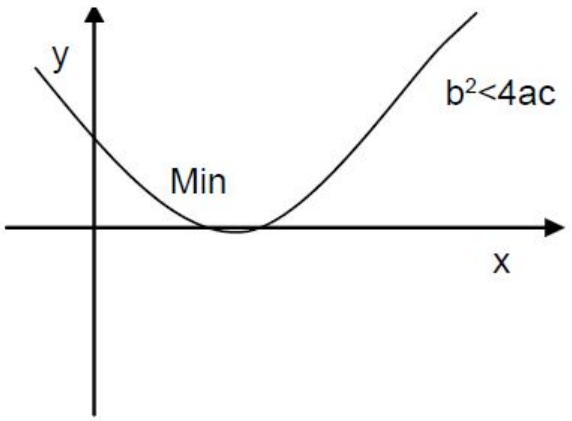
Recall: if ax2+bx+c = 0

2). A quadratic function has a single turning point.

3). A quadratic function is completely specified once any three points which lie on this curve are given.

Quadratic sketches





4. Linear Functions

The linear function is a polynomial of the form: y = a + bx whereby a represents y – intercept i.e. value of y when x is zero, b represents the slope or gradient i.e. the value that y changes when x changes by one unit.

Sketches of linear function