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First Year Master - Public Management

Online Courses

Quantitative Management Techniques

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Introduction

Recently, the need for statistics has increased due to their role in scientifically analyzing data to help researchers make informed decisions. Due to the increased volume of information and data, the use of computers and software has become an integral part of statistical analysis operations. The use of computers has enabled better results, regardless of the volume of data.

These courses are based on quantitative techniques and serve as a reference for students who need to use statistical methods. Quantitative techniques are often one of the most difficult subjects for students. The goal of these courses is to overcome these difficulties through clear explanations and by providing various exercises. These courses focus on the theoretical aspect while explaining each theory in an applied manner.

Quantitative techniques involve the collection, analysis, and interpretation of data through a set of mathematical or statistical models. This operation aims to describe one or more variables from a data set (sample) and make appropriate decisions that can be generalized to the population from which the sample was drawn.

It is well known that collecting information from all members of a population is a difficult task, often unfeasible, as it requires a lot of time, effort, and money. In contrast, taking a random and representative sample from that population is a simpler process that requires less time, effort, and money.

Quantitative management techniques are tools and mathematical and statistical methods used to analyze and solve complex management problems. They are used in various fields such as finance, production management, logistics, marketing, and human resource management.

The main quantitative management techniques include:

1. Descriptive Statistics
2. Time Series Analysis

3. Regression and Correlation
4. Linear Programming
5. Decision Models
6. Simulation
7. Forecasting Methods

Introduction to Quantitative Techniques

Quantitative methods are considered effective tools for streamlining administrative decisions in terms of saving effort, time, and resources to reach the optimal solution to the problems faced by the researcher. These methods require effort and time to define the problem, collect the data, and then analyze and process the information.

Simon Harriret, a specialist in quantitative methods, proposed a decision-making model – define the problem, establish criteria for searching for a solution, and use quantitative methods.

Definition of Quantitative Methods

Quantitative methods are a set of techniques, equations, and models that help solve problems rationally. They rely on quantification (quantification) using mathematical methods and models to solve a problem.

Lomba indicates that the quantitative approach requires problems to be defined and subjected to analysis, while Steven W. states that the quantitative approach is an attempt to find the optimal solution through a mathematical method.

Use of Quantitative Methods

The development of computers and software has facilitated the use of quantitative methods to process large amounts of data and analyze them quickly, thereby obtaining the best possible solutions.

Review of Some General Concepts on Confidence Intervals, Mean, Variance, and Proportion

We extract samples from a population to estimate the parameters of that population. Estimation of parameters can be done by a single number, called point estimation, or by two numbers, called interval estimation.

- **Point Estimation**
- **Interval Estimation**

A – If we have a population that follows a normal distribution with mean μ and standard deviation σ, and we draw a sample from this population, the confidence interval for the mean is written as:

Graphical representation of the normal distribution

x¯=∑i=1nxin\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}x¯=n∑i=1nxi

σx¯=∑(xi−x¯)2n−1\sigma_{\bar{x}} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}σx¯=n−1∑(xi−x¯)2

μ∈(x¯−zα/2·σn;x¯+zα/2·σn)\mu \in \left(\bar{x} - z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}} ; \bar{x} + z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}} \right)μ∈(x¯−zα/2·nσ;x¯+zα/2·nσ)

Example: Draw a sample from a population of size 36 (n=36) with a mean of 10 (sample mean) and a confidence level of 95% (α=0.05):

μ∈(100−1.96·1036;100+1.96·1036)=(96.73;103.27)\mu \in (100 - 1.96 \cdot \frac{10}{\sqrt{36}} ; 100 + 1.96 \cdot \frac{10}{\sqrt{36}}) = (96.73 ; 103.27)μ∈(100−1.96·3610;100+1.96·3610)=(96.73;103.27)

B – If we draw a sample from a normally distributed population with sample size n ≥ 30 and the population variance is unknown (we use the Student's t-distribution).

Graphical representation of the Student's t-distribution.

Example: Given the following data, determine the confidence interval around the population mean.

1. Descriptive Statistics

Descriptive statistics allow us to summarize and analyze data simply. They are used to provide an overview of a data set without necessarily establishing a causal relationship.

Main Tools:

- **Mean (or Arithmetic Mean)**: It is the sum of values divided by the number of values.
  Mean=∑i=1nXin\text{Mean} = \frac{\sum_{i=1}^{n} X_i}{n}Mean=n∑i=1nXi
- **Median**: The middle value when the data is arranged in ascending order.
- **Standard Deviation**: Measures the dispersion of values relative to the mean.
  σ=∑i=1n(Xi−X‾)2n\sigma = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n}}σ=n∑i=1n(Xi−X‾)2

Corrected Exercise Example:

Exercise: Given the following data set: 5, 7, 9, 8, 6. Calculate the mean and standard deviation.

Solution:

- **Mean**: X‾=5+7+9+8+65=355=7\bar{X} = \frac{5 + 7 + 9 + 8 + 6}{5} = \frac{35}{5} = 7X‾=55+7+9+8+6=535=7
- **Standard Deviation**:
  σ=(5−7)2+(7−7)2+(9−7)2+(8−7)2+(6−7)25=4+0+4+1+15=2≈1.41\sigma = \sqrt{\frac{(5-7)^2 + (7-7)^2 + (9-7)^2 + (8-7)^2 + (6-7)^2}{5}} = \sqrt{\frac{4 + 0 + 4 + 1 + 1}{5}} = \sqrt{2} \approx 1.41σ=5(5−7)2+(7−7)2+(9−7)2+(8−7)2+(6−7)2=54+0+4+1+1=2≈1.41

2. Time Series Analysis

Time series analysis is a technique used to analyze data collected over time to forecast future trends.

Examples of Tools:

- **Moving Average**: Used to smooth time series data by eliminating random fluctuations.
- **ARIMA Models**: Used to predict time series by considering autoregressive, differencing, and moving average components.

Corrected Exercise Example:

Exercise: We have the following stock index values for five consecutive days: 120, 125, 130, 135, 140. Calculate the 3-day moving average.

Solution:

- **3-Day Moving Average**:
  - For day 3: 120+125+1303=125\frac{120 + 125 + 130}{3} = 1253120+125+130=125
  - For day 4: 125+130+1353=130\frac{125 + 130 + 135}{3} = 1303125+130+135=130
  - For day 5: 130+135+1403=135\frac{130 + 135 + 140}{3} = 1353130+135+140=135

3. Regression and Correlation

Regression is a method used to model the relationship between a dependent variable and one or more independent variables. Correlation measures the strength and direction of the relationship between two variables.

Formula for Simple Linear Regression:

Y=a+bXY = a + bXY=a+bX

Where:

- YYY is the dependent variable,
- XXX is the independent variable,
- aaa is the y-intercept,
- bbb is the regression coefficient.

Corrected Exercise Example:

Exercise: Given the following data:

X=[1,2,3,4,5]X = [1, 2, 3, 4, 5]X=[1,2,3,4,5]

Y=[2,4,5,4,5]Y = [2, 4, 5, 4, 5]Y=[2,4,5,4,5]

Calculate the linear regression.

Solution:

1. Calculate the mean of XXX and YYY:
   - X¯=1+2+3+4+55=3\bar{X} = \frac{1 + 2 + 3 + 4 + 5}{5} = 3X¯=51+2+3+4+5=3
   - Y¯=2+4+5+4+55=4\bar{Y} = \frac{2 + 4 + 5 + 4 + 5}{5} = 4Y¯=52+4+5+4+5=4
2. Calculate the regression coefficient bbb:

b=∑(Xi−X¯)(Yi−Y¯)∑(Xi−X¯)2=0.545b = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2} = 0.545b=∑(Xi−X¯)2∑(Xi−X¯)(Yi−Y¯)=0.545

3. Calculate the intercept aaa:

a=Y¯−bX¯=4−(0.545)(3)=2.365a = \bar{Y} - b\bar{X} = 4 - (0.545)(3) = 2.365a=Y¯−bX¯=4−(0.545)(3)=2.365

Thus, the regression line is:

Y=2.365+0.545XY = 2.365 + 0.545XY=2.365+0.545X

4. Linear Programming

Linear programming is a technique used to optimize an objective under certain constraints. It is used in maximization or minimization problems.

Formulation of a Linear Programming Problem:

Maximize or minimize an objective function subject to linear constraints.

Example: Maximize Z=3X+4YZ = 3X + 4YZ=3X+4Y

Subject to the constraints:

- X+2Y≤8X + 2Y \leq 8X+2Y≤8
- 3X+Y≤93X + Y \leq 93X+Y≤9
- X≥0,Y≥0X \geq 0, Y \geq 0X≥0,Y≥0

Conclusion

Quantitative management techniques are essential tools for making informed decisions in the management of an organization. They enable the processing of large amounts of data and forecasting future behaviors, which facilitates resource optimization and strategic decision-making.

The corrected exercises are useful for reinforcing the understanding of these concepts and their application in real-world situations.

References

1. Heizer, J., & Render, B. (2014). Principles of Operations Management (9th ed.). Pearson.
2. Taha, H. A. (2017). Operations Research: An Introduction (10th ed.). Pearson.
3. Hillier, F. S., & Lieberman, G. J. (2015). Introduction to Operations Research (10th ed.). McGraw-Hill Education.
4. Slack, N., Chambers, S., & Johnston, R. (2010). Operations Management (6th ed.). Pearson Education.
5. Camm, J. D., Cochran, J. J., Fry, M. J., Ohlmann, J. W., & Anderson, D. R. (2015). Quantitative Methods for Business (12th ed.). Cengage Learning.
6. Pindyck, R. S., & Rubinfeld, D. L. (2017). Microeconomics (9th ed.). Pearson.
7. Bertsekas, D. P., & Tsitsiklis, J. N. (2008). Introduction to Probability (2nd ed.). Athena Scientific.
8. Pereira, F. S., & Da Silva, E. L. (2013). Introduction to Linear Programming. Springer.