Chapter 1 : An introduction to statistics

Brief summary from chapter I

I. Core Concepts: Data, Populations, and Samples

At its foundation, statistics deals with **data**, which are defined as "facts and figures from which conclusions can be drawn." A collection of such data for a specific study is called a **data set**. Within a data set, **elements** are the individual entities being studied (e.g., people, objects, events), and a **variable** is "any characteristic of an element."

Measurement is the process of assigning a value of a variable to an element. This leads to two primary types of variables:

- **Quantitative Variables**: Represent quantities and are expressed as numbers (e.g., "how much" or "how many"). Examples include annual starting salary, age, and number of children.
- **Qualitative (Categorical) Variables**: Represent categories. Examples include a person's gender, the make of an automobile, or satisfaction with a product.

Qualitative variables can be further broken down into:

- **Ordinal**: Rank-order categories where ranks are relative to each other (e.g., low, moderate, or high risk).

Data can also be categorized by the time of collection:

- **Cross-sectional data**: Collected "at the same or approximately the same point in time."
- **Time series data**: Collected "over different time periods."

A crucial distinction in statistics is between a **population** and a **sample**:

- **Population**: "The set of all elements about which we wish to draw conclusions" (e.g., all last year's graduates of a program). An examination of an entire population is a **census**, but this is "usually too expensive, too time consuming, and too much effort for a large population."
- **Sample**: "A selected subset of the units of a population." Samples are used when populations are too large for a census, allowing for **statistical inference**.

II. Descriptive Statistics and Statistical Inference

- **Descriptive Statistics**: "The science of describing the important aspects of a set of measurements." This involves summarizing and presenting data from a given set of measurements.

- **Statistical Inference:** "The science of using a sample of measurements to make generalizations about the important aspects of a population of measurements." For instance, using a sample of starting salaries to estimate trends in the entire population of graduates' salaries.

III. Sampling Methods: Selecting a Representative Sample

For statistical inference to be accurate, the sample must "accurately reflect the population under study." The primary method discussed for achieving this is the **random sample**:

- **Random Sample:** A sample "selected from a population so that: Each population unit has the same chance of being selected as every other unit. Each possible sample (of the same size) has the same chance of being selected."
- **Sampling without replacement** is the "usual and customary sampling method," where a sampled unit is not selected again.
- **Sampling with replacement** allows a unit to be reselected, but "the same unit in the sample does not contribute new information."

> 💡 When a true random sample is difficult to obtain due to the inability to list all population units, a **systematic sample** can be used to approximate a random sample. This involves "Randomly enter[ing] the population and systematically sampl[ing] every kth unit."

- **Stratified random sampling:** Dividing the population into "nonoverlapping groups of similar units (strata)" and then selecting a random sample from each stratum.
- **Cluster sampling.**
- **Multi-stage cluster sampling.**

IV. Scales of Measurement

An "Optional" section details four scales of measurement for variables, building upon the qualitative/quantitative distinction:

1. **Nominative:** "A qualitative variable for which there is no meaningful ordering, or ranking, of the categories" (e.g., gender, car color).
2. **Ordinal:** "A qualitative variable for which there is a meaningful ordering, or ranking, of the categories" (e.g., teaching effectiveness ratings like low, moderate, high).
3. **Interval:** Possesses "all of the characteristics of ordinal," but measurements are on a numerical scale with an "arbitrary zero point." This means "zero does not mean the absence of the quantity that we are trying to measure." Values can only be compared by the interval between them, not by ratios (e.g., temperature, where 0°F does not mean no heat, and 60°F is not twice as warm as 30°F).
4. **Ratio:** Possesses "all of the characteristics of interval," but measurements are on a numerical scale with a "meaningful zero point." Here, "Zero means 'none' or 'nothing'," and "values can be compared in terms of their interval and ratio." Most quantitative variables in business and finance, such as earnings, profit, age, distance, height, and weight, are ratio variables.

V. Data Acquisition and Study Design

The document touches on methods for obtaining data:

- **Existing sources:** Data "already gathered by public or private sources" (e.g., Internet, library).

- **Experimental and observational studies:** Data collected "ourselves for a specific purpose."
- **Response variable:** The "variable of interest."
- **Factors (independent variables):** "Other variables related to [the] response variable."
- **Experimental study:** Involves manipulating the independent variables.
- **Observational study:** Occurs when independent variables cannot be controlled.

A **process** is defined as "a sequence of operations that takes inputs and turns them into outputs." When sampling a process, the "population" refers to all output produced in the past, present, and future. A process is considered **in statistical control** "if it does not exhibit any unusual process variations," often visualized using a **runs plot**.

VI. Case Studies Illustrated

The chapter includes three brief case studies to exemplify the application of sampling and statistical inference:

1. **The Cell Phone Case**: Estimating cell phone costs by taking "a random sample of 100 employees on a 500-minute plan."
2. **The Marketing Research Case**: Rating a new bottle design using a "mall intercept method" with a "sample size of 60."
3. **The Car Mileage Case**: Estimating mileage for a new car model to determine qualification for a tax credit, using a "sample of 50 cars."

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