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# STATISTICAL SOFTWARE FOR DATA ANALYSIS

EXAM REVISION NOTES

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# MODULE I

## INTRODUCTION TO STATISTICAL SOFTWARE & DATA MANAGEMENT

**THE STATISTICAL COMPUTING REVOLUTION IN COMMERCE:** The exponential expansion of digital business platforms, enterprise resource planning (ERP) architectures, point-of-sale (POS) terminals, and algorithmic capital markets has generated unprecedented volumes of high-velocity commercial data.

**The Role of Statistical Software**

**DATA TYPOLOGY, MEASUREMENT SCALES METADATA ARCHITECTURE:** The mathematical validity of any statistical test is strictly conditional upon the Scale of Measurement of the variables under examination.

**Variable Classification in Statistical Software:** Statistical programs streamline Stevens' four classical scales into operational software formats:

**R Data Class Architecture**

- **factor:** Qualitative nominal categories.
- **ordered factor:** Ranked ordinal variables.
- **numeric / double:** Continuous real numbers.
- **integer:** Discrete countable values.
- **character:** Plain textual strings.

**Handling Multi-Response Questionnaire Items:** "). In statistical software, these cannot be recorded in a single variable cell.

- **1. Multiple Dichotomy Method:** ; Each variable is coded as (1 = Checked (Yes)) and (0 = Unchecked (No)).
- **2. Multiple Category Method:** ; Variables represent selection slots: $CHANNEL_1$, $CHANNEL_2$, each recording the numeric code of the chosen option.

**Comma-Separated Values (.csv)**

**Software Ingestion Workflows**

**Theoretical Framework of Missing Data (Little Rubin Taxonomy):** Missing data points must be diagnosed according to their underlying missingness mechanism:

- **1. Missing Completely at Random (MCAR):** The probability of an observation being missing is completely unrelated to any observed or unobserved variable:P(M | Y(obs), Y(mis)) = P(M) ]; Benign; reduces statistical power but introduces zero bias.
- **2. Missing at Random (MAR):** Missingness is related to observed variables in the dataset, but unrelated to the missing value itself: [ P(M | Y(obs), Y(mis)) = P(M | Y(obs)) ]; Listwise deletion yields biased estimates.
- **3. Missing Not at Random (MNAR):** , high-income earners refusing to disclose salary.

**Deletion Techniques**

**DATA TRANSFORMATION DATASET RESTRUCTURING:** Raw variables frequently fail to meet parametric distribution assumptions or require mathematical restructuring to align with econometric models.

**Variable Recoding Binning**

**STEP-BY-STEP PRACTICAL INDUSTRY CASE ILLUSTRATIONS:** Solution Step-by-Step Codebook Architecture:

- **Solution Step-by-Step Working Notes:** Solution Step-by-Step Working Notes:
- **Step 1: Compute Quartiles:** 25^{textth}) value.
- **Step 4: Remedial Winsorization:** Under Winsorization, rather than deleting outliers (which causes loss of statistical degrees of freedom), the extreme values are replaced by the nearest acceptable boundary percentile values (here, the upper boundary value before outlier threshold, (X = 35)): • Winsorized Series: 15, 18, 20, 22, 25, 26, 28, 30, 32, 35, 35, 35.
- **Solution Procedural Workflow:** Solution Procedural Workflow:

**Empirical Casework: Forensic Analysis, Audit Trail Verification, and Internal Controls:** Empirical accounting investigations across modern industrial enterprises illustrate that financial distortion, fraud, and misstatement rarely occur as isolated incidents; rather, they stem from structural vulnerabilities within accounting workflows, segregation-of-duties lapses, or inadequate internal audit scrutiny.

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# MODULE II

## DESCRIPTIVE STATISTICS, CROSS-TABULATION & DATA VISUALIZATION

**DESCRIPTIVE STATISTICS IN STATISTICAL SOFTWARE ENVIRONMENTS:** Before estimating econometric equations or conducting confirmatory hypothesis tests, empirical researchers must thoroughly explore the fundamental distributional properties of their dataset.

**Measures of Central Tendency**

**Higher-Order Distributional Moments: Skewness Kurtosis:** Evaluating the departure of an empirical distribution from the theoretical Gaussian bell curve requires analyzing third and fourth standardized moments:

- **1. Skewness (gamma$_1$):** , household income, corporate revenue).
- **2. Kurtosis (gamma$_2$):** , financial asset returns).

**SOFTWARE PROCEDURES FOR DESCRIPTIVE SUMMARIES:** Leading statistical suites provide dedicated analytical procedures tailored to exploratory data profiling:

**Microsoft Excel R Computational Equivalents**

- **Arithmetic Mean:** rm = TRUE)
- **Median:** rm = TRUE)
- **Sample Standard Deviation:** rm = TRUE)
- **Interquartile Range (IQR):** rm = TRUE)

**Cell Percentage Configurations**

**Interpreting Relationships**

**Methodological Assumptions of the Chi-Square Test**

- **Random Sampling:** Data must be drawn randomly and independently from the population.
- **Mutual Exclusivity:** Each subject or transaction must fall into exactly one cell in the contingency table.
- **Cochran's Minimum Expected Frequency Rule (1954):** In an (r × c) table, at least 80% of the cells must have expected frequencies of 5 or more ((E(ij) ≥ 5)).
- **No cell:** 0)).
- **Remedial Actions for Violations:** For (2 × 2) tables with small expected counts ((E(ij) Fisher's Exact Test instead of Pearson's Chi-Square.

**Measures of Association for Categorical Data:** While the Chi-Square test establishes whether an association is statistically significant, it is sensitive to sample size and does not quantify the strength of the relationship.

- **1. Phi Coefficient (phi):** [ phi = √((chi²) / (N)); Exclusively utilized for 2×2 tables.
- **2. Cramér's (V):** V=N·min(r−1,c−1)χ2; Universal standard for larger r×c tables.
- **3. Contingency Coefficient (C):** 707).
- **4. Goodman Kruskal's Lambda (λ):** λ=N−max(Ri)∑max(fij)−max(Ri); Proportional Reduction in Error (PRE) measure.

**Categorical Visualizations**

**The Geometry of the Box-and-Whisker Plot**

**Specialized Commercial Visualizations**

- **1. Pareto Chart:** ; Root-cause quality control: Identifies the "vital few" defects (80%) versus the "trivial many" (20%) per Juran's Pareto Principle.
- **2. Scatterplot with Lowess / OLS Fit:** ; Evaluating pricing elasticity, advertising response functions, cost-volume-profit linear relationships.
- **3. Correlation Heatmap:** ; Screening financial portfolio assets for diversification; identifying multicollinearity among regression predictors.
- **4. Ogive Curves:** ; Graphical determination of median, quartiles, deciles, and wage distribution percentiles in labor economics.

**STEP-BY-STEP PRACTICAL INDUSTRY CASE ILLUSTRATIONS:** Solution Step-by-Step Working Notes:

- **Step 1: Measures of Central Tendency:** • ∑X=28+32+35+36+40+42+45+46+48+50+52+55+58+62+98=727.
- **Step 2: Measures of Dispersion:** • Computing Sum of of squared deviations (∑ X−X¯²):
- **Step 3: Quartiles and IQR:** 00 lakhs lt;/strong gt;.
- **Step 5: Managerial Interpretation:** 47 lakhs) is heavily inflated by the flagship store outlier (₹ 98 lakhs).

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# MODULE III

## INFERENTIAL STATISTICS & HYPOTHESIS TESTING USING SOFTWARE

**ARCHITECTURE OF STATISTICAL INFERENCE HYPOTHESIS TESTING:** In corporate management, decisions must frequently be made regarding massive consumer populations, extensive supply chains, or financial markets where examining every individual unit is physically impossible or economically prohibitive.

**The Central Limit Theorem (CLT)**

**THE ONE-SAMPLE T-TEST:** The One-Sample (t)-Test is utilized to determine whether the arithmetic mean of a single quantitative continuous variable drawn from an approximately normal population departs significantly from a known benchmark, statutory standard, or historical baseline ((mean $(mu)_0$)).

**Levene's Test for Equality of Variances (Homoscedasticity):** The mathematical validity of the standard pooled (t)-test depends upon the assumption of Homogeneity of Variances (σ12=σ22).

- **Non-Significant(p > 0.05):** Equal variances assumed (σ12=σ22).
- **Significant(p≤0.05):** Equal variances NOT assumed (σ12 =σ22).

**The Problem of Familywise Error Rate Inflation:** Conducting multiple individual (t)-tests across (k) groups requires (m = (k(k - 1)) / (2)) distinct tests. The compounded probability of committing at least one Type I error across the set of tests (the Familywise Error Rate, αfamily) escalates exponentially:αfamily=1−(1−α)m For instance, with (k = 4) groups, (m = (4(3)) / (2) = 6) tests.

**Post-Hoc Multiple Comparison Procedures:** A statistically significant omnibus (F)-test (p at least one group mean differs from another, but does not identify which specific pairs differ.

**Scheffé's Procedure**

**DISTRIBUTION-FREE NON-PARAMETRIC TESTS:** When empirical datasets violate the core assumptions of normality (severe skewness, extreme outliers) or are measured on an ordinal ranking scale, parametric (t)-tests and ANOVA yield distorted (p)-values.

- **Independent Samples (t)-Test:** Mann-Whitney (U) Test(Wilcoxon Rank-Sum); ($U = n_1 n_2 + (n_1(n_1 + 1)) / (2) - R_1$); Compares mean ranks across two independent groups; tests for median shifts.
- **Paired Samples (t)-Test:** Wilcoxon Signed-Rank Test; (T = min(W^+, W^-)); Tests whether the median of paired directional differences equals zero.
- **One-Way ANOVA:** Kruskal-Wallis (H) Test; ($H = (12) / (N(N+1)) \sum (R(j)^2) / (n(j)) - 3(N+1)$); Compares mean ranks across 3 or more groups; evaluated as Chi-Square (df = k - 1).

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# MODULE IV

## CORRELATION, REGRESSION & MULTIVARIATE ANALYSIS USING SOFTWARE

**CORRELATION ANALYSIS IN STATISTICAL SOFTWARE ENVIRONMENTS:** In corporate empirical modeling, analysts frequently examine multi-variable intercorrelations across financial statements, customer satisfaction indices, and macroeconomic indicators.

**Partial Correlation Architecture**

**DECODING THE THREE CANONICAL REGRESSION OUTPUT TABLES:** ), the software generates three core analytical output tables that must be evaluated sequentially:

**Linearity of Relationship**

**Independence of Errors**

**VARIABLE SELECTION METHODS: ENTER, HIERARCHICAL STEPWISE**

- **1. Standard Enter (Simultaneous):** ; Default baseline method.
- **2. Hierarchical (Block-wise):** Predictors are entered in pre-planned sequential blocks dictated by theory.
- **3. Stepwise (Forward / Backward):** ; Purely data-driven; useful for exploratory predictive screening.

**Binary Logistic Regression (Logit)**

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