Hypothesis Testing and Summary Measures Worksheet

Module: Research Methods and Professional Practice
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Introduction

This worksheet demonstrates the application of **inferential statistics** — specifically hypothesis testing — to real datasets using Microsoft Excel and LibreOffice Calc.

According to Field (2018), statistical inference allows researchers to generalise from sample data to the wider population, using probability theory to determine whether differences are genuine or due to chance. Each exercise in this worksheet illustrates a different form of the *t-test*, supported by prior *F-tests* where necessary to confirm equality of variances.

Overview of Hypothesis Testing

The hypothesis-testing process generally follows five steps (Upton and Cook, 2014):

1. **State hypotheses** — establish the null (H_0) and alternative (H_1) hypotheses.
2. **Select significance level** ($\alpha = 0.05$).
3. **Choose appropriate tests** (paired or independent).
4. **Calculate test statistics** (t or F) using Excel Data Analysis Toolpak.
5. **Interpret the p-value** — if $p < \alpha$, reject H_0; otherwise fail to reject H_0.

Example 7.1 – Related Samples t-Test (Two-Tailed)

Objective:
Determine whether the mean number of items sold differs between two container designs.

Dataset: Data Set F (`Exa7.4F.xlsx`)

Variables:
Con1 = Design 1 sales; Con2 = Design 2 sales.

Procedure (Excel)

1. Open the workbook `Exa7.4F.xlsx`.
2. Select **Data → Data Analysis → t-Test: Paired Two Sample for Means**.
3. Enter:
    - Variable 1 Range = B1:B11
    - Variable 2 Range = C1:C11
    - Labels = checked
    - Hypothesised Mean Difference = 0
    - Alpha = 0.05
    - Output Range = E1
4. In E16 type “Difference in Means”; in F16 enter `=F4-G4`.

Output

t-Test: Paired Two Sample for Means	Con1	Con2
Mean	172.6	159.4
Variance	750.27	789.38
Observations	10	10
Pearson Correlation	0.863	
Hypothesised Mean Difference	0	
df	9	
t Stat	2.875	
P(T≤t) one-tail	0.009	
P(T≤t) two-tail	0.018	
Difference in Means	**13.2**	

Interpretation

t = 2.875 (df = 9), p (two-tailed) = 0.018 < 0.05 → significant.
Mean sales for Design 1 (172.6) exceed Design 2 (159.4) by ≈ 13 units.
Conclusion: Design 1 is preferred (Open University, 2023).

Exercise 7.1 – One-Tailed Version

Testing H_0: $\mu_1 \leq \mu_2$ vs H_1: $\mu_1 > \mu_2$ yields p(one-tail) = 0.009 < 0.05.
Hence, **Design 1 leads to significantly higher sales**.

Example 7.2 – Independent Samples t-Test

Objective: Compare mean weight loss between two diets.

Dataset: Data Set B (`Exa7.6B.xlsx`)

Step 1 – F-Test for Equality of Variances

F-Test Two-Sample for Variances	Diet A	Diet B
Mean	5.341	3.710
Variance	6.429	7.668
Observations	50	50
F	0.839	
P(F≤f) one-tail	0.270	
p(two-tailed)	**0.540**	

p = 0.54 > 0.05 → equal variances assumed.

Step 2 – t-Test (Equal Variances Assumed)

t-Test Two-Sample Assuming Equal Variances	Diet A	Diet B
Mean	5.341	3.710
Variance	6.429	7.668
Observations	50	50
Pooled Variance	7.048	
df	98	
t Stat	3.072	
P(T≤t) two-tail	0.0028	
Difference in Means	**1.631 kg**	

Interpretation

t = 3.072 (df = 98), p = 0.0028 < 0.01 → highly significant.
Average loss: Diet A = 5.34 kg; Diet B = 3.71 kg.
Conclusion: Diet A produces greater mean weight loss.

Exercise 7.2 – Bank Cardholder Income Comparison

Dataset: `Exa8.6C.xlsx`
Objective: Test whether mean income for males > females.

Procedure: F-test → t-test (one-tailed).
Hypotheses: H_0: μ□ ≤ μ_f; H_1: μ□ > μ_f.
If p < 0.05, reject H_0 → male income significantly higher.

Assumptions: normality, independence, equal variances.

Exercise 7.3 – Filtration Agents (Two-Tailed)

Dataset: `Exa8.4G.xlsx`
Objective: Determine whether mean impurity differs between two filters.
Interpretation: p(two-tailed) < 0.05 → significant difference; otherwise no difference.

Exercise 7.4 – Filtration Agents (One-Tailed)

Objective: Assess whether Filter Agent 1 is more effective (lower impurity).
Hypotheses: H_0: $\mu_1 \geq \mu_2$; H_1: $\mu_1 < \mu_2$.
If p(one-tail) < 0.05 → Filter Agent 1 significantly better.

Exercise 7.5 – Bank Cardholder Data (Reinforcement)

Dataset: `Exa7.6C.xlsx`
Objective: Re-test whether population mean income for males > females.
Same approach as Exercise 7.2.
If p (one-tail) < 0.05 → Reject H_0; male income significantly higher.

LibreOffice Equivalent

Use: `=TTEST(range1; range2; tails; type)`
(1 = paired, 2 = equal variances, 3 = unequal).
Example: `=TTEST(B2:B51; B52:B101; 2; 2)`
→ Two-tailed independent t-test with equal variances.

Summary and Interpretation Guidance

- Two-tailed tests → no predicted direction.
- One-tailed tests → directional expectation.
- Always report t, df, and p values (Field, 2018).

Example write-up:

The mean weight loss for Diet A (M = 5.34 kg) was significantly greater than for Diet B (M = 3.71 kg), t(98) = 3.07, p = 0.003 (two-tailed). Diet A is therefore more effective.

Reflection

Through this exercise, I learnt how to select and apply appropriate t-tests and F-tests to real datasets. Initially, understanding the difference between one-tailed and two-tailed tests was challenging, but by comparing p-values and critical values I gained clarity on their interpretation. I also developed confidence in using Excel's Data Analysis Toolpak to perform these tests efficiently. This practical experience enhances my ability to analyse quantitative data and draw valid conclusions in future academic and professional research contexts (Field, 2018; Open University, 2023).

References

Field, A. (2018) *Discovering Statistics Using IBM SPSS Statistics.* 5th edn. London: SAGE Publications.

Open University (2023) *Research Methods and Professional Practice – Unit 7: Hypothesis Testing.* University of Essex Online.

Upton, G. and Cook, I. (2014) *Oxford Dictionary of Statistics.* 3rd edn. Oxford: Oxford University Press.

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