Are we facing gender equality in employment?

Authors

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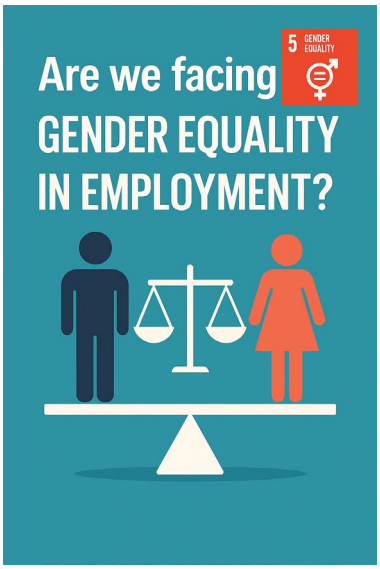
Type of activity

A data analysis project (individual or small group) that can be addressed in Statistical methods classes or proposed as a student's homework to further discuss in class. The statistical method used for solving is a two-sample hypothesis test (independent samples t-test) and effect size (Cohen's d).

It is related to SDG 5 "Enforce Gender Equality".

Target educational level

It can be addressed to higher education students – Bachelor's or Master's level.



Source of educational materials

- ILO Statistics Database – Labour Force Participation: https://ilostat.ilo.org/
- OECD Gender Data Portal: https://www.oecd.org/gender/data/

- Field, A. (2018). Discovering Statistics Using IBM SPSS Statistics (Chapters on hypothesis testing)

Problem statement

"Are women paid less than men for the same work? A statistical investigation into gender-based pay disparities"

Your country has ratified SDG 5, but recent headlines suggest persistent inequalities in earnings between genders. You have been commissioned by a national policy research group to conduct a statistical analysis comparing average salaries of men and women with equivalent qualifications and positions in the same sector. Your goal is to determine if a significant difference in average earnings exists and to quantify the magnitude of this difference.

General resolution

Step 1 – Data selection

Students will use the ILO or OECD gender wage gap datasets. They should:

- Select one country (their own, probably) and one sector (e.g., public administration, education, IT).
- Extract sample data on annual wages for at least 30 males and 30 females in comparable positions.

Step 2 – Preliminary data checks

Students should perform exploratory data analysis to:

- Check for missing values, outliers, and the shape of each sample distribution.
- Visualise data using histograms or boxplots.

Step 3 – Assumption testing

Before conducting a *t*-test, students should verify assumptions:

- Normality of distributions using the Shapiro-Wilk test.

- Homogeneity of variances using Levene's test.

Step 4 – Hypothesis formulation
Define the hypotheses:

- H_0: There is no difference in mean salaries between male and female employees.
- H_1: There is a difference in mean salaries between male and female employees.

Step 5 – Statistical testing
Apply the two-sample *t*-test (assuming unequal or equal variances as appropriate). Calculate:

- *t*-statistic and *p*-value
- 95% confidence interval for the mean difference
- Cohen's *d* as a measure of effect size

Step 6 – Interpretation and policy relevance
Students interpret the findings in plain language:

- Is the difference statistically significant?
- How large is the effect?
- What implications do the findings have for SDG 5?

Encourage students to discuss:

- Limitations of the data (e.g., sampling bias, sector specificity)
- Broader structural issues contributing to gender pay inequality
- Potential policy actions supported by data

Example of a problem statement and its resolution

A policy group wants to determine if gender pay inequality still exists in the IT sector in Portugal. As a data analyst, you are asked to compare the average monthly salary of male and female IT professionals with similar qualifications

and years of experience. Use statistical methods to assess whether a statistically significant difference exists and whether the effect is meaningful.

Detailed resolution:

Step-by-Step Solution (Hypothetical Dataset):

Step 1 – Dataset (Simulated)

Gender	Monthly Salary (€)	Gender	Monthly Salary (€)
Male	3200	Female	2800
Male	3400	Female	2950
Male	3100	Female	2700
Male	3300	Female	2900
Male	3600	Female	3000
Male	3500	Female	2750
Male	3000	Female	3100
Male	3700	Female	2950
Male	3400	Female	2850
Male	3550	Female	2900

Sample sizes:

$$n_m = 10; \bar{x}_m = 3375;\ s_m = 225.154$$

$$n_f = 10;\ \bar{x}_f = 2890; s_f = 119.722$$

Step 2 – Hypotheses

Null hypothesis: H0: $\mu_{male} = \mu_{female}$ versus Alternative hypothesis: H1: $\mu_{male} \neq \mu_{female}$

Step 3 – Conduct the *t*-test (assuming unequal variances)

Using the formula for the Welch's *t*-test:

$$t = \frac{\bar{x}_m - \bar{x}_f}{\sqrt{\frac{s_m^2}{n_m} + \frac{s_f^2}{n_f}}} = \frac{3375 - 2890}{\sqrt{\frac{225.154^2}{10} + \frac{119.722^2}{10}}} = \frac{485}{80.64} \approx 6.014$$

Degrees of freedom (Welch-Satterthwaite approximation):

$$df = \frac{\left(\frac{s_m^2}{n_m} + \frac{s_f^2}{n_f}\right)^2}{\frac{\left(\frac{s_m^2}{n_m}\right)^2}{n_m - 1} + \frac{\left(\frac{s_f^2}{n_f}\right)^2}{n_f - 1}} = 13.713$$

Using a *t*-distribution table or software, the critical value for $df = 14$ and $\alpha = 0.05$ (two-tailed) is approximately 2.144.

Since $t = 6.014 > 2.14$, we reject the null hypothesis.

Step 4 – Effect size (Cohen's *d*)

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s}$$

where

$$s_{pooled} = \sqrt{\frac{(n_m - 1)s_m^2 + (n_f - 1)s_f^2}{n_m + n_f - 2}} = \sqrt{\frac{50694.324 + 14333.357}{2}} \approx 180.316$$

Thus,

$$d = \frac{485}{180.316} \approx 2.69$$

An effect size of 2.69 is considered **very large** (Cohen's convention: 0.2 = small, 0.5 = medium, 0.8 = large).

Interpretation and Implications:

The analysis reveals:

- A **statistically significant** difference in average salaries.

- A **very large effect size**, indicating practical and policy relevance.
- The **findings support claims of a gender pay gap in the IT sector.**

Students should be invited to reflect on:

- Ethical implications of wage inequality.
- Need for policy enforcement or transparency.
- Statistical caveats: Is the sample representative? Were all relevant variables controlled?