

Introduction to Hypothesis Testing in Python

February 9, 2022

1 Hypothesis Testing

From lecture, we know that hypothesis testing is a critical tool in determining what the value of a parameter could be.

We know that the basis of our testing has two attributes:

Null Hypothesis: H_0

Alternative Hypothesis: H_a

The tests we have discussed in lecture are:

- One Population Proportion
- Difference in Population Proportions
- One Population Mean
- Difference in Population Means

In this tutorial, I will introduce some functions that are extremely useful when calculating a t-statistic and p-value for a hypothesis test.

Let's quickly review the following ways to calculate a test statistic for the tests listed above.

The equation is:

$$\frac{\text{Best Estimate} - \text{Hypothesized Estimate}}{\text{Standard Error of Estimate}}$$

We will use the examples from our lectures and use python functions to streamline our tests.

```
In [1]: import statsmodels.api as sm
import numpy as np
import pandas as pd
import scipy.stats.distributions as dist
```

1.0.1 One Population Proportion

Research Question In previous years 52% of parents believed that electronics and social media was the cause of their teenager's lack of sleep. Do more parents today believe that their teenager's lack of sleep is caused due to electronics and social media?

Population: Parents with a teenager (age 13-18)

Parameter of Interest: p

Null Hypothesis: $p = 0.52$

Alternative Hypthosis: $p > 0.52$ (note that this is a one-sided test)

1018 Parents

56% believe that their teenager's lack of sleep is caused due to electronics and social media.

```
In [2]: n = 1018
        pnull = .52
        phat = .56
        sm.stats.proportions_ztest(phat * n, n, pnull, alternative='larger', prop_var=0.52)
```

```
Out [2]: (2.5545334262132955, 0.005316510991822442)
```

1.0.2 Difference in Population Proportions

Research Question Is there a significant difference between the population proportions of parents of black children and parents of Hispanic children who report that their child has had some swimming lessons?

Populations: All parents of black children age 6-18 and all parents of Hispanic children age 6-18

Parameter of Interest: $p_1 - p_2$, where p_1 = black and p_2 = hispanic

Null Hypothesis: $p_1 - p_2 = 0$

Alternative Hypothesis: $p_1 - p_2 \neq 0$

91 out of 247 (36.8%) sampled parents of black children report that their child has had some swimming lessons.

120 out of 308 (38.9%) sampled parents of Hispanic children report that their child has had some swimming lessons.

```
In [22]: # This example implements the analysis from the "Difference in Two Proportions" lecture
```

```
# Sample sizes
n1 = 247
n2 = 308

# Number of parents reporting that their child had some swimming lessons
y1 = 91
y2 = 120

p1 = 0.37
p2 = 0.39

population1 = np.random.binomial(1, p1, n1)
population2 = np.random.binomial(1, p2, n2)

sm.stats.ttest_ind(population1, population2)
```

```
Out [22]: (-2.2407226273829397, 0.02544022063654473, 553.0)
```

```
In [23]: # Estimates of the population proportions
```

```
p1 = round(y1 / n1, 2)
p2 = round(y2 / n2, 2)

# Estimate of the combined population proportion
phat = (y1 + y2) / (n1 + n2)
```

```

# Estimate of the variance of the combined population proportion
va = phat * (1 - phat)

# Estimate of the standard error of the combined population proportion
se = np.sqrt(va * (1 / n1 + 1 / n2))

In [24]: # Test statistic and its p-value
test_stat = (p1 - p2) / se
pvalue = 2*dist.norm.cdf(-np.abs(test_stat))

# Print the test statistic its p-value
print("Test Statistic")
print(round(test_stat, 2))

print("\nP-Value")
print(round(pvalue, 2))

```

Test Statistic

-0.48

P-Value

0.63

1.0.3 One Population Mean

Research Question Is the average cartwheel distance (in inches) for adults more than 80 inches?

Population: All adults

Parameter of Interest: μ , population mean cartwheel distance. **Null Hypothesis:** $\mu = 80$ **Alternative Hypothesis:** $\mu > 80$

25 Adults

$\mu = 82.46$

$\sigma = 15.06$

```

In [25]: df = pd.read_csv("Cartwheeldata.csv")
df.head()

```

```

Out [25]:
   ID  Age  Gender  GenderGroup  Glasses  GlassesGroup  Height  Wingspan  \
0    1   56      F             1         Y             1    62.0    61.0
1    2   26      F             1         Y             1    62.0    60.0
2    3   33      F             1         Y             1    66.0    64.0
3    4   39      F             1         N             0    64.0    63.0
4    5   27      M             2         N             0    73.0    75.0

   CWDistance  Complete  CompleteGroup  Score
0           79         Y              1      7
1           70         Y              1      8
2           85         Y              1      7
3           87         Y              1     10
4           72         N              0      4

```

```
In [26]: n = len(df)
         mean = df["CWDistance"].mean()
         sd = df["CWDistance"].std()
         (n, mean, sd)

Out[26]: (25, 82.48, 15.058552387264852)

In [27]: sm.stats.ztest(df["CWDistance"], value = 80, alternative = "larger")

Out[27]: (0.8234523266982029, 0.20512540845395266)
```

1.0.4 Difference in Population Means

Research Question Considering adults in the NHANES data, do males have a significantly higher mean Body Mass Index than females?

Population: Adults in the NHANES data.

Parameter of Interest: $\mu_1 - \mu_2$, Body Mass Index.

Null Hypothesis: $\mu_1 = \mu_2$

Alternative Hypothesis: $\mu_1 \neq \mu_2$

2976 Females $\mu_1 = 29.94$

$\sigma_1 = 7.75$

2759 Male Adults

$\mu_2 = 28.78$

$\sigma_2 = 6.25$

$\mu_1 - \mu_2 = 1.16$

```
In [28]: url = "nhanes_2015_2016.csv"
         da = pd.read_csv(url)
         da.head()
```

```
Out[28]:
```

	SEQN	ALQ101	ALQ110	ALQ130	SMQ020	RIAGENDR	RIDAGEYR	RIDRETH1	\
0	83732	1.0	NaN	1.0	1	1	62	3	
1	83733	1.0	NaN	6.0	1	1	53	3	
2	83734	1.0	NaN	NaN	1	1	78	3	
3	83735	2.0	1.0	1.0	2	2	56	3	
4	83736	2.0	1.0	1.0	2	2	42	4	

	DMDCITZN	DMDEDUC2	...	BPXSY2	BPXDI2	BMXWT	BMXHT	BMXBMI	BMXLEG	\
0	1.0	5.0	...	124.0	64.0	94.8	184.5	27.8	43.3	
1	2.0	3.0	...	140.0	88.0	90.4	171.4	30.8	38.0	
2	1.0	3.0	...	132.0	44.0	83.4	170.1	28.8	35.6	
3	1.0	5.0	...	134.0	68.0	109.8	160.9	42.4	38.5	
4	1.0	4.0	...	114.0	54.0	55.2	164.9	20.3	37.4	

	BMXARML	BMXARMC	BMXWAIST	HIQ210
0	43.6	35.9	101.1	2.0
1	40.0	33.2	107.9	NaN
2	37.0	31.0	116.5	2.0
3	37.7	38.3	110.1	2.0

```
4      36.0      27.2      80.4      2.0
```

```
[5 rows x 28 columns]
```

```
In [29]: females = da[da["RIAGENDR"] == 2]
        male = da[da["RIAGENDR"] == 1]
```

```
In [30]: n1 = len(females)
        mu1 = females["BMXBMI"].mean()
        sd1 = females["BMXBMI"].std()

        (n1, mu1, sd1)
```

```
Out [30]: (2976, 29.93994565217392, 7.753318809545674)
```

```
In [31]: n2 = len(male)
        mu2 = male["BMXBMI"].mean()
        sd2 = male["BMXBMI"].std()

        (n2, mu2, sd2)
```

```
Out [31]: (2759, 28.778072111846942, 6.2525676168014614)
```

```
In [32]: sm.stats.ztest(females["BMXBMI"].dropna(), male["BMXBMI"].dropna())
```

```
Out [32]: (6.1755933531383205, 6.591544431126401e-10)
```