nb

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0.2 Entry Number: 2018MT10742

[1]:

```
import pandas as pd
import numpy as np
from scipy import stats
```

[2]:

```
data = pd.read_csv("2018MT10742.csv")["x"]
confidence = 0.05
```

0.3 Question 1

[3]:

```
print(f'Data mean = {data.mean()}')
```

```
Data mean = 0.055421994850962520
```

[4]:

```
mean_test = 0.055
n = len(data)
t_stat = (data.mean() - mean_test) / (data.std() / np.sqrt(n))
crit_t = stats.t.ppf(1 - confidence/2, len(data) - 1)
print(f't-statistic from data = {t_stat}, critical t value = {crit_t}')
```

```
t-statistic from data = 0.5307691833236253, critical t value =
1.9604386466615242
```

0.4 Question 2

[5]:

```
print(f'Data variance = {data.var()}')
```

```
Data variance = 0.003160624548083802
```

[6]:

```
var_test = 0.003
n = len(data)
chi_stat = (n - 1) * data.var() / var_test
lower_interval = stats.chi2.ppf(confidence / 2, len(data) - 1)
upper_interval = stats.chi2.ppf(1 - confidence / 2, len(data) - 1)
print(f'Non-rejection interval: [{lower_interval}, {upper_interval}], statistic:
 ↪ {chi_stat}')
```

```
Non-rejection interval: [4804.924332159057, 5196.864170605186], statistic:
5266.654038623643
```

0.5 Question 3

[7]:

```
from scipy.stats import expon

_, l_inv = expon.fit(data)
lmbda = 1 / l_inv
print(f"Lambda = {lmbda}")
```

```
Lambda = 18.0503363179046
```

[8]:

```
data.sort_values().to_numpy()
```

[8]:

```
array([2.13650573e-05, 2.23091805e-05, 2.51095173e-05, …,
       4.46536831e-01, 5.06904574e-01, 5.45918198e-01])
```

[9]:

```
# Making groups so nP >= 5
sorted_vals = data.sort_values().to_numpy()
begin = 0
prev_begin = 0
end = sorted_vals[0]
num_elems = 1
i = 1
test_stat = 0
num_vals = len(sorted_vals)
k = 0

while i < num_vals:
    prob = expon.cdf(end, scale=1/lmbda) - expon.cdf(begin, scale=1/lmbda)
    if prob * num_elems >= 5:
        observed_freq = num_elems
        theoretical_freq = prob * num_vals
        print(f"[{begin}, {end}]: obs {observed_freq}, exp {theoretical_freq}")
        test_stat += (observed_freq - theoretical_freq) ** 2 / theoretical_freq
        k += 1
        prev_begin = begin
        begin = end
        end = sorted_vals[i]
        num_elems = 1
    else:
        end = sorted_vals[i]
        num_elems += 1

    i += 1

# Some elements at the end remain and they need to be merged.
```

```
test_stat -= (observed_freq - theoretical_freq) ** 2 / theoretical_freq # reset␣
 ↪test stat
observed_freq += num_elems
theoretical_freq = (1 - expon.cdf(prev_begin, scale=1/lmbda)) * num_vals
print(f"-MERGED- [{prev_begin}, infty]: obs {observed_freq}, exp␣
 ↪{theoretical_freq}")
test_stat += (observed_freq - theoretical_freq) ** 2 / theoretical_freq # reset
```

```
[0, 0.0017439629694336]: obs 162, exp 154.9440449311792
[0.0017439629694336, 0.0035901173493425]: obs 159, exp 158.79471841318335
[0.0035901173493425, 0.0055230804977731]: obs 156, exp 160.68709182503312
[0.0055230804977731, 0.0074497451747043]: obs 165, exp 154.68039963442266
[0.0074497451747043, 0.0095957056678184]: obs 153, exp 166.0707530587882
[0.0095957056678184, 0.0115294054202321]: obs 175, exp 144.23305791606722
[0.0115294054202321, 0.013790033524856]: obs 155, exp 162.3577297215366
[0.013790033524856, 0.0160745185696416]: obs 159, exp 157.47726662320548
[0.0160745185696416, 0.0183992279538264]: obs 163, exp 153.72099993394616
[0.0183992279538264, 0.0209817649900085]: obs 155, exp 163.3744736166079
[0.0209817649900085, 0.0237293217796832]: obs 152, exp 165.65241552076643
[0.0237293217796832, 0.0265271883302679]: obs 158, exp 160.45158142814458
[0.0265271883302679, 0.0294746515444583]: obs 157, exp 160.49118459253415
[0.0294746515444583, 0.0325016818371498]: obs 161, exp 156.1726030606214
[0.0325016818371498, 0.0357484724890027]: obs 160, exp 158.2922854368235
[0.0357484724890027, 0.0390158164808218]: obs 167, exp 150.19948221893287
[0.0390158164808218, 0.0426015546522048]: obs 162, exp 154.95436146570896
[0.0426015546522048, 0.0467430904691259]: obs 151, exp 166.92611927092926
[0.0467430904691259, 0.0511774961916778]: obs 152, exp 165.42418849484764
[0.0511774961916778, 0.0558332057773837]: obs 159, exp 160.00438584990505
[0.0558332057773837, 0.0609813326040511]: obs 155, exp 161.9558997159376
[0.0609813326040511, 0.0664812690658543]: obs 160, exp 157.1778511896227
[0.0664812690658543, 0.0726160336159011]: obs 160, exp 157.8599507311096
[0.0726160336159011, 0.0795424963404417]: obs 158, exp 158.4353114830117
[0.0795424963404417, 0.0871229805005603]: obs 165, exp 152.1360717793413
[0.0871229805005603, 0.0958022515083787]: obs 169, exp 150.45006396765703
[0.0958022515083787, 0.108189892743496]: obs 141, exp 177.7397648576129
[0.108189892743496, 0.123044447655928]: obs 151, exp 166.82973498648724
[0.123044447655928, 0.14210498536945]: obs 161, exp 157.92675310078664
[0.14210498536945, 0.170873000360718]: obs 162, exp 155.77263506035777
[0.170873000360718, 0.233254688855908]: obs 162, exp 154.59914301057808
-MERGED- [0.170873000360718, infty]: obs 237, exp 228.80682011489185
```

[10]:

```
from scipy.stats import chi2
test_stat
tabled_value = chi2.ppf(1-confidence,k - 1)
print(f"Test stat: {test_stat}, Table val: {tabled_value}")
if test_stat > tabled_value:
    print("REJECT NULL")
```

```
else:
    print("CAN'T REJECT NULL")
```

```
Test stat: 29.74999162219288, Table val: 43.77297182574219
CAN'T REJECT NULL
```

0.6 Question 4

[11]:

```
import matplotlib.pyplot as plt
from scipy.stats import t
def perform_regression(X, Y):
    xmean = X.mean()
    ymean = Y.mean()
    slope = np.dot(X - xmean, Y - ymean) / np.sum((X - xmean) ** 2)
    intercept = ymean - slope * xmean

    print(f"Slope = {slope}, Intercept = {intercept}")

    # Plot regression results
    fig, ax = plt.subplots()
    ax.plot(X, Y, 'b.', label="Actual Data")

    linex = np.linspace(X.min() - 2, X.max() + 2, 500)
    liney = slope * linex + intercept
    ax.plot(linex, liney, 'r', label="Fitted line")

    ax.legend()

    # Estimating error variance
    rss = np.sum((Y - slope * X - intercept) ** 2)
    variance = rss / (len(X) - 2)
    print(f"Error Variance Estimate = {variance}")

    # Calculating R^2 and adjusted R^2
    tss = np.sum((Y - ymean) ** 2)
    r2 = 1 - rss / tss
    num_params = 1
    adj_r2 = 1 - ((1 - r2) * (len(X) - 1)) / (len(X) - num_params - 1)
    print(f"R^2 = {r2}, Adjusted R^2 = {adj_r2}")

    # Statistical significance of slope
    print("\nTesting for slope:")
    variance_slope = variance / np.sum((X - xmean) ** 2)
    t_stat = slope / np.sqrt(variance_slope)
    crit_stat = t.ppf(1-confidence/2, len(X) - 2)
    print(f"T statistic = {t_stat}, Critical value = {crit_stat}")
    if np.abs(t_stat) > crit_stat:
        print("Statistically signifcant")
    else:
        print("Not significant")

    # Statistical significance of intercept
    print("\nTesting for intercept:")
    variance_intercept = np.sum(X ** 2) / (len(X) * np.sum((X - xmean) ** 2)) *␣
 ↪variance
    t_stat = intercept / np.sqrt(variance_intercept)
    crit_stat = t.ppf(1-confidence/2, len(X) - 2)
    print(f"T statistic = {t_stat}, Critical value = {crit_stat}")
    if np.abs(t_stat) > crit_stat:
        print("Statistically signifcant")
    else:
        print("Not significant")

    return fig, ax
```

[12]:

```
death = pd.read_csv("death.csv", usecols=[0, 2], index_col=0)
incd = pd.read_csv("incd.csv", index_col=0)
death.columns = ['death_rate']
combined_data = death.assign(incd_rate=incd)
```

[13]:

```
def is_float(s):
    try:
        float(s)
        return True
    except ValueError:
        return False
```

[14]:

```
cleaned_data = combined_data[combined_data['death_rate'].apply(is_float) &␣
 ↪combined_data['incd_rate'].apply(is_float)]
cleaned_data = cleaned_data.apply(lambda series: series.apply(float))
```

[15]:

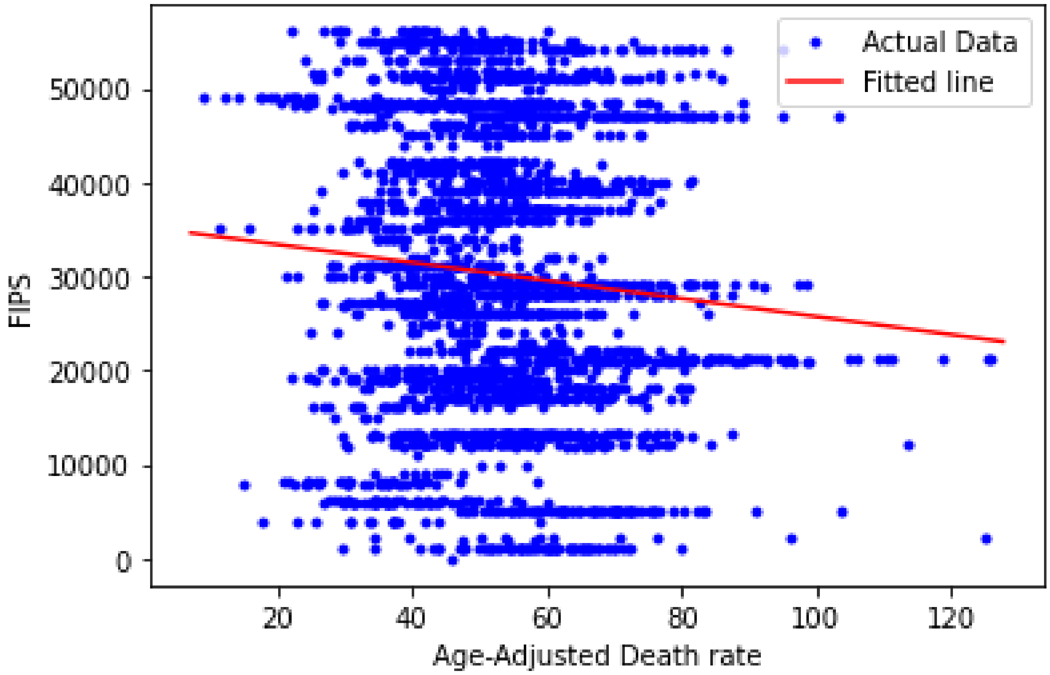
```
cleaned_death = death[death['death_rate'].apply(is_float)]
cleaned_death = cleaned_death["death_rate"].transform(float)
fig, ax = perform_regression(cleaned_death.to_numpy(), cleaned_death.index.
 ↪to_numpy())
ax.set_xlabel("Age-Adjusted Death rate")
ax.set_ylabel("FIPS")
pass
```

```
Slope = -95.90555683611262, Intercept = 35323.81271849963
Error Variance Estimate = 229335846.73241743
R^2 = 0.00783997307129658, Adjusted R^2 = 0.007487016818387149

Testing for slope:
T statistic = -4.71299354991779, Critical value = 1.9608082661638189
```

```
Statistically signifcant

Testing for intercept:
T statistic = 31.558695167259373, Critical value = 1.9608082661638189
Statistically signifcant
```



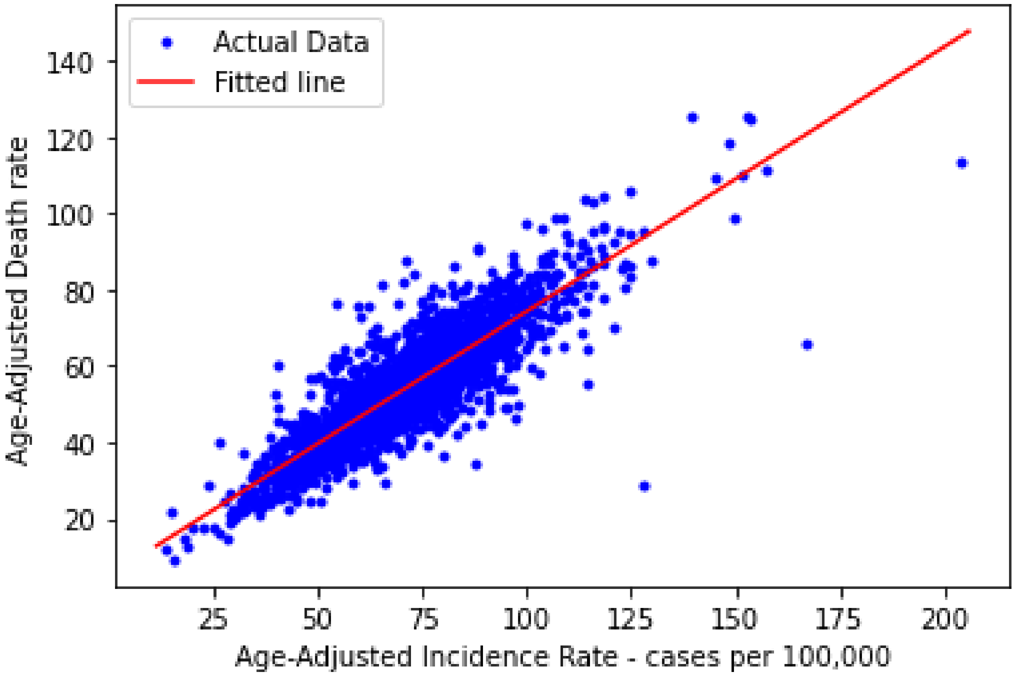
[16]:

```
fig, ax = perform_regression(cleaned_data["incd_rate"].to_numpy(),␣
 ↪cleaned_data["death_rate"].to_numpy())
ax.set_xlabel("Age-Adjusted Incidence Rate - cases per 100,000")
ax.set_ylabel("Age-Adjusted Death rate")
pass
```

```
Slope = 0.6948087365901285, Intercept = 4.788864452589401
Error Variance Estimate = 49.70772610775537
R^2 = 0.7547929054348136, Adjusted R^2 = 0.7546972708425495

Testing for slope:
T statistic = 88.83956009829721, Critical value = 1.9608896368168331
Statistically signifcant

Testing for intercept:
T statistic = 8.45362565222265, Critical value = 1.9608896368168331
Statistically signifcant
```


Actual Data
Fitted line
Age-Adjusted Death rate
140
120
100
80
60
40
20
25
50
75
100
125
150
175
200
Age-Adjusted Incidence Rate - cases per 100,000