# Hypothesis Testing With Beer:

## A Statistical Exploration of Craft Beer in the United States

# Data Selection and Initial Analysis

- Data was originally in two sets-- they were joined by brewery ID

**Loading the Dataset and Understanding the Data**

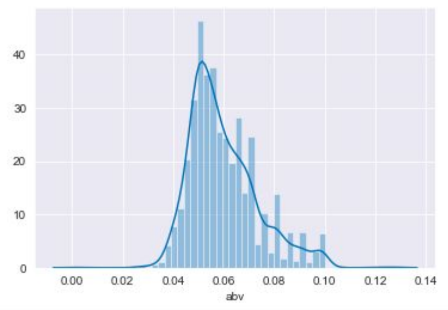
In [5]:
```
brewery = pd.read_csv('data/beer_and_brewery.csv')
brewery.head()
```

Out[5]:

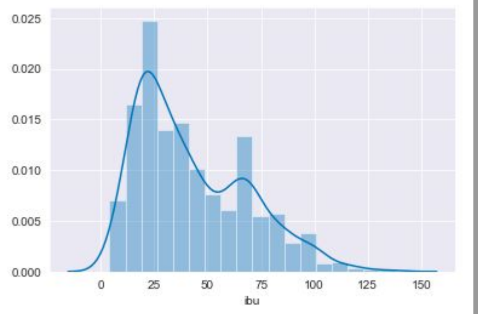
| | Unnamed: 0 | beer_id | abv | ibu | id | beer_name | style | brewery_id | ounces | brewery_name | city | state |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 0 | 0.050 | NaN | 1436 | Pub Beer | American Pale Lager | 408 | 12.0 | 10 Barrel Brewing Company | Bend | OR |
| **1** | 1 | 1 | 0.066 | NaN | 2265 | Devil's Cup | American Pale Ale (APA) | 177 | 12.0 | 18th Street Brewery | Gary | IN |
| **2** | 2 | 2 | 0.071 | NaN | 2264 | Rise of the Phoenix | American IPA | 177 | 12.0 | 18th Street Brewery | Gary | IN |
| **3** | 3 | 3 | 0.090 | NaN | 2263 | Sinister | American Double / Imperial IPA | 177 | 12.0 | 18th Street Brewery | Gary | IN |
| **4** | 4 | 4 | 0.075 | NaN | 2262 | Sex and Candy | American IPA | 177 | 12.0 | 18th Street Brewery | Gary | IN |

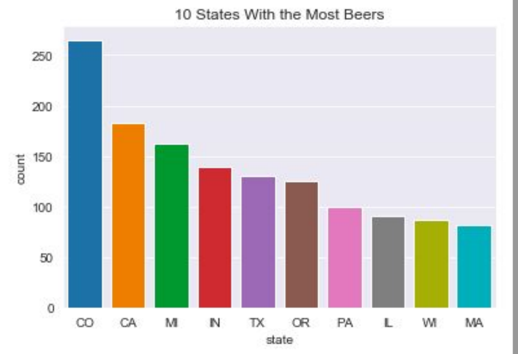
- Here we see distribution plots of **ABV** and **IBU** and **value counts of beers** from the top 10 states:

```
There are 2348 ABV values in the dataset.
```



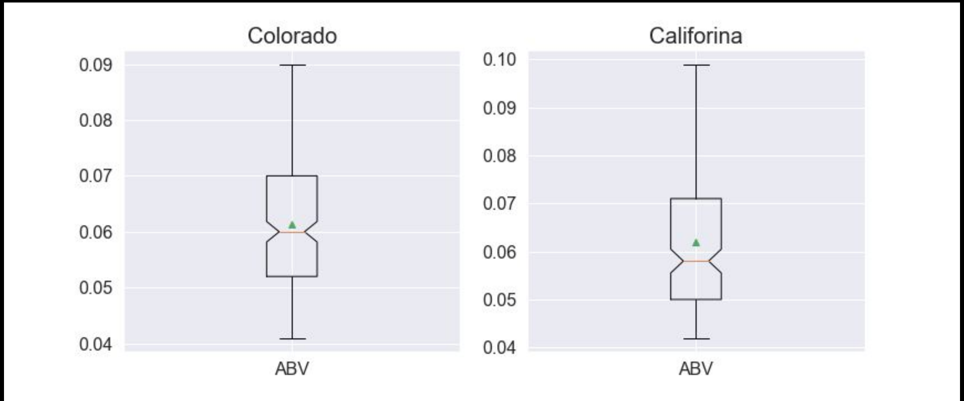

```
There are 1405 IBU values in the dataset.
```

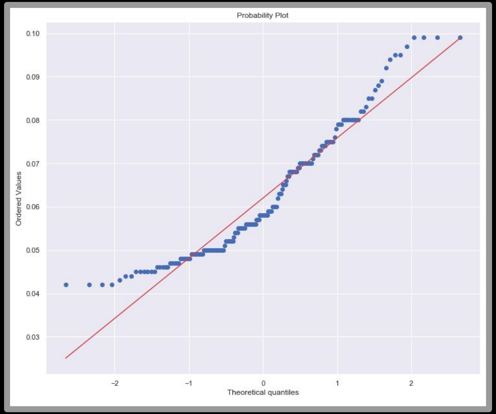


# Test 1: **Comparing ABV from Colorado and California**

- Is there a difference in ABV between beers brewed in Colorado and California?
    - We examine the box-plot and QQ plot to get a sense of the data:




- We set our **Null and Alternative Hypothesis:**

**Null Hypothesis:** $H_0: \quad \mu_1 = \mu_2$

**Alternative hypothesis** $H_a: \quad \mu_1 ! = \mu_2$

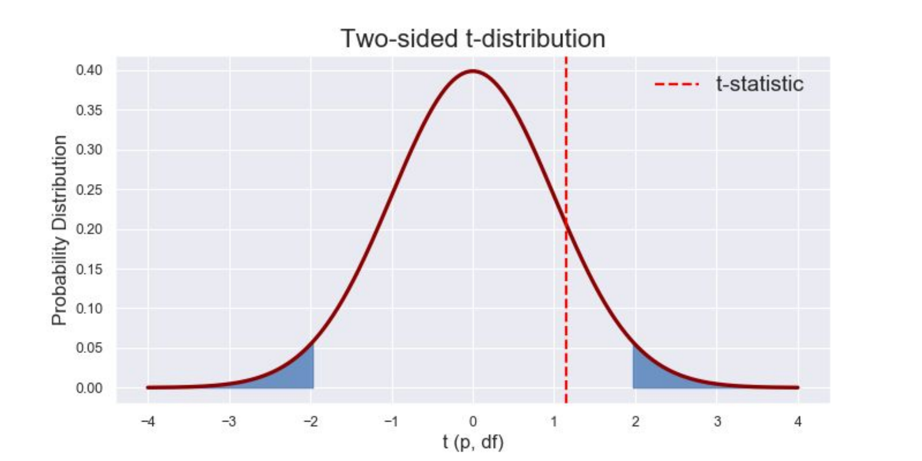
# Test 1: **Comparing Beers from Colorado and California**

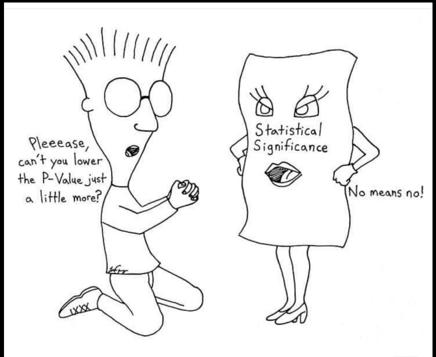
- We run a user-generated function to determine the t-statistic, critical t-values, and p-value

```
In [32]:
import test_moduls  as test
t_stat = test.twosample_tstatistic(CA_brewery, CO_brewery, alpha=0.05)
```

```
Null hypothesis is True with t-statistic =  1.149 , critical t-value =  1.9701 and p-value =  0.2517

-----------------group info---------------------------
The groups contain 113 and  125 observations. Means are:  0.065 and 0.063 respectivelly
```

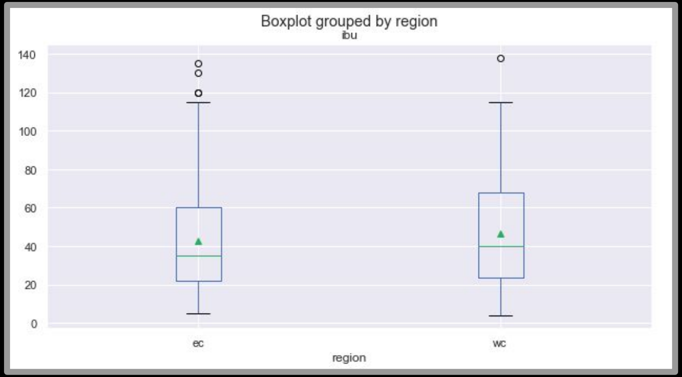
- We run a user-generated function to generate and view a visualization

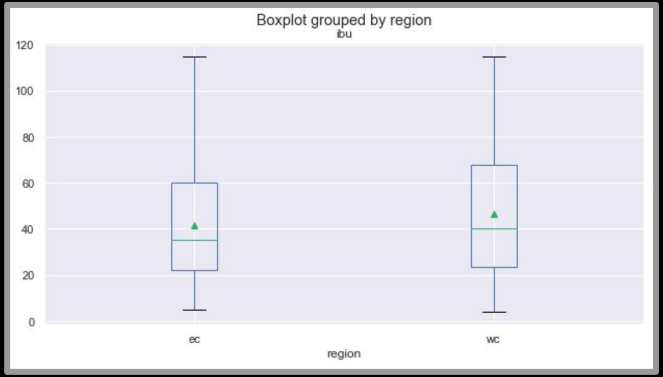


# Test 2: **Comparing IBU from East Coast and West Coast**

- Is there a difference in IBU between beers brewed on the East Coast and West Coast?
    - Outliers are removed from the set; we examine the box-plots




- We set our **null-hypothesis** and **alternative hypothesis**

## 2.1. Set Null Hypotheses

The null hypothesis is there is no difference in IBU between beers brewed on the East Coast and beers brewed on the West Coast.

> **$H_0$: The mean IBU difference between East Coast beers and West Coast beers is zero. i.e. $H_0 = H_1$**

## 2.2. Set Alternate Hypothesis

> **$H_1$ (2-tailed): The mean difference between East Coast and West Coast beers is different.**

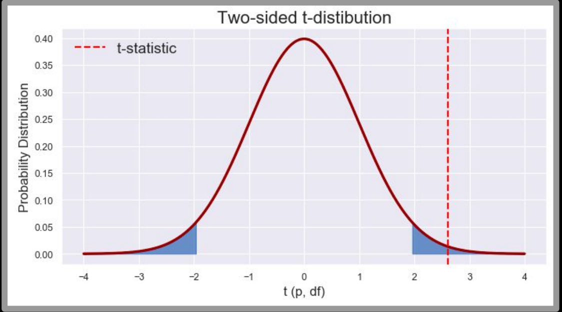
# Test 2: **Comparing IBU from East Coast and West Coast**

- We run user-generated functions to determine the t-statistic, critical t-values, and p-value
  - Two-tailed t-test and Welch's t-test

```
In [41]: t_stat = test.twosample_tstatistic(wc_ibu, ec_ibu)

         Null hypohesis rejected. Results are statistically significant             with t-statistic= 2.585 , critical t-val
         ue=  1.9631 and p-value =  0.005

         -----------------group info---------------------------
         The groups contain 427 and  329 observations. Means are:  46.452 and 41.6717 respectivelly
```

```
In [23]: welch_t = test.welch_t(wc_ibu, ec_ibu)
         print("Welch's t-statistic is: ", round(welch_t,4))
         welch_df = test.welch_df(wc_ibu, ec_ibu)
         print("Welch's degrees of fredoom (df):", round(welch_df,4))

         # converting this to p_value
         p_welch = test.p_value_welch_ttest(wc_ibu, ec_ibu, two_sided=True)

         Welch's t-statistic is:  2.6058
         Welch's degrees of fredoom (df): 724.9698
         Null hypohesis rejected. Results are statistically significant
                  with t-value =  2.6058 , critical t-value =  1.647 , and p-value =  0.0047
```

- We see that the t-statistic is 2.585 in the two-tailed t-test and 2.606 in the Welch's t-test
  - Using both tests, we reject the null hypothesis




| | Sample Mean | Sample Size | Sample Variance |
|---|---|---|---|
| East Coast | 42.69 | 333 | 25.88 |
| West Coast | 46.67 | 428 | 26.22 |

# Test 3: ANOVA test

- Is there a difference in IBU between beers brewed in DC/MD/VA, MA, MN, TX, and CO?

| | Sample Size | Sample Mean | Sample Variance |
|---|---|---|---|
| Washington State | 41 | 41.66 | 356.42 |
| Minnesota | 44 | 49.27 | 543.20 |
| DMV | 44 | 45.32 | 594.35 |
| Texas | 83 | 42.60 | 658.70 |
| Colorado | 136 | 49.93 | 632.40 |

- We set our **null-hypothesis** and **alternative hypothesis**

**Null Hypothesis:** $H_0: \quad \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$

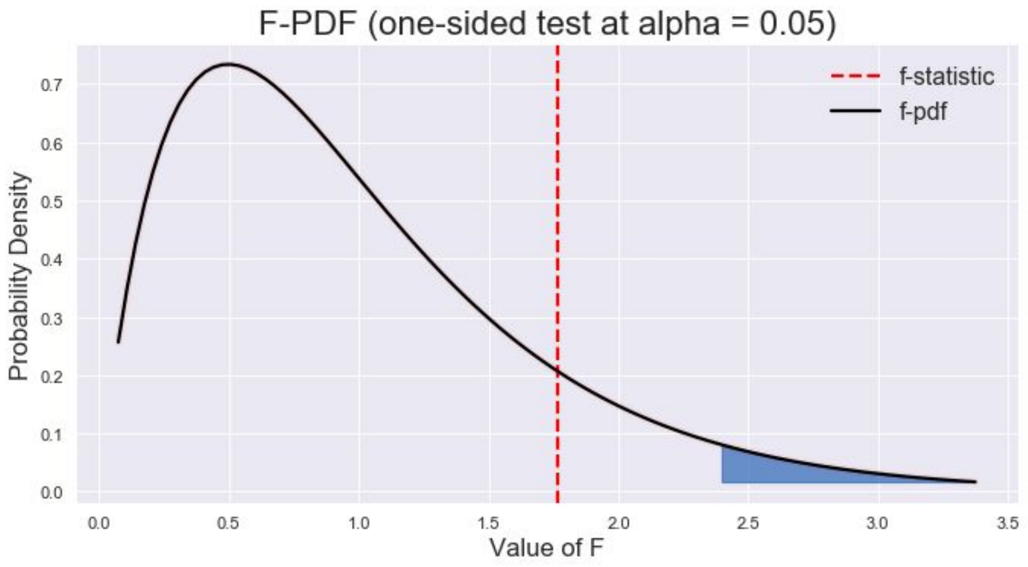
**Alternative Hypothesis:** $H_a:$ not all means are equal

# Test 3: **Comparing IBU from Five States**

- We fail to reject the Null Hypothesis with f_statistic = **1.6114**, and p_value = 0.1777.
  - We say the mean IBU is the same in WA, MN, CO, TX , DMV area:

```
vis.f_distribution(dfn, dfd, f_anova, p_value, alpha=0.05)
```

```
Null hypothesis is True with f-statistic =  1.7642 , critical f-value =  2.398 and p-value =  0.1356
>> We fail to reject the Null Hypohesis
```



# Conclusions

- There is no mean ABV difference between beers from Colorado and beers from Californias

- There is a significant mean IBU difference between beers from the East Coast and West Coast
  - West Coast beers are more bitter!

- There is no mean IBU difference among beers from CO, WA, MN, DMV, TX

# Next Steps

- Data
  - Collect more US data
  - Collect data that includes foreign beers
  - Collect time-series data to explore changes to the industry over time

- Tests
  - Explore the relationship between ABV and IBU using two-way ANOVA

# Q&A