Central to Stats: Sampling!

INTRODUCTION TO STATISTICS IN SPREADSHEETS

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Lesson Overview

- Samples vs populations
- Central Limit Theorem (CLT)

So far, you have...

- Calculated descriptive statistics

Mean:	1,483.33
Median:	1,481.67
Mode:	1481.668
Standard Deviation:	400.2464

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- Made data visualizations

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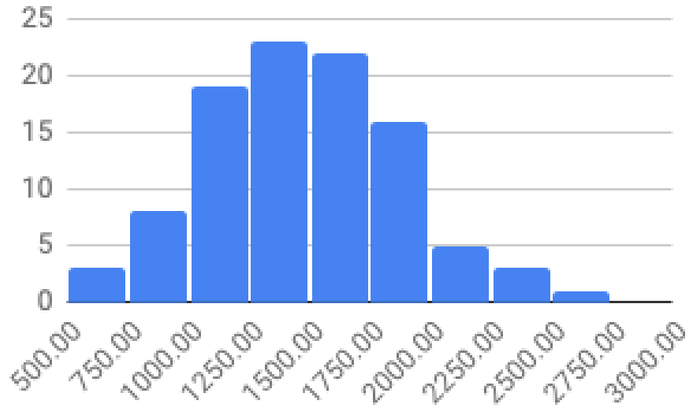

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- Used **all** of the data

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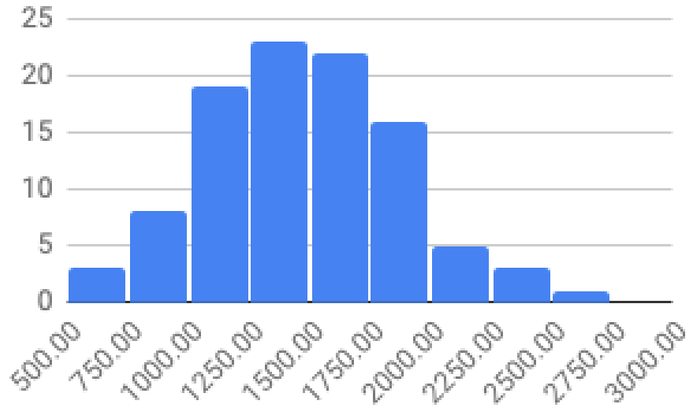

So far, you have...

- Calculated descriptive statistics
- Made data visualizations
- Used **all** of the data
- Worked with "populations"

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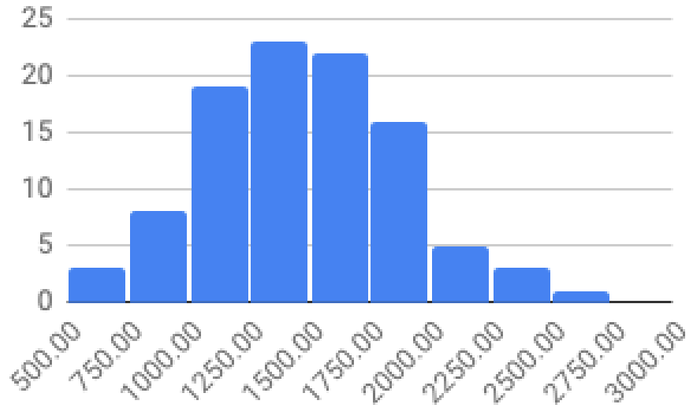

What is a population?

- An *entire* distribution of observations/events
- Costly and time consuming to work with
- Better to "sample" the population

Sampling to the rescue

- A *subset* from a population
- Meant to represent the population
- The larger the sample size, the closer the statistics of the sample will emulate the statistics of the population

- If a sample size from an independent, random variable is **large enough**, then the sampling distribution will be normal or nearly normal

Central Limit Theorem (CLT)

- "Large enough" is vague...
- How accurate do you need to be? This affects the sample size needed
- The more closely the population follows a normal distribution, the fewer samples will be required
- **Minimum number needed is between 30 and 40**

Off to do some sampling!

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Hypothesis Testing

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Anatomy of hypothesis testing

"The average Ferrari price is higher than the average sports car price"

- Hypothesis: Any testable claim

Null Vs Alternate Testable Hypotheses

- **Null Hypothesis**
  - Represents the status quo (accepted fact)
  - Represented by `H0`
- Example `H0` : Average Ferrari Price **EQUALS** Average Sports Car Price
- **Alternate/Research Hypothesis**
  - Challenger statement
  - Represented by `H1`
- Example `H1` : Average Ferrari Price **DOES NOT EQUAL** Average Sports Car Price

Common sense testing

Null Hypothesis (`H0`):

> Average Ferrari Price equals Average Sports Car Price

Alternate Hypothesis (`H1`):

> Average Ferrari Price does not equal Average Sports Car Price

- Average Ferrari Price (Sample Size = 50) = $252,000
- Average non-Ferrari Sports Car Price (Sample Size = 50) = $85,000
- `REJECT` the Null Hypothesis (`H0`)

Another common sense test

Null Hypothesis (`H0`):

> Average Toyota Price equals Average Honda Price

Alternate Hypothesis (`H1`):

> Average Toyota Price does not equal Average Honda Price

- Average Toyota Price (Sample Size = 50) = $23,845
- Average Honda Price (Sample Size = 50) = $23,720
- `FAIL TO REJECT` the Null Hypothesis (`H0`)

Removing subjectivity in a test

- Hypothesis tests use "test statistics" to verify hypotheses
- Example: `t-test` (In Spreadsheets: `T.TEST(range1, range2, tails, type)`)
  - Produces a "p-value"
  - p-value: Probability that the results you see are due to chance/error
  - Choose a p-value cutoff (Example: 1%/0.01, or 5%/0.05)
  - If p-value Is less than the cutoff, `REJECT` the Null Hypothesis
    - Conclude that there **IS** a difference between the samples

- Spreadsheets Formula:

```
= T.TEST(range1, range2, tails, type)
```

- If testing **only** `GREATER THAN` / `>` or `LESS THAN` / `<`:
  - The test has `1` tail
- If the `H0` operator is `EQUALS` / `=`:
  - `2` tails, as the values can be above **or** below the mean
- If measuring the same observations at different times:
  - Type = `1`
- If measuring different observations with same variance:
  - Type = `2`
- If measuring different observations with different variances:
  - Type = `3`

Let's practice!

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Hypothesis Testing with the Z-test

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T-Tests

- Spreadsheets Formula:

```
T.TEST(range1, range2, tails, type)
```

- Infers whether there is a difference between two means

Comparing T-Tests and Z-Tests

Similarities

- Determine whether two population means are statistically different
- Select a p-value cutoff prior to the test (Usually `0.05`)
- If the resulting p-value is less than `0.05` , then `REJECT H0`
  - Else, `FAIL TO REJECT H0` .

Contrasting T-Tests and Z-Tests

Z-Test

Formula:

```
=Z.TEST(range1, testStatistic, StDev)
```

- Needs 1 range
- Needs a test statistic (i.e, population mean)
- Used with bigger datasets (n > 30)

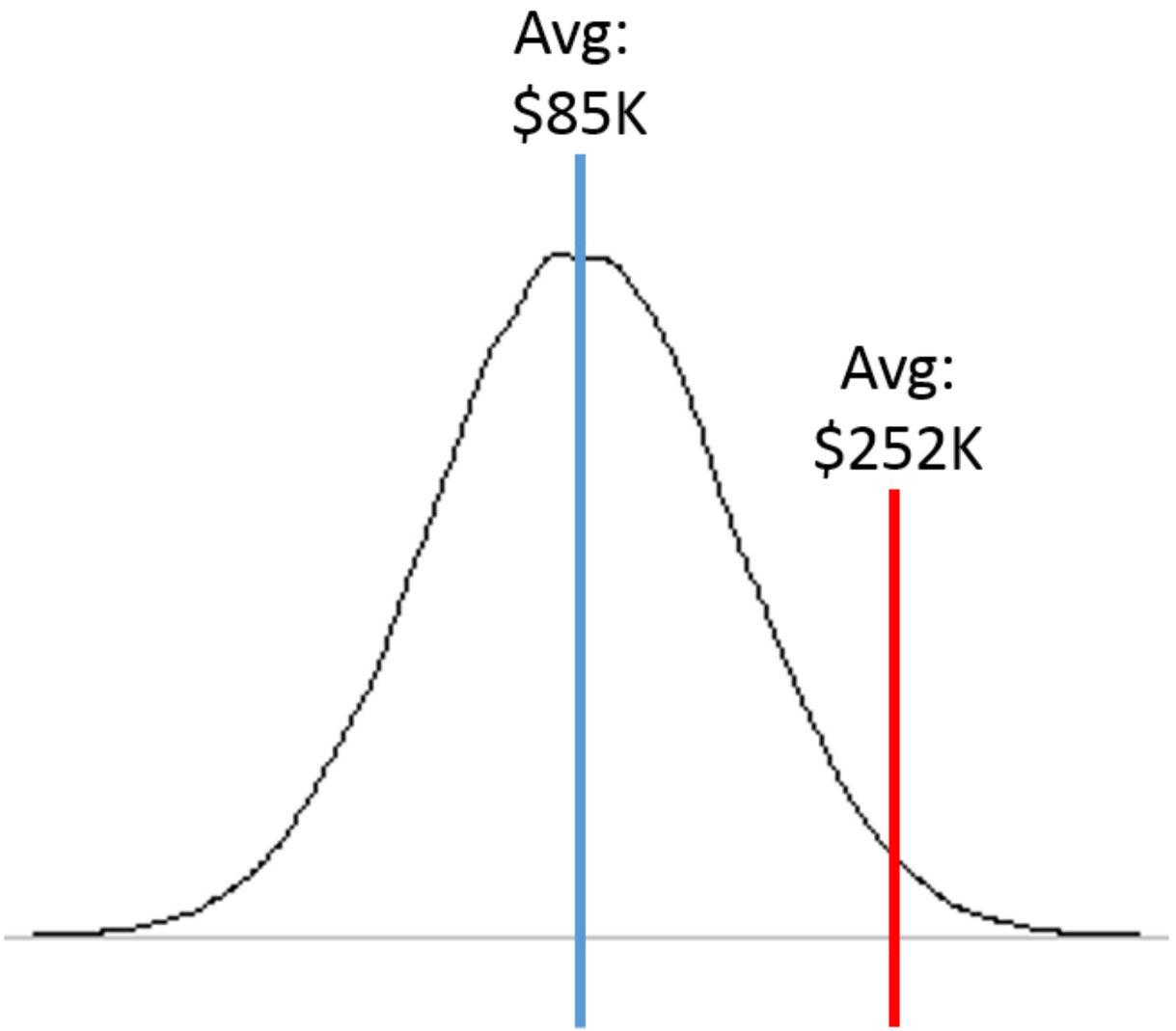
T-Test

Formula:

```
T.TEST(range1, range2, tails, type)
```

- Needs 2 ranges
- Works when variance is unknown
- Used with smaller datasets (n < 30)

[1] https://keydifferences.com/difference-between-t-test-and-z-test.html


Avg:
$85K
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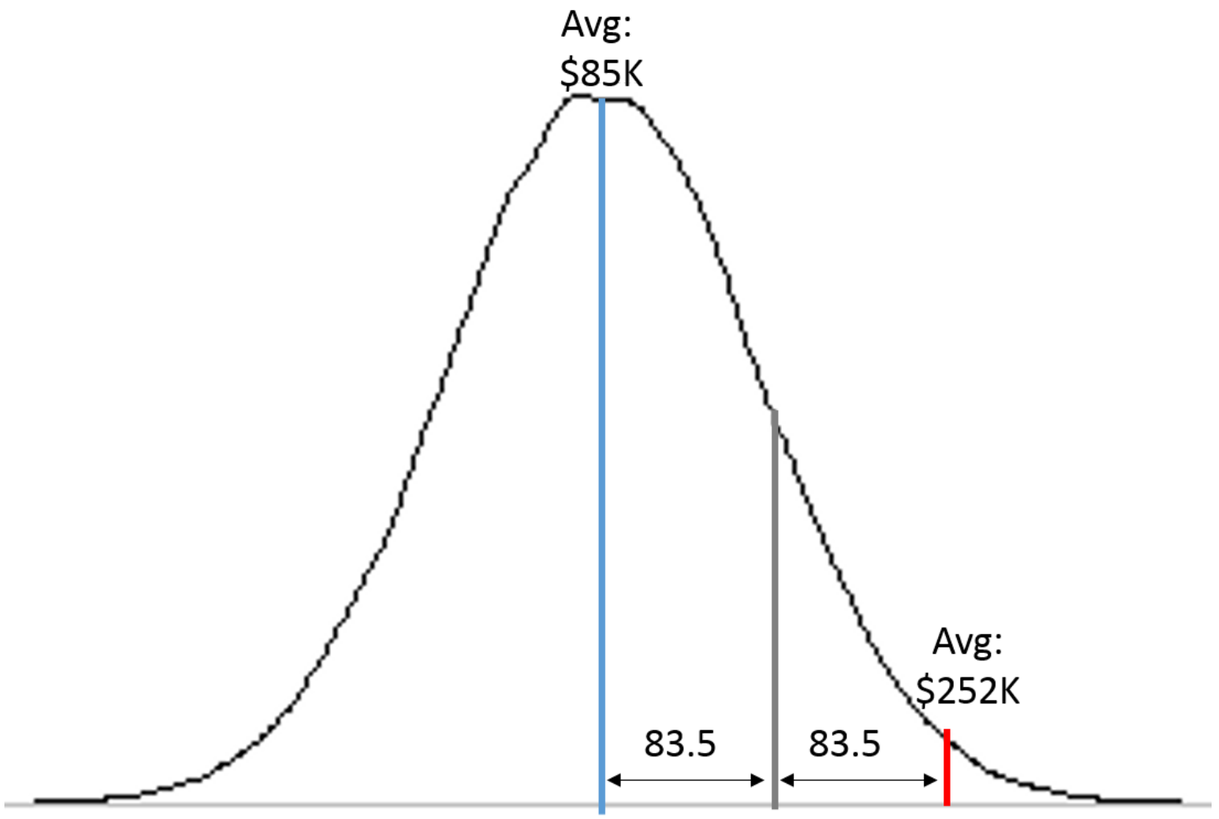
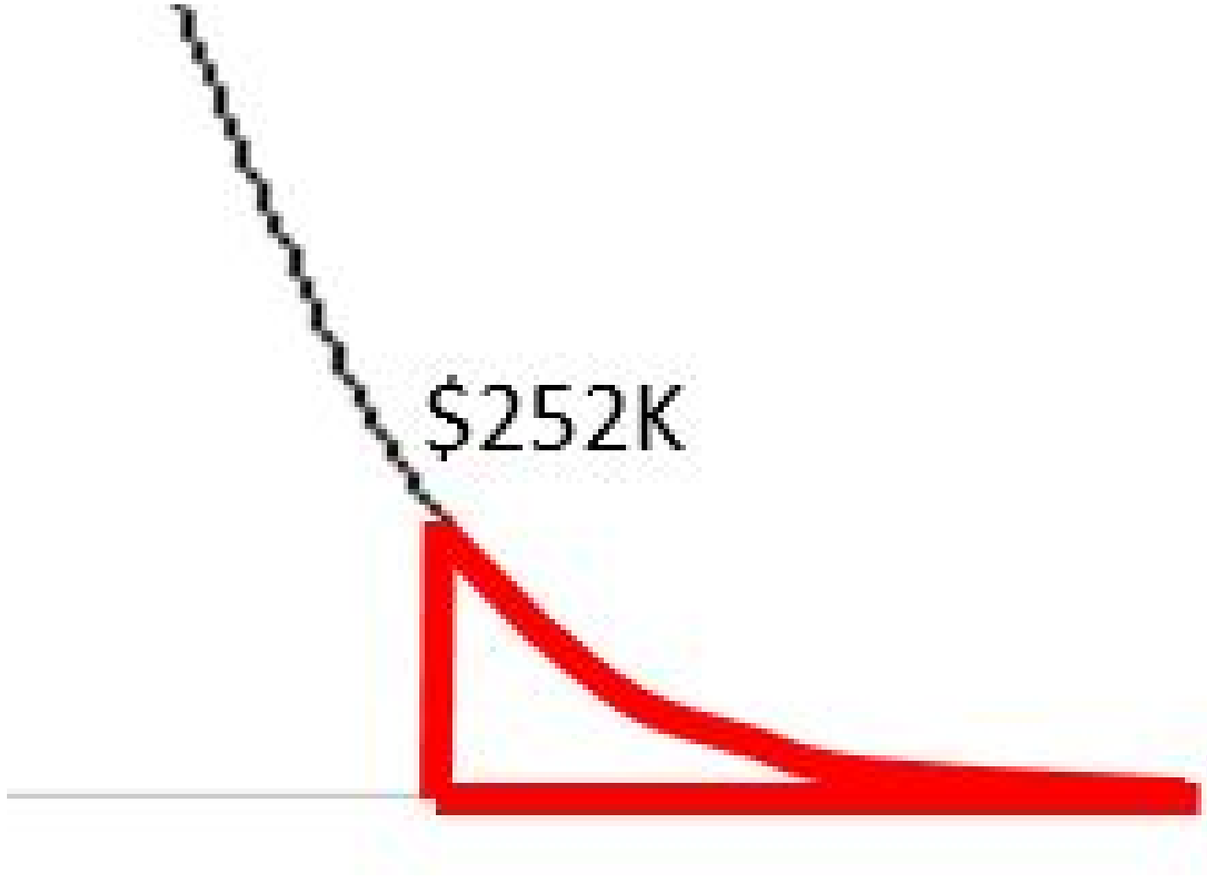

Avg:
$85K
Avg:
$252K
83.5
83.5

Z-Tests calculate the probability



Z-Tests in Spreadsheets

```
Z.TEST(data, value, [standard_deviation])
```

- `FAIL TO REJECT` `H0` if the -value is greater than `0.05`
- `REJECT` `H0` if the p-value is less than `0.05`

Let's practice!

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Hypothesis Testing with the Chi-squared test

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Applications of the chi-squared test

- Comparing samples for meaningful differences
- Example: Did the treatment actually work?

[1] https://www.pexels.com/photo/20-mg-label-blister-pack-208512/

Testing before and after

Two possibilities:

- The difference in the new group stems from random sampling (`H0`)
- There is in fact a meaningful difference (`H1`)

Chi-squared tests also provide a p-value

Chi-squared test conditions

For a chi-squared test to be useful:

- Data has to be in groups (e.g: "Old treatment", "New treatment")
- Avoid really small expected values (`< 5`)

Testing the independence of two groups

- "Clinically proven"
- "Lab tested"
- Experiment needs to control for lifestyle factors
- Compare weight within two groups
  - One treated with the supplement, and the other not

[1] https://www.pexels.com/photo/woman-girl-jeans-clothes-53528/

Chi-squared test in Spreadsheets

```
CHITEST(observed_range, expected_range)
```

- `FAIL TO REJECT` `H0` if the p-value is greater than `0.05`
- `REJECT` `H0` if the p-value is less than `0.05`

Let's practice!

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