

# Can Variance Be Negative?

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## RECOMMENDED CITATION

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Yes, variance can be negative. Variance is a measure of how much a set of numbers varies from the mean, and if the numbers are all below the mean, the variance will be negative. This occurs when all the numbers in a set are equal, as the deviation from the mean is zero. As variance is the square of the deviation, it will be negative in this case.

In statistics, the term **variance** refers to how spread out values are in a given dataset.

One common question students often have about variance is:

*Can variance be negative?*

The answer: **No, variance cannot be negative.** The lowest value it can take on is zero.

To find out why this is the case, we need to understand how variance is actually calculated.

## How to Calculate Variance

The formula to find the variance of a sample (denoted as **s<sup>2</sup>**) is:

$$s^2 = \sum (x_i - \bar{x})^2 / (n-1)$$

where:

**x**: The sample mean

**x<sub>i</sub>**: The *i*th observation in the sample

**N**: The sample size

$\Sigma$ : A Greek symbol that means "sum"

For example, suppose we have the following dataset with 10 values:

| Dataset |
|---------|
| 6       |
| 7       |
| 10      |
| 13      |
| 14      |
| 14      |
| 18      |
| 19      |
| 22      |
| 24      |

We can use the following steps to calculate the variance of this sample:

### Step 1: Find the Mean

The mean is simply the average. This turns out to be **14.7**.

### Step 2: Find the Squared Deviations

Next, we can calculate the squared deviation of each individual value from the mean.

| Dataset | $(x_i - \bar{x})^2$ |
|---------|---------------------|
| 6       | 75.69               |
| 7       | 59.29               |
| 10      | 22.09               |
| 13      | 2.89                |
| 14      | 0.49                |
| 14      | 0.49                |
| 18      | 10.89               |
| 19      | 18.49               |
| 22      | 53.29               |
| 24      | 86.49               |

### Step 3: Find the Sum of Squared Deviations

Next, we can take the sum of all the squared deviations:

| Dataset | $(x_i - \bar{x})^2$ |
|---------|---------------------|
| 6       | 75.69               |
| 7       | 59.29               |
| 10      | 22.09               |
| 13      | 2.89                |
| 14      | 0.49                |
| 14      | 0.49                |
| 18      | 10.89               |
| 19      | 18.49               |
| 22      | 53.29               |
| 24      | 86.49               |
| sum     | 330.10              |

#### Step 4: Calculate the Sample Variance

Lastly, we can calculate the sample variance as the sum of squared deviations divided by (n-1):

$$s^2 = 330.1 / (10-1) = 330.1 / 9 = 36.678$$

The sample variance turns out to be **36.678**.

#### An Example of Zero Variance

The only way that a dataset can have a variance of zero is if **all of the values in the dataset are the same**.

For example, the following dataset has a sample variance of zero:

| Dataset |
|---------|
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |
| 15      |

The mean of the dataset is 15 and none of the individual values deviate from the mean. Thus, the sum of the squared deviations will be zero and the sample variance will simply be zero.

### Can Standard Deviation Be Negative?

A more common way to measure the spread of values in a dataset is to use the standard deviation, which is simply the square root of the variance.

For example, if the variance of a given sample is  $s^2 = 36.678$ , then the standard deviation (written as  $s$ ) is calculated as:

$$s = \sqrt{s^2} = \sqrt{36.678} = 6.056$$

Since we already know that variance is always zero or a positive number, then this means that **the standard deviation can never be negative since** the square root of zero or a positive number can't be negative.