

# Uncertainty and Expected Value

#CMSC320

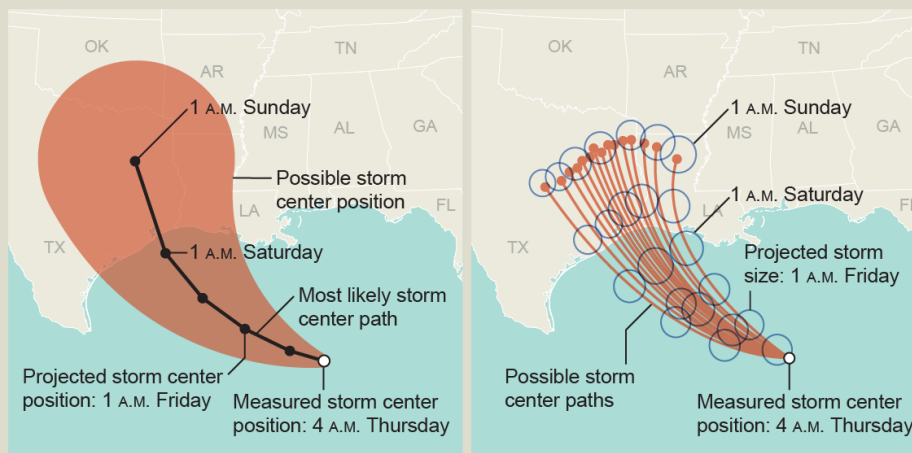
#probability\_statistics

#M1

## Uncertainty

The idea behind **uncertainty** is that the outcome of events can be predicted but there is not guarantee that the predicted outcome will always occur, we always have some level of **uncertainty** in whether our predictions will be reflected by reality.

"Cone of uncertainty" (left) shows where a hurricane may head, according to a group of forecasts. An alternative is to show the specific path predicted by each forecast (right). Both approaches have pros and cons in helping people judge the risk they may face, but the one on the right makes it clearer that the path is difficult to predict.



### Definition

Uncertainty is the *error in predicted compared to observed* values of some event.

## Purpose and Properties

Uncertainty can be used to assess the reliability of predictions

### **High Uncertainty**

- Low Prediction Reliability
- High Outcome Variance

### **Low Uncertainty**

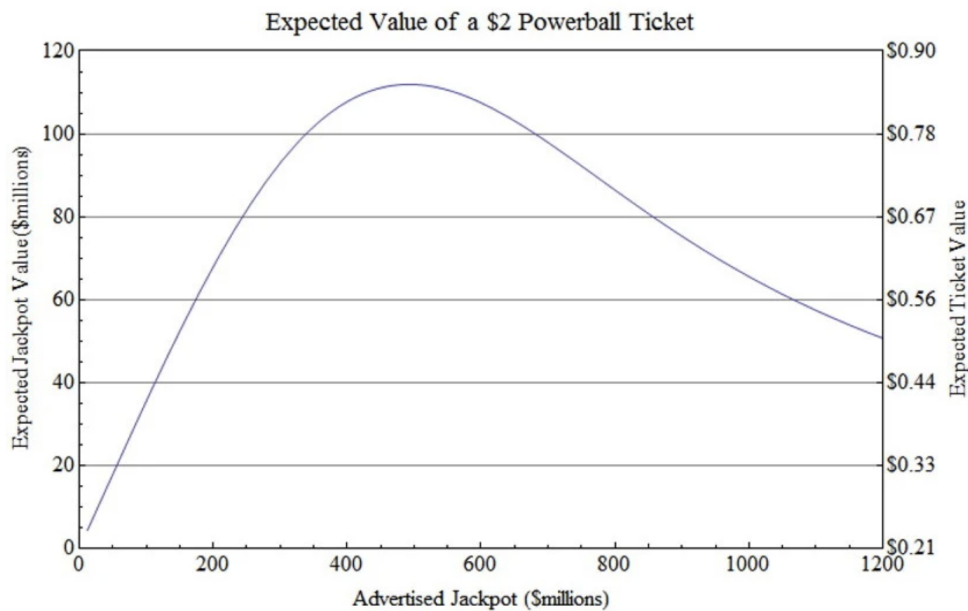
- High Prediction Reliability
- Low Outcome Variance

## **Examples of Uncertainty Measures**

- Standard deviation
- IQR

## **Expected Value**

Expected value is a central tendency measure (determines what is the average or typical value in a dataset). Expected value can help quantify risk and aid in decision making.



How much value you expect to gain from betting on a \$2 powerball ticket

### Definition

The *expected outcome* based on some *repeated trail* of a statistical experiment.

## Formula

Expected value is the sum of all possible products of the value associated with a statistical outcome and its respective probability

$$E[X] = \sum x_i p(x_i)$$

## Example

Suppose you are rolling a fair six-sided die, and you want to calculate the expected value of the roll. The possible outcomes are the numbers 1, 2, 3, 4, 5, and 6, each with equal probability of 1/6. What is the expected value in this scenario?

To calculate the expected value, you can use the above formula:

Expected Value = (Outcome 1 *Probability 1*) + (*Outcome 2* Probability 2) + ... + (Outcome n \* Probability n)

Expected Value = (1 *1/6*) + (*2* 1/6) + (3 *1/6*) + (*4* 1/6) + (5 *1/6*) + (*6* 1/6)

Expected Value = 3.5

## Expected Value vs Mean

| Expected Value  | Mean   |
|---|--|
| Expected value is the weighted average of all possible outcomes of a random variable, where the weights are the probabilities of each outcome | Mean is the arithmetic average of a set of numbers             |
| Expected value considers all possible outcomes of a random variable   | Mean only considers the values that actually occur in the data |

## Sources

1. *Everything you need to know about the math of Powerball*. Big Think. (2022, November 11). Retrieved March 19, 2023, from <https://bigthink.com/starts-with-a-bang/math-of-powerball/#:~:text=If%20you%20want%20to%20calculate,total%20worth%20of%20each%20ticket>.
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3. Soni, D. (2019, July 16). *What is expected value?* Medium. Retrieved March 19, 2023, from <https://towardsdatascience.com/what-is-expected-value-4815bdbd84de>