AGAINST ALL ODDS
EPISODE 19 – "PROBABILITY MODELS"
TRANSCRIPT

FUNDER CREDITS

INTRO

Pardis Sabeti
Hello, I'm Pardis Sabeti and this is *Against All Odds*, where we make statistics count.

Probability is the language of uncertainty. And understanding probability is what allows statisticians to predict the outcomes of random phenomena over the long term – from the very complex, like weather, to the very simple, like a coin toss. Or maybe of more interest to the gamblers out there, a dice toss!

Every casino patron has his or her own personal technique for trying to hit a big jackpot.

> **Gamblers**
> Most of it's luck, but the skill is about 10%...
> You'll have to quit while you're ahead because that's the only way you'll beat the game…
> I'll probably keep playin'…keep playin', try to win as much as I can…

Pardis Sabeti
But no matter your method, the house always has the upper hand. After all, statisticians aren't the only experts in probability; casino owners have also mastered the art.

> **Steven Norton**
> In casino gaming, the house edge is very small, unlike the lottery where it's like 50%. We have a percentage advantage in most games that is less than 1%.

Pardis Sabeti
With such a seemingly small advantage, how does the casino make any money? Part of their bottom line depends on the huge number of players they attract every day. Over thousands and thousands of gamblers, that small edge starts to generate big revenues. And unlike most guests, casinos are playing the long game, not just hoping for a short-term windfall.

> **Craps Dealer**
> Nine for the winner!
>
> **Casino Patron**
> Winner! Winner!
>
> **Steven Norton**

When a player first comes in, his chance of beating us is about 50-50. A smart gambler will come in and bet the maximum he can afford to lose on one roll and walk away either a winner or loser because the house edge has only been one half of one percent on that particular bet. So he's got a forty nine and a half percent chance of winning, we've got a 50% chance of winning.

Pardis Sabeti

Of course, most people don't play this way. While at the table, the more bets placed by a gambler, the more likely he or she is to lose in the long term. So the casino is counting on the individual who tries to get too much of a good thing.

Steven Norton

Most players, though, enjoy the fun of casino gambling and they want to stay at the table for a longer period of time to enjoy that and that basically gives us a bigger edge.

Pardis Sabeti

Even with the odds stacked against them from the get-go, the glitz of the casino and the promise of a possible bonanza keep many gamblers coming back for more.

Gamblers

I broke out about even. It was fun.
[How'd you do?]
I lost my shirt.
[You what?]
Lost my shirt.
[You gunna come back?]
Sure. I come back all the time. Lose my shirt every week.
I won a little bit. About $50. [That's a lot!] Oh…no it's not. I'll be back next week. Maybe next week I'll do a little better.

Pardis Sabeti

Though winning is against the odds, it's not against *all* odds. There's always a chance that, next time, they'll hit the jackpot.

Casinos count on the fact that over the very long term, they know with near certainty the average result of thousands and thousands of chance outcomes… even though you never know what will happen on any one particular roll of the dice. That's why the house always wins in the end. Statisticians can create probability models to mathematically describe this fact.

Let's explore the probability model for one of the more popular casino games, craps. Craps is a dice game with roots that go back hundreds of years. Depending on how players bet, money is made or lost based on the 'shooter'

rolling certain numbers and not others. Smart gamblers want to know, if they're playing with fair dice, what is the probability of any particular roll coming up?

Here's where statisticians start building that probability model. First, we define the sample space, *S*, that is the set of all possible outcomes. Rolling two six-sided dice means we have 36 possible outcomes.

Next we need to assign probabilities to each of the possible outcomes in our sample space. Each roll is independent, meaning that the occurrence of one doesn't influence the probability of another. If the dice are perfectly balanced, all 36 outcomes are equally likely. In the long run, each of the outcomes would come up on one thirty-sixth of the rolls. So the probability for each outcome is 1 in 36. That's a .278 chance or around 3%. Probabilities are always between 0 and 1, with those closer to 0 less likely to happen, and those closer to 1 more likely to happen. The sum of the probabilities of all the possible outcomes in a sample space always equals 1.

Gamblers usually don't care what comes up on each die, they're more worried about what the two dice add up to together. So the sample space they're interested in for rolling two dice looks like this….

Each roll has an equal chance of occurring, but that's not true for each sum between two and twelve. For example, there's only one way to roll a two, known as "snake eyes," and one way to roll a twelve, called "boxcars." But not all sums between two and twelve have equal chances of occurring. For instance, there are six ways to roll a seven, meaning the probability of rolling a seven is six in thirty-six, or one in six—about seventeen percent.

Here's the probability model for how many spots are going to turn up when a player rolls two dice. Remember, a probability model is made up of all the possible outcomes together with the probabilities associated with them. By tweaking the payout for each roll, the casino can use the probability model to ensure that over the long term, no one will beat the house. You can see this in action when you consider the most common roll – a seven – is the one that instantly loses the round once it's underway. No wonder rolling a seven is called, "craps."

You might want to know the probability of rolling anything other than a 7. We can use the Complement Rule to figure this out. It's pretty simple. It says that the probability an event doesn't occur is 1 minus the probability that it does. So the probability of not rolling a 7 is one minus one-sixth, or five-sixths.

The probability model for rolling two dice provides plenty of other examples, too. Let's say one gambler placed separate bets on 4 and 5. He wants the next roll to add up to one or the other of those two numbers. What are the chances he'll win? We can turn to the probability model to figure that out. First of all, these two

events – rolling a four or rolling a five – are what statisticians call mutually exclusive. These two events have no outcomes in common – if one happens then the other couldn't have. With one roll of a pair of dice, you cannot simultaneously roll both a four and a five; you roll one or the other or something else entirely. Because these events are mutually exclusive, we can use the Addition Rule to figure out the gambler's chances of winning.

Just check back with our probability model to find the probability of rolling 4 and the probability of rolling 5. Add the two together and you can see that our gambler has about a 19% chance of having a 4 or 5 rolled next; so one of his bets will pay off.

Craps players can also bet that the shooter will roll a number "the hard way," meaning by rolling doubles. Let's say one gambler bets the shooter will roll a six the hard way. What are the chances that this bet will pay off on the next roll?

We can figure this one out using the Multiplication Rule. It says that if two events are independent then the probability of them both happening is the product of their individual probabilities. The roll of one die is our Event A and the roll of the other is our Event B. This time the events we're interested in are a three coming up on each of the dice. Whatever comes out on top of the one die doesn't affect what comes out on top of the other, so the two events in this case are indeed independent.

Rather than the probability model we've been using for rolling two dice at once, we need a new one for the chances of each number coming up on the roll of a single die. That's not too complicated since each of the six sides is equally likely to hit. So the individual probability for each die to roll a three is one in six. If we plug those probabilities into the Multiplication Rule, we find that the chances of rolling a hard six is one in thirty six. So that's the probability that this bet will win on the shooter's next roll.

Unfortunately, no matter how skilled you get in using probability models, they won't give you a 100% guarantee of winning a jackpot in Vegas… but I would bet big money that understanding them will help you in our later modules!

For *Against All Odds*, I'm Pardis Sabeti. See you next time!

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