Trip to the Big Wheel

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Abstract: Using the theorem of probability and expected value, we calculate the average value of the 'Big Wheel' on the game show Price is Right. These calculations allow us to mathematically determine when a player should spin again or stop based on the opponents' spin value and the order the player is spinning in.

Introduction

The Price is Right is a game show that first aired on CBS on September 4, 1972. The game show randomly selects nine contestants from the audience to play the game. These contestants must bid closest to the face value of a prize to be able to play the game. In the end six contestants will have the opportunity to play another game and a chance at the showcase showdown. Each round three contestants will spin the big wheel, hoping to obtain $1.00 in either one or two spins. The contestant closest to $1.00 without going over will move on to the showcase showdown with the winning contestant from Round 2 of the big wheel.

The 'Big Wheel'

The Wheel is divided into 20 equal divisions, each with a monetary value. The divisions include the values from $0.05 to $1.00 in $0.05 increments. These monetary amounts are randomly placed among the wheel.

Rules of Play

As stated above, three contestants will have a chance at the wheel each round. The three contestants will go in order of their prior winnings in the show. The contestant with the lowest earnings will go first. This contestant must spin the wheel once. The contestant then has the option of spinning again or staying at the value of the first spin. The contestant must not go over $1.00 in order for he or she to remain in the game. The second contestant also has the option of spinning once or twice. The second contestant must score a larger amount than the contestant before to continue playing. However, if the contestant goes over $1.00 he or she will be disqualified from the game. If the second contestant spins a larger value than the prior contestant, the prior contestant loses and is out of the game. Finally, the third contestant follows the same procedure. The contestant with the highest score under or equal to $1.00 wins the game. In the case of a tie there is a one-spin spin-off and the highest scorer wins.

Average Value

The average value, or expected value is the value we would expect if we spun the wheel many times. This can be calculated by taking the number of outcomes, *x,* and the probability of each outcome, *p,* and then using the following formula:

$$E(x) = x_1 p_1 + x_2 p_2 + ... + x_n p_n .$$

Since the wheel has 20 equal divisions the probability of each value is 1/20. Since each outcome has the same probability, we can use the following formula:

$$E(x) = x_1 p_1 + x_2 p_2 + ... + x_n p_n = (x_1 + x_2 + ... + x_n) p$$

$$E(x) = \frac{(0.05 + 0.10 + 0.15 + ... + 0.95 + 1.00)}{20}$$

$$E(x) = \$0.525 \approx \$0.53$$

Thus, the average value for one spin of the wheel is approximately $0.53. Therefore, the expected value for the total of the two consecutive spins would be

$0.525 + $0.525 = $1.05.

Probability

In order to decide whether or not a contestant should spin again, we must calculate the probability of exceeding $1.00 compared with the probability the next contestant could beat the initial spin value. The probability of going over $1.00 can be calculated by counting the possibilities that exist greater than $1.00 divided by the total number of outcomes. The probability of the opponent beating the 1st contestant's initial spin can be calculated by adding the probability of the first spin beating the 1st contestant with the probability of defeating the contestant with the total of two spins.

$$P(x > \$1.00) \quad \text{vs.} \quad P\,(\text{opponent beating } x)$$

If the probability of the contestant going over $1.00 is less than the probability of the opponent beating the 1st contestant, the optimal decision would be to spin again. The contestant should spin again because the odds of the opponent beating her score are higher than the odds the contestant's second spin will bring the total over $1.00.

$$P(x > \$1.00) \;<\; P\,(\text{opponent beating } x)$$

However, if the probability of the contestant going over $1.00 is greater than the probability that the opponent will beat the initial score, the best decision would be to stay at the initial score. In other words, it is more likely that the 1st contestant will go over $1.00 if he or she spins again than the opponent will be able to beat the contestants original spin.

$$P(x > \$1.00) \;>\; P\,(\text{opponent beating } x)$$

Table 1 illustrates the discussed probabilities for each initial spin.

Table 1

Initial Spin	**P**(*x* > $1.00) (Probability of going over $1.00)	**P(**opponent beating *x* (does not include ties) in 1 or 2 spins)
$0.05	5%	19/20 + (1/20) (190/400) = 97.38%
$0.10	10%	18/20 + (2/20) (189/400) = 94.73%
$0.15	15%	17/20 + (3/20) (187/400) =92.01%
$0.20	20%	16/20 + (4/20) (184/400) = 89.20%
$0.25	25%	15/20 + (5/20) (180/400) = 86.25%
$0.30	30%	14/20 + (6/20) (175/400) = 83.13%
$0.35	35%	13/20 +(7/20) (169/400) = 79.79%
$0.40	40%	12/20 + (8/20) (162/400) = 76.20%
$0.45	45%	11/20 +(9/20) (154/400) = 72.33%
$0.50	50%	10/20 +(10/20) (145/400) = 68.13%
$0.55	55%	9/20 +(11/20) (135/400) = 63.56%
$0.60	60%	8/20 +(12/20) (124/400) = 58.60%
$0.65	65%	7/20 +(13/20) (112/400) = 53.20%
$0.70	70%	6/20 +(14/20) (99/400) = 47.33%
$0.75	75%	5/20 +(15/20) (85/400)= 40.94%
$0.80	80%	4/20 +(16/20) (70/400) = 34.00%
$0.85	85%	3/20 +(17/20) (54/400) = 26.48%
$0.90	90%	2/20 +(18/20) (37/400) = 18.33%
$0.95	95%	1/20 +(19/20) (19/400) = 9.51%
$1.00	-	-

Results

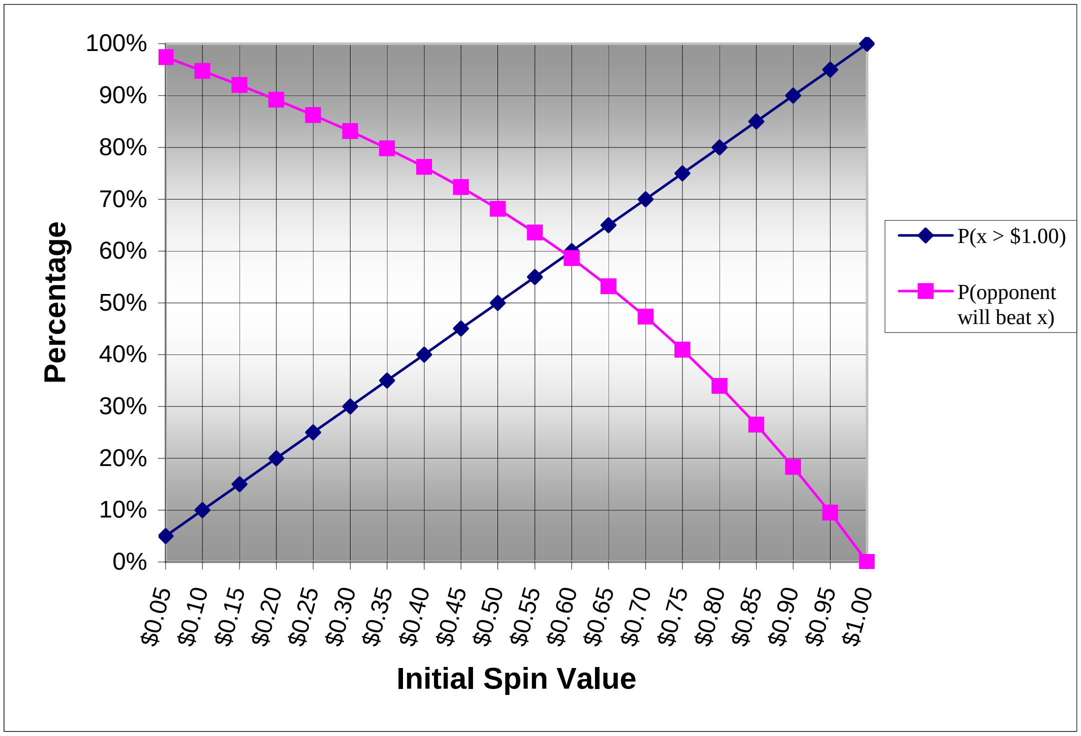
Our calculations allow us to determine the optimal decisions each contestant should make based on his or her standings. The table above tells us that if the initial spin is \$0.55 or less it is optimal to spin again. This is due to the fact that the probability of the next spin causing the contestants total value to exceed \$1.00 is less likely than the opponent's odds of beating the 1st contestants initial spin. Thus, a contestant in this standing should spin again.

$x \le \$0.55$ the $P(x > \$1.00)$ < $P\,(\text{opponent beating } x)$

However, if the contestant spins \$0.60 or higher on his or her first spin, it is best to stop. This decision is made because it is more likely that the contestant will over spin than his or her opponent will beat her previous score.

$x \ge \$0.60$ the $P(x > \$1.00)$ > $P\,(\text{opponent beating } x)$

Graph 1



This concept can also be represented visually in Graph 1 above. The probability the opponent will beat the initial spin is greater than the probability of the contestant over spinning through \$0.55. The graph shows us this relationship reverses at the \$0.60 value. Therefore, we can conclude that a contestant should spin again if their initial spin was \$0.55 or less. However, if the contestant spins \$0.60 or more, he or she should stay at this value.