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Spinning the Big Wheel on "The Price is Right": A Spreadsheet Simulation Exercise

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Abstract

A popular game played in each broadcast of the United States television game show "The Price is Right" has contestants spinning a large wheel comprised of twenty different monetary values (in 5-cent increments from \$0.05 to \$1.00). A player wins by scoring closest to, without exceeding, \$1.00. Players may accomplish this in one or a total of two spins. We develop a spreadsheet modeling exercise, useful in an introductory undergraduate Spreadsheet Analytics course, to simulate the spinning of the wheel and to determine optimal spinning strategies.

KEYWORDS: Spreadsheet simulation, Decision-making, Game shows, Entertainment

1. Introduction

Effectively illustrating analytical concepts through applications that directly relate to the interests of our students can enhance our pedagogy. Indeed, if students observe a principle demonstrated within an environment they readily understand and appreciate, they may be more likely to retain awareness of the concept [2].

Generally, North American college students enjoy game shows and participating in games of chance. They find such games to be entertaining and engaging. Nonetheless, many of our students loathe spreadsheet analytics and its associated emphasis on statistical problem-solving. Essentially, we aimed to create a simulation exercise that would couple a student's inherent interest in games with training in basic spreadsheet model-building.

"The Price is Right" is a day-time show, the second longest-running game show in television history. On November 5th, 2009, it celebrated its 7,000th edition. Popular U.S. television personality Bob Barker hosted nearly 6,000 episodes from 1972-2007, helping to give away nearly $500 million in prizes to over 50,000 contestants. Nearly two million people have attended studio tapings of the show, with roughly a third of these being college students.

The show's format calls for audience involvement. At the beginning of each episode, four audience members are randomly chosen to "come on down" to participate in contestant's row. These four individuals estimate the dollar value of a particular item, with the winner being the player with the closest bid (without exceeding the prize's dollar value). In all, six of these bidding games are conducted during a one-hour episode, with involvement from nine players (the initial four contestants in addition to five others who replace a winner during subsequent stages of the show). The six winners of the bidding contests each participate in one of a variety of games, with prizes ranging from bedroom suites to vacations to luxury automobiles.

The three winners from each "half" of an episode compete in a "Showcase Showdown". This involves the spinning of a large wheel comprised of twenty sections. Each section corresponds to a particular monetary value ranging in 5-cent increments from $0.05 to $1.00. Players can take at most two spins of the wheel. The winner is the player with a total spin amount closest to, but not exceeding, $1.00. Should two (or more) players have the same score after completion of their turn, a "spin-off" is then held with each player receiving an additional spin of the wheel. The player with the higher (or highest) total on this third spin wins.

A particular player may be required to make an intriguing strategic decision during the spinning of the big wheel. Should their initial spin be less than $1.00, would it be wise for the player to take a second spin? How is this decision affected by the order in which the player participates during this event? Spinning a second time permits the player to earn a total score closer to $1.00, thus giving the contestant a greater chance of winning the game. Nonetheless, it is possible that the additional spin may catapult the player over the $1.00 threshold, thereby automatically eliminating them from further competition. The probability of exceeding $1.00 would grow as the total of the first spin increases. The decision as to utilize the second spin evokes considerable audience reaction, especially for those initial spin values that fall in the "intermediate" range of possible amounts. Proper decision-making (and a bit of luck!) may prove beneficial, since winners of each of the two "Showcase Showdowns" subsequently compete in a final bidding game on a host of fabulous prizes known as a "Showcase". Prize totals in this portion of the show can amount to tens of thousands of dollars.

Given the widespread appeal of game shows, especially among collegiate students, an instructor may be able to generate considerable classroom interest and participation by utilizing an in-class exercise based on game-show decision-making. This is the thrust of our paper. We seek to develop an exercise - suitable for an introductory undergraduate Spreadsheet Analytics course - to simulate the spinning of the big wheel during the "Showcase Showdown". We shall begin by exploring the decision process of a particular player in a two-person version (perhaps the earliest participant was automatically eliminated by exceeding the $1.00 threshold), then we shall consider the initial contestant's decision process during a traditional three-person game. We will develop our simulation models with @RISK, a powerful spreadsheet add-in for effectively modeling real-world decisions [1].

The format of this paper is as follows. In section 2, we illustrate the development of our spreadsheet model, while the section 3 provides model results. We finish the paper with a few remarks on our use of this example during an undergraduate course.

2. Spreadsheet Model Development

Before exploring the development of our spreadsheet model, we wish to remark that Coe and Butterworth [3] have analytically determined the optimal stopping points for the "Showcase Showdown" competition on the "Price is Right" television show. For a two-person game, they discovered that players should stop at any total at or above $0.55. In a three-player game, the first contestant should stop at any total at or above $0.70. Although we intend to demonstrate that our results will support their findings, we feel that creating a spreadsheet model of this decision-making situation is a worthwhile objective. It provides certain pedagogical benefits such as deeper understanding of the material [4]. This type of spreadsheet model permits instructors to innovatively introduce (or crystallize) the important subject of simulation.

For the two-player "Showcase Showdown", our objective is to calculate the probability that the first player ultimately wins this game as a function of the observed value on their initial spin, and whether or not the player takes advantage of their second spin. Figure 1 presents a screenshot of the spreadsheet for the two-player game.

	A	B	C	D	E	F	G	H	I	J
1	Player 1				Player 2				Player 1	Player 2
2	Total on 1st Spin	2nd spin	Total		Total on 1st Spin	2nd spin	Total		Spin-off	Spin-off
3	$0.45	$0.35	$0.80		$0.25	$0.05	$0.30		$0.50	$0.30
4										
5	Does Player 1 win?	TRUE	1							
6										
7	Possible totals on 1st Spin		Other spin totals							
8	$0.05		$0.05							
9	$0.10		$0.10							
10	$0.15		$0.15							
11	$0.20		$0.20							
12	$0.25		$0.25							
13	$0.30		$0.30							
14	$0.35		$0.35							
15	$0.40		$0.40							
16	$0.45		$0.45							
17	$0.50		$0.50							
18	$0.55		$0.55							
19	$0.60		$0.60							
20	$0.65		$0.65							
21	$0.70		$0.70							
22	$0.75		$0.75							
23	$0.80		$0.80							
24	$0.85		$0.85							
25	$0.90		$0.90							
26	$0.95		$0.95							
27			$1.00							

Figure 1: Two-player "Showcase Showdown" game

The value in cell A3 refers to the particular score obtained by Player 1 after their initial spin. Since we want to model a range of potential first spin values, it is helpful to use a RISKSIMTABLE (A8:A26) function in this cell. This specific @RISK function allows us to run several simulations for each value of a particular variable (in this case, the different possible first spin values). For the case of a player opting to spin again, we would want to explore all values from $0.05 to $0.95 (should a player score $1.00 on their first spin, they would <u>never</u> want to use their second spin – they have already guaranteed themselves of at least heading to a spin-off!). If we are examining the decision of a player to stay with their initial spin, we would consider all values from $0.05 to $1.00.

The random, probabilistic elements of our spreadsheet model are the actual spin values. In cell B3, we require a function that will generate random spin amounts. We suggest using the function RISKDUNIFORM(C8:C27). This @RISK function draws random values from a discrete uniform distribution (hence the name DUNIFORM) containing the 20 possibilities in cell C8 through C27 (the values

\$0.05 through \$1.00). We note that if we are exploring the case in which the contestant opts not to take their second spin, then the value in cell B3 is, simply, zero. Cell C3 is the sum of the first two spins, in other words, SUM(A3:B3). Cells E3 and F3 represent the spin amounts for Player 2. The same RISKDUNIFORM function described above can be used in these cells. As with Player 1, we need to total the score for Player 2. This is done in cell G3.

Cells I3 and J3 are included in the event that a spin-off is needed in the "Showcase Showdown". Recall that this situation is required should the players be tied after their spin(s) of the wheel. The entries in these cells would be our usual RISKDUNIFORM functions.

As a numerical example, we have incorporated possible spin values and resulting totals in Figure 1. This example illustrates a specific simulation run in which the first player earned \$0.45 on their first spin and opted to spin again. The result of their second spin provided them with a total of \$0.80, which exceeded the subsequent spin total of Player 2. Player 1 won this game. (The spin-off values are listed in the table for sake of completeness).

From a student's perspective, one of the more complex parts of this exercise may involve analytically calculating whether or not the first player wins the "Showcase Showdown". We need to create an expression in our spreadsheet to determine this event. Consequently, we use cell B5 to determine whether or not Player 1 wins.

For the expression in cell B5, will borrow partially from the notation adopted by [3]. Let us define the following variables:

S_{ij} = spin amount for player i on spin j
T_i = total spin value for player i (in other words, $S_{i1} + S_{i2}$)
SP_i = spin-off amount for player i

Discussion with the students ought to evoke four distinct possibilities that lead to victory for Player 1. These events are:

-Player 1 has a spin total less than or equal to \$1.00 and Player 2's first spin is lower than Player 1's total. Player 2 spins again and exceeds the \$1.00 threshold. This can be represented as:

$T_1 \leq 1.00$ <u>and</u> $S_{21} < T_1$ <u>and</u> $S_{21} + S_{22} > 1.00$

-Player 1 has a spin total less than or equal to \$1.00 and Player 2's first spin is lower than Player 1's total. Player 2 spins again and their resulting total is still below Player 1's total. This is given by:

$T_1 \leq 1.00$ <u>and</u> $S_{21} < T_1$ <u>and</u> $S_{21} + S_{22} < T_1$

-Player 1 has a spin total less than or equal to $1.00 and Player 2's first spin equals Player 1's total. In the spin-off, Player 1's spin exceeded Player 2's spin. (Note that we are implicitly assuming that Player 2 does not re-spin after a tie regardless of Player 1's total. Thus, any tie in the original round of spinning will automatically precipitate a spin-off). We have the following representation:

$$T_1 \leq 1.00 \ \underline{\text{and}}\ S_{21} = T_1 \ \underline{\text{and}}\ SP_1 > SP_2$$

-Player 1 has a spin total less than or equal to $1.00 and Player 2's first spin is lower than Player 1's total. Player 2 spins again and obtains a total equal to Player 1's amount. In the spin-off, Player 1 defeats Player 2. This is illustrated by:

$$T_1 \leq 1.00 \ \underline{\text{and}}\ S_{21} < T_1 \ \underline{\text{and}}\ S_{21} + S_{22} = T_1 \ \underline{\text{and}}\ SP_1 > SP_2$$

Our model contains an additional assumption; namely, we are only conducting one "round" of spin-offs. There exists a possibility, albeit a very small one, that Player 1 and Player 2 could both tie after their spin-off, thus necessitating an additional spin of the wheel for each player. Incorporating the event of a second spin-off would have enhanced the realism of our approach, at the expense of an increase in the number of terms in our expression in cell B5. We are confident that only considering one round of spin-offs (in essence, giving the victory to Player 2 in the event of a tie in the first spin-off) will not dramatically affect our model results. This, obviously, could generate an interesting set of classroom discussions. Tradeoffs between model realism and complexity become apparent.

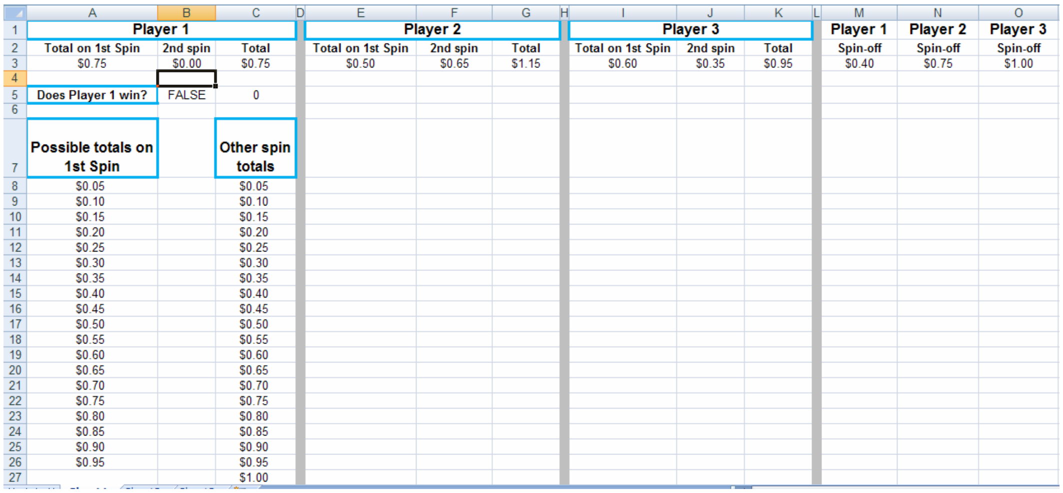
Victory by Player 1 can be represented in cell B5 by an "OR" statement with a series of "AND" expressions. To wit, we have:

OR (AND(C3<=1,E3<C3,G3>1), AND(C3<=1, E3<C3,G3<C3),
AND(C3<=1, C3=E3,I3>J3), AND(C3<=1,E3<C3,G3=C3,I3>J3))

Each of the four possibilities for Player 1 winning is represented in the expression. The "OR" statement implies that so long as one of these conditions holds, Player 1 wins. This expression will return the term "TRUE" if Player 1 emerges victorious, and "FALSE" if Player 1 loses. Cell C5 is our output cell for this simulation model. It counts the total number of instances in which Player 1 emerged victorious. This cell uses the following statement: IF (B5 = TRUE,1,0).

For each of our 10,000 replications for the different first spin values, @RISK will keep track of the number of times Player 1 prevailed in the "Showcase Showdown". An average relative frequency of victory can be calculated by dividing the number of victories by total replications. We will run analyses for either using the second spin, or declining this opportunity.

The three-contestant game can be modeled in a similar fashion. Figure 2 illustrates a spreadsheet screenshot for the three-player version.



	A	B	C	E	F	G	I	J	K	M	N	O
1	Player 1			Player 2			Player 3			Player 1	Player 2	Player 3
2	Total on 1st Spin	2nd spin	Total	Total on 1st Spin	2nd spin	Total	Total on 1st Spin	2nd spin	Total	Spin-off	Spin-off	Spin-off
3	$0.75	$0.00	$0.75	$0.50	$0.65	$1.15	$0.60	$0.35	$0.95	$0.40	$0.75	$1.00
4												
5	Does Player 1 win?	FALSE	0									
6												
7	Possible totals on 1st Spin		Other spin totals									
8	$0.05		$0.05									
9	$0.10		$0.10									
10	$0.15		$0.15									
11	$0.20		$0.20									
12	$0.25		$0.25									
13	$0.30		$0.30									
14	$0.35		$0.35									
15	$0.40		$0.40									
16	$0.45		$0.45									
17	$0.50		$0.50									
18	$0.55		$0.55									
19	$0.60		$0.60									
20	$0.65		$0.65									
21	$0.70		$0.70									
22	$0.75		$0.75									
23	$0.80		$0.80									
24	$0.85		$0.85									
25	$0.90		$0.90									
26	$0.95		$0.95									
27			$1.00									

Figure 2: Three-player "Showcase Showdown" game

As before, cell A3 refers to the particular score obtained by Player 1 after their first spin. In this particular numerical example, we are illustrating the case of Player 1 foregoing their second spin of the wheel; hence the value of 0 in cell B3.

Cells E3 through K3 represent spin amounts and resulting totals for Players 2 and 3. Finally, cells M3 through O3 contain spin-off values for the three contestants. Our numerical example lists a particular simulation run in which the first player, although they recorded a value of $0.75 on their initial (and only) spin, did not emerge victorious. Player 3 won with a total of $0.95 (Player 2 had been eliminated by going over $1.00). Again, for sake of completeness, the spin-off values are listed for each participant.

We can use similar logic as that adopted in the two-player game to determine the events that result in victory for Player 1. In all, there are 16 such events as illustrated in Table 1. The cells at the intersection of a particular row for Player 2 and a specific column for Player 3 correspond to these winning scenarios.

Table 1: Winning scenarios for Player 1 in a three-person game

		Player 3			
		$T_1 \leq 1.00$ and $S_{31} < T_1$ and $T_3 > 1.00$	$T_1 \leq 1.00$ and $S_{31} < T_1$ and $S_{31} + S_{32} < T_1$	$T_1 \leq 1.00$ and $S_{31} = T_1$ and $SP_1 > SP_3$	$T_1 \leq 1.00$ and $S_{31} < T_1$ and $S_{31} + S_{32} = T_1$ and $SP_1 > SP_3$
	$T_1 \leq 1.00$ and $S_{21} < T_1$ and $T_2 > 1.00$				
	$T_1 \leq 1.00$ and $S_{21} < T_1$ and $S_{21} + S_{22} < T_1$				
Player 2	$T_1 \leq 1.00$ and $S_{21} = T_1$ and $SP_1 > SP_2$				
	$T_1 \leq 1.00$ and $S_{21} < T_1$ and $S_{21} + S_{22} = T_1$ and $SP_1 > SP_2$				

Cell B5 in Figure 2 uses an "OR" statement with several "AND" expressions to illustrate the 16 possible scenarios resulting in victory for Player 1. As with the two-player version, this statement will return "TRUE" and "FALSE" readings for victory and loss, respectively. An "IF" statement in cell C5 quantifies the "TRUE" and "FALSE" results.

3. Results

Using @RISK, we performed 10,000 replications for each initial spin amount. Table 2 presents the results of our modeling efforts with shaded cells corresponding to the better decision in each case.

Table 2: Model Results

Total after 1st spin	Two-player		Three-player	
	P(Win|Spin)	P(Win|Stop)	P(Win|Spin)	P(Win|Stop)
$0.05	0.3451	0.0236	0.2085	0.0003
$0.10	0.3448	0.0253	0.2084	0.0009
$0.15	0.3417	0.0336	0.2082	0.0023
$0.20	0.3405	0.0480	0.2064	0.0029
$0.25	0.3370	0.0707	0.2056	0.0061
$0.30	0.3274	0.0921	0.2042	0.0107
$0.35	0.3216	0.1194	0.2041	0.0162
$0.40	0.3168	0.1514	0.1988	0.0238
$0.45	0.3102	0.1907	0.1987	0.0382
$0.50	0.2950	0.2389	0.1937	0.0577
$0.55	0.2796	0.2865	0.1905	0.0843
$0.60	0.2619	0.3404	0.1820	0.1150
$0.65	0.2399	0.3993	0.1735	0.1590
$0.70	0.2211	0.4657	0.1636	0.2166
$0.75	0.1929	0.5362	0.1521	0.2848
$0.80	0.1613	0.6023	0.1322	0.3727
$0.85	0.1286	0.6869	0.1096	0.4719
$0.90	0.0905	0.7672	0.0795	0.5933
$0.95	0.0473	0.8523	0.0448	0.7351
$1.00	0.0000	0.9492	0.0000	0.9002

In-class discussion could comment on the change in probabilities as the total after the first spin increases. As the first spin total climbs, the probability of winning should the contestant spin again drops, while “staying put” results in a greater and greater likelihood of victory. Moreover, as one would expect, the probabilities of victory in the three-player game are always less than those observed in a two-player contest for all initial spin values.

In the two-player game, the first contestant ought to spin again as long as their first spin was \$0.50 or less (although the probabilities of victory were very similar for each strategy when the first spin was \$0.55). When there are three players, the first participant should spin one more time if their initial attempt scored \$0.65 or less. Even scoring \$1.00 on the first spin - and thus staying - still does not guarantee victory. The probabilities are about 5% (in the two-player game) and roughly 10% (in a three-player event) that a subsequent contestant will also score \$1.00 in their spin(s), then defeat Player 1 in a spin-off.

4. Discussion

We have developed a spreadsheet model to simulate the spinning of the wheel during the "Showcase Showdown", a popular game conducted twice during each taping of the U.S. television game show "The Price is Right". This model can be used in an instructor's efforts to innovatively introduce the important topic of simulation. Notwithstanding our use of @RISK and its built-in functions to develop this model, an instructor could conceivably use standard Excel functions (such as RAND) and data tables for the simulation exercise.

We used this in-class simulation example during two different semesters within a required senior undergraduate Spreadsheet Analytics course. All participants in the course were Bachelors of Science in Business Administration students and had received modest introduction to spreadsheets through a first-year Computer Science offering and a second-year Statistics course. The Spreadsheet Analytics course was taught in a computer lab so each student had access to a personal computer with which to develop their model. In order to provide some consistency with respect to model versions, we offered the students a rough template listing the suggested columns in Figures 1 and 2. We then had the students develop the simulation features for the 2-player and 3-player games and run a model to identify optimal stopping points. We observed that students appeared to genuinely enjoy creating these simulation models. Indeed, the enthusiasm with which our students approached the topic – as shown by the in-class discussion to determine how best to model the various simulation pieces - demonstrated that relevant, compelling examples pertinent to a student's background facilitate awareness, interest and engagement.

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