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Analyzing The Price is Right

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Analyzing The Price is Right

A Major Qualifying Project

Submitted to the faculty of

Worcester Polytechnic Institute

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

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Date:

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Abstract

The purpose of this MQP is to analyze all the games on The Price is Right and find strategies to improve the constant’s probability of winning assuming they have no pricing knowledge. Using analytics and simulations, every game was analyzed and put in categories of low, medium, or high strategy. The project includes a catalog of all the current Price is Right games, including a description of the game; the strategy that should be implemented to improve the contestant’s odds; and the probability of winning with and without strategy.
Acknowledgements

We would like to thank our advisors Barry Posterro and Jon Abraham for their time and guidance during this project.
# Table of Contents

Abstract ............................................................................................................................................... 1
Acknowledgements ........................................................................................................................... 2
Table of Contents ............................................................................................................................... 3
1 Introduction ....................................................................................................................................... 4
2 Background ...................................................................................................................................... 5
3 Format of The Price is Right ........................................................................................................... 9
4 Results ........................................................................................................................................... 11
   Low Strategy Games ....................................................................................................................... 12
   Medium Strategy Games ................................................................................................................. 49
   High Strategy Games ..................................................................................................................... 56
   Other Games .................................................................................................................................. 73
5 Conclusions ..................................................................................................................................... 80
6 Recommendations .......................................................................................................................... 81
References .......................................................................................................................................... 82
1 Introduction

Dating back to the late 1930’s the first game shows debuted on radio and television. They were an instant hit as the idea of winning money and prizes for playing games or answering questions was very exciting. The shows have evolved over the years as radio was phased out and more emphasis was put on television broadcasts. The production value and more importantly the prizes began to increase. There were many shows that came and went, but one show that has survived over the years, and even through a large scandal, is The Price is Right. The Price is Right today is different than the 1950’s version of the show, but the idea is the same. The focus of this project is on this game show itself, as it has over 100 games that can be analyzed.

The goal of this project was to break down game shows to their mathematical components and find the optimal strategies of winning with little or no information on the topic of the game. The focus is on using only the probability behind the game to determine strategies that maximize a contestant’s probability of winning. The goal is to be able to go onto a game show with no studying necessary short of what strategies are best for each game and have the best probabilities of winning the prizes.
2 Background

The current version of The Price is Right came to televisions across America in 1972. The show allows contestants to win cash and prizes though various games related to pricing merchandise. It is ranked number 5 of all-time greatest game shows. The show has around 80 games at any given time for the producers to choose from. Some games cycle in and out of being active to keep the show new. Each game does not have equal chances of winning. While some games have a 50-50 chance, others have much lower odds down all the way to below 5 percent. Some games appear to allow for strategies even with no knowledge of the price to help improve the probability of winning. Exploring, developing, and analyzing these strategies is the basis of our project. We set out to go through the currently active games on the show and determine which, if any, have strategy to increase the odds of winning when compared to guessing. The goal is be to find solutions to the games where implementing a strategy increases the probability of winning, even without general pricing knowledge.

The idea of mathematics behind game shows was popularized by the Monty Hall problem from Let’s Make a Deal. It was first solved in 1975 by a statistician but became more public in 1990 from the “ask Marilyn” column in Parade magazine. The basis of this problem is on stage there are three doors. Behind two doors are goats, and behind one door is a new car. The contestant chooses a door and afterwards the host, Monty Hall, opens one of the other two doors and asks “Would you like to switch your choice?” In the math it is shown that changing doors has a large advantage giving you a 2/3 chance instead of the original 1/3. The key to the problem is that the host knows which door contains the car so whatever door he opens will be a goat. This means the 2/3 chance of being a door you didn’t chose moves to the one door left unopened. This question was very controversial for a number of reasons but the math behind the fact that
switching increasing your chances holds true. An exaggerated example to help understand the concept is as follows. Imagine there were 100 doors with one car and 99 goats and a player chooses a random door at random. The host then selects 98 of the doors to be opened all revealing goats, leaving only one door and gives them the offer to switch. Clearly in this case switching is in their favor as in most cases (99 out of 100) the door Monty Hall chose not to open will most likely contain the car. The host knows where the car is so when he has to open the other doors he would never reveal the door with the car and thus the one door left has much greater odds of hiding the car.

Similar to the approach of solving the Monty Hall problem, we use probability and statistics to determine the baseline of winning each game on the Price is Right. Then, we set out to find the best strategy and compare the results against the baseline of playing the games randomly. We will also be using simulations, as did statisticians for the Monty Hall problem, to verify the analytics and the calculated probabilities of winning.

Finding ways to optimize game shows has resulted in numerous scandals. One of the biggest scandals on a game show involved Michael Larson. The game show Press Your Luck which aired in 1983 had three contestants. The game began with a trivia round where contestants could win spins on the Big Board. On the Big Board, consisting of 18 squares, the squares themselves would switch between three images rapidly. As this was happening a light would randomly jump from square to square which the contestants could stop by hitting a button. There were cash prizes along with extra spins and also the infamous whammy. If the light was stopped on a whammy then all prizes were lost. Michael Larson was an out of work ice cream truck driver and part time air conditioner mechanic. He was obsessed with the possibility of getting rich quick. After seeing the show, Larson began recording the shows on his TV. He soon realized
there were only five patterns created from a randomizer that would move the light around the board. He began to memorize the patterns and would practice with his TV remote stopping the light on the best prizes making sure to get the extra spins. In May of 1984 he spent his life savings to fly out to California to audition. He was denied at first, but his effort did not go unnoticed and the producer gave him a chance after hearing that he spent his life savings to try to make an appearance on the show. On the show, during the trivia section, he seemed to be like the other contestants, very emotional and entertaining to watch. He was first to be on the Big Board where he missed the top prizes hitting smaller ones and was visibly upset while still winning money. Then after this mistake he got very focused, acting unlike most excitable contestants because he was following the pattern and proceeded to win the top prize on the board 40 times in a row totaling $102,851. The most anyone had ever won on a game show before this was $40,000 and was very rare. The producers reviewed the tapes in slow motion and were not able to disqualify him for cheating because he did not break any of the rules. They eventually paid him but did not allow him to come back to the show as he surpassed the cap of $25,000. The patterns of the Big Board were replaced with five new ones and eventually upgraded to 32 patterns after Larson’s appearance, making this trick impossible to repeat.

Another example of someone gaming the system legally was Theodore Slauson on the Price is Right. Ted was obsessed with the show since he was a boy. He found that in multiple episodes the same product was shown with the same price. He began memorizing them and calling them out on future episodes. He eventually created a spread sheet with over 2,000 items and their prices and brands. He memorized them all and at 18 drove to try and get on the show. He tried for years and years helping the contestants on stage but himself was never called up. Finally, in 1992, on his 24th attempt, he was called on the stage. He did win some money and
prizes from his game but unfortunately did not make it past the Big Wheel. In 2008, Slauson was helping a contestant on stage as he had before, but in this case it was during the final showcase. He gave the exact amount and the contestant was able to give the exact price, sparking one of the largest controversies in the history of the show. Drew Carey, the host, was in disbelief and due to the impossibility of it never believed the episode would air. The episode did air and eventually led to the creation of this documentary following Ted Slauson.

These past notable events in game shows are the main inspiration for this project, especially *The Perfect Bid*, as it is about *The Price is Right*. Ted’s method is the best as the show is all about pricing however not everyone would take the time or effort to do something like this. He also had created his own simulations of some of the games. Our project aims to take an opposite approach and assume no knowledge of pricing and still find ways to increase the probability of winning. As there only around 80 games in rotation at a time on the show someone would only need to know 80 or less strategies instead of over 2,000 individual prices. Any knowledge of pricing in most cases will only increase a contestant’s odds along with these strategies.
3 Format of The Price is Right

The Price is Right begins with four audience members being called down to the front to participate for a chance to move on to later stages within the game show. They are shown a prize and must guess the price of the item and try to not go over. The person who has not gone over and is the closest in price is brought on the stage to play a pricing game. This is where the focus of our project is as there are over 100 of these pricing games and are where contestants can win prizes from small household items to trips and cars. In some cases on special editions the prizes can be $100,000. After this has happened three times, with a new contestant replacing the one who has just played a pricing game at the microphones to guess the next prize for a chance to play a game, the remaining contestants move onto the Final Showcase. The Showcase Showdown, also referred to as the Big Wheel, is where the three contestants get up to two spins on the wheel that are added to try and get as close to $1.00 without going over.
The wheel has values from 5 cents to a dollar incrementing by 5 cents and placed in a random order. The two players who have the highest amounts without going over continue onto the final showcase. This is where each contestant is shown their own showcase made of a set of prizes that have ranged from $10,000 to $90,000. They each then make a guess of the total price and again the closest without going over will win their showcase and if their guess was in a certain range currently $250 than they win both showcases.
4 Results

The price is right has over 100 games with about 80 in rotation at any given time. We decided to only do the games that are currently being used as many of the old games appear as they will not be brought back on the show unless they are re-vamped. We went through all those games and put them into one of four categories low strategy, medium strategy, high strategy, and other. These distinctions will be discussed in further length in their sections but essentially are as they are named are the amount of strategy that can be found within the game with no pricing knowledge. The final category other is for games where having no pricing knowledge would make it impossible to analyze the game or games that have unquantifiable elements such as putting a golf ball into a hole. Within the games that have a level of strategy we have included a basic description of the game and the rules and an image. There is also the probability of winning the game with no strategy and the probability of winning with the strategies we found in each game. Additionally, there is a hyperlink to a clip of the game provided by The Price is Right website. These links are also included in appendix _ with the games ordered alphabetically.
Low Strategy Games

There are games where there is no strategy and the only way to increase your odds of winning would be by having knowledge of the items priced. With that being said, it is still possible to win with no knowledge as many of them are just picking an option out a set of options. The math for the probabilities on these games are very simple. For example, there are two options for a price, choice A or choice B. The calculations have been included for some of the games, but for a game with only two clear options, the probability is listed as 50%. As these games have no strategy, they were included for completion of the catalog of all current games that are being played and are not the main focus of this project.
Golden Road (low strategy)

Rules: The price of an item, in cents, is revealed. The contestant must determine which of the two digits in that price is the missing digit in the price of the next prize with three digits. If correct, the contestant then uses the price of the three-digit prize to identify the missing digit of a prize with four digits in its price. If correct, the contestant then uses the price of the four-digit prize to identify the missing digit in a luxury prize.

Assumptions: None

Strategy: None

Probability of winning: $(1/2)*(1/3)*(1/4) = 4.167\%$
**Triple Play** *(low strategy)*

![Image of Triple Play](source: youtube.com/thepriceisright)

**Rules:** The contestant is shown three cars, from least expensive to most expensive. For the first car, the contestant is shown two prices, and must pick the price that is closest to the actual price of the car without going over. If correct, the contestant moves on to the next most expensive car, and repeats the process but with three options. If correct again, the contestant moves on to the most expensive car, and repeats the process but with four options.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability for the first car is \( \frac{1}{2} \), the probability for the second car is \( \frac{1}{3} \), and the probability for the final car is \( \frac{1}{4} \), and since the contestant doesn’t have the option to stop after getting a car right, these probabilities combine to make \( \frac{1}{24} = 4.167\% \) probability of winning the entire game and all three cars.
Hi Lo (low strategy)

Rules: Six grocery items are shown to the contestant. The contestant must select the three most expensive items. If successful, the contestant wins a bonus prize.

Assumptions: None

Strategy: None

Probability of winning: \((3/6)*(2/5)*(1/4) = 5\%\)
Half Off (low strategy)

Rules: The contestant is shown 16 boxes, one of which contains $10,000. The contestant is then shown two small prizes with prices attached. One prize is the retail price and one is the half off price. If the contestant identifies which prize is half off the actual price, then half of the empty boxes are removed. This process is repeated for a total of three pairs of small prizes. The contestant then selects a box. If the box contains the $10,000, then the contestant wins $10,000. The contestant may also win $1,000 by guessing correctly on all three of the pairs of items regardless if they win the $10,000 or not.

Assumptions: None

Strategy: None

Probability of winning:

Probability of winning the $1,000 = (1/2)^3 = 12.5% 

Probability of winning the $10,000 

<table>
<thead>
<tr>
<th>Boxes Left</th>
<th>Probability getting</th>
<th>Probability Winning</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>.125</td>
<td>6.25%</td>
</tr>
<tr>
<td>8</td>
<td>.375</td>
<td>12.5%</td>
</tr>
<tr>
<td>4</td>
<td>.375</td>
<td>25%</td>
</tr>
<tr>
<td>2</td>
<td>.125</td>
<td>50%</td>
</tr>
</tbody>
</table>
More or Less (low strategy)

Rules: The contestant is shown four prizes, the last of which is a car. Each prize has an incorrect price displayed. The contestant must identify whether the actual price is more or less than displayed price. If correct they win that prize and get to continues to the next prize.

Assumptions: None

Strategy: None

Probability of winning: There are 4 prizes and each has 50% chance of winning. 
$$(1/2)^4 = 6.25\%$$
Grand Game (low strategy)

Rules: Six grocery items are shown to the contestant, along with a target price. Each time the contestant selects an item that is lower than the target price, a zero is added on to the contestant’s bank of $1. If the contestant selects the four items that are less than the target price, then the contestant wins $10,000.

Assumptions: None

Strategy: None

Probability of winning:

<table>
<thead>
<tr>
<th>Amount</th>
<th>Probability Winning</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1</td>
<td>1</td>
</tr>
<tr>
<td>$10</td>
<td>66.66%</td>
</tr>
<tr>
<td>$100</td>
<td>40%</td>
</tr>
<tr>
<td>$1,000</td>
<td>20%</td>
</tr>
<tr>
<td>$10,000</td>
<td>(4/6<em>3/5</em>2/4*1/2) = 10%</td>
</tr>
</tbody>
</table>
**Freeze Frame (low strategy)**

Rules: Eight pairs of digits rotate around a game board. Two pairs enter a frame at a time forming a four digit price. The contestant must stop the rotation on the correct price corresponding to the prize.

Assumptions: None

Strategy: None

Probability of winning: This game has 8 possible options so $1/8 = 12.5\%$
Easy as 1 2 3 (low strategy)

Rules: Three prizes are shown to the contestant. The contestant must place blocks labeled 1, 2, and 3 on the least expensive, next more expensive, and most expensive prizes, respectively.

Assumptions: None

Strategy: None

Probability of winning: As there are 6 possible combinations the probability of winning are 1/6 = 16.67%
**Gridlock (low strategy)**

**Rules:** The contestant is shown two sets of 3 cars which have a two digit number. The first set is the 2nd and 3rd digit of the price of car and the last set of cars is the final digits of the price. The contestant gets two total guesses and must first guess the 2nd and 3rd digit and then the final three.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** If they use both guesses in either section they have a 1/3 for one section and ½ for the other section to get the correct number. This game has up to a 1/6 = 16.67% chance of winning. They could also guess both first try which is a 11.11% chance, but does not result in an additional prize.
Make Your Move (low strategy)

Rules: Three prizes – one with two digits, one with three digits, and one with four digits – are shown to the contestant, along with a series of nine numbers. The contestant must identify which numbers belong to which prizes, using each number only once. If successful, the contestant wins all three prizes.

Assumptions: None

Strategy: None

Probability of winning: For this game with a string of 9 numbers in a fixed order a 4,3, and 2 digit prize there are 6 possible arrangements. $\frac{1}{6} = 16.67\%$
Safe Crackers (low strategy)

Rules: The contestant is shown a prize, and given the three digits that make up its price on a series of three combination locks. These numbers do not repeat. In guessing the price of the prize correctly, the contestant wins the prizes behind the safe door.

Assumptions: None

Strategy: None

Probability of winning: Since the numbers are not repeated, there are six different permutations that the digits can be arranged into, as seen below assigning A, B, and C as the different digit options:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

This means the probability of winning this game, with no pricing knowledge, is 1/6 = 16.67%. However, typically it is clear that one of the digits is not the hundreds digit of the actual price, especially when one of the digits is a 0. This means that with pricing knowledge, the probability of winning this game is ¼ = 25%.
**Push Over** *(low strategy)*

Source: youtube.com/thepriceisright

**Rules:** The contestant is shown a prize, then shown a series of nine blocks with various digits on them. The contestant’s goal is to pick the series of four blocks in a row that represent the actual price of the prize. Contestants must also be cautious of the fact that once a block has been pushed over off of the table, it cannot be retrieved, so it is wise to make a decision before pushing the blocks.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** This means there are six possible prices to guess from the nine blocks, giving the game $\frac{1}{6} = 16.67\%$ probability of winning. However, oftentimes one of the blocks shows a 0, in which case the prize will not start with that digit, thus eliminating one of the six options from the start. With a 0 shown on one of the blocks that could potentially be the thousands place of the guess, the probability increases to $\frac{1}{5} = 20\%$. 
Gas Money (low strategy)

Rules: Five potential prices for a car are shown with one being the actual price. The contestant must select the incorrect prices. Each incorrect price an amount of money (4000, 3000, 2000 or 1000) are shown. Each time the contestant can take the sum of money or keep playing. If they win they win the $10,000 and the car. If they choose the correct price they lose everything.

Assumptions: None

Strategy: None

Probability of winning: The probability of winning the $10,000 and the car is (4/5)*(3/4)*(2/3)*(1/2) = 20%. There is a utility rate that must be considered per contestant. Although the expected value of the cash will never exceed the prize if the guarantee of a dollar amount has higher personal value than taking the chance the contestant should choose the money.
Pick a Pair (low strategy)

Rules: The contestant is given six items commonly found in a grocery store. There are three pairs of items with the same price out of the six. The contestant’s task is to match two items with the same price. First, the contestant chooses the item he or she wants to start with, and is shown the price. Then, the contestant must choose which of the other five items has the same price as the item he or she initially picked to win.

Assumptions: None

Strategy: None

Probability of winning: Without pricing knowledge, the probability of winning this game are $1/5 = 0.2 = 20\%$. However, with pricing knowledge, the contestant can easily pick out one of the products with a clearly lower or higher price than most the other items. Then, picking the item that seems it would have the same price is much easier than picking from five items that arguably have similar prices.
Danger Price *(low strategy)*

Rules: Four prizes are shown to a contestant and a “danger price” is also shown. The contestant must choose the three prizes that do not have the danger price and if successful wins all four prizes.

Assumptions: None

Strategy: None

Probability of winning: The first round there is a $\frac{3}{4}$ chance to not choose the danger price then $\frac{2}{3}$ then $\frac{1}{2}$. This results in a $(\frac{3}{4})(\frac{2}{3})(\frac{1}{2}) = \frac{1}{4} = 25\%$ chance of winning.
**Double Cross** *(low strategy)*

**Rules:** The contestant is shown two prizes and two lines of numbers that intersect in the center. The contest must highlight the prices of the prizes. When one prize is adjusted the other is adjusted automatically as well.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** As the two prices move in unison and there is only enough room for each prize to have 4 options this game has a 25% chance of winning.
Range Game (low strategy)

![Image of Range Game meter](source:youtube.com/thepriceisright)

**Rules:** The contestant is shown a prize, then directed to a meter with a range of $600 from the lowest possible guess to the highest possible guess. Within that range is the actual price of the prize. A range of $150 will then slowly climb the meter, and the contestant’s task is to stop the rising target range when it contains the actual price of the prize. In doing so correctly, the contestant wins the prize.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability of winning this game is as follows:

\[
P[\text{actual price in target range}] = \int_x^{x+150} \left( \frac{1}{600} \right) dx = \left( \frac{x + 150}{600} \right) - \left( \frac{x}{600} \right) = \frac{150}{600} = \frac{1}{4}
\]

Therefore, the probability of winning this game is \(1/4 = 0.25 = 25\%\).
Shopping Spree (low strategy)

Rules: The contestant is presented with four different prizes. There is also a displayed number, typically a four digit number. The contestant’s goal is to pick three of the four prizes such that their total value is greater than the displayed number. Simply put, the contestant wants to pick the three most expensive prizes out of the four shown in order to win.

Assumptions: None

Strategy: None

Probability of winning: There are 4 total combinations of prizes to pick, with only one of the combinations not containing the least expensive item, giving this game a \( \frac{1}{4} = 0.25 \) probability of winning without assuming any pricing knowledge. This is seen below, assigning the items numbers in order by their value, with 1 being the least expensive and 4 being the most expensive:

\[
\binom{4}{3} = \frac{4!}{1!3!} = 4 \text{ combinations}
\]

There is only one combination that does not include 1, the least expensive prize, and thus a \( \frac{1}{4} = 25\% \) chance of winning without any given pricing knowledge.

The probability of winning this game can also be considered by looking at the one prize out of the four that is not included in the correct combination of the three most expensive prizes. In other words, the probability of winning is simply picking the one prize out of the four with the lowest value, leaving a \( \frac{1}{4} = 25\% \) probability of winning.
Two for the Price of One (low strategy)

Rules: The contestant is shown two prizes, one of which the objective is to guess the price. Then the contestant is shown three pairs of numbers, one for the ones place, one for the tens place, and one for the hundreds place of the actual price. The contestant is allowed to reveal one of the three correct numbers for the actual price. In guessing which numbers make up the actual price of the prize, the contestant wins both prizes.

Assumptions: General pricing knowledge

Strategy: The contestant will know what number goes in the hundreds place, and will use the free number on the tens or ones place.

Probability of winning: With this simple strategy based on some pricing knowledge, the probability of winning is \( \frac{1}{2} = 50\% \), as only a digit for only one place value must be chosen. However, without this strategy or basic pricing familiarity, the probability of winning is \( (\frac{1}{2})^2 = \frac{1}{4} = 25\% \), as digits for two place values must be chosen.
**Flip Flop** *(low strategy)*

Rules: This game shows an incorrect price for a prize. The contestant can interchange the first two digits, the last two digits or both.

Assumptions: None

Strategy: None

Probability of winning: There are three possible options meaning this game has a $1/3 = 33.33\%$ chance of winning.
Balance Game (low strategy)

Rules: The contestant is given 3 bags to choose from and must place two on the scale to balance with the price of the prize.

Assumptions: None

Strategy: None

Probability of winning: There are 3 combinations of 2 options with only one being correct. Another way of thinking about the probability of winning this game is that one bag out of the three must be chosen to not be placed on the balance. This gives this game a $1/3 = 33.33\%$ chance of winning.
Most Expensive (low strategy)

Rules: The contestant is shown three different prizes, and must guess which one is the most expensive. If guessed correctly, the contestant wins all three prizes.

Assumptions: None

Strategy: None

Probability of winning: Without pricing knowledge, the contestant’s probability of winning this game is $1/3 = 33.33\%$. 

Source: youtube.com/thepriceisright
One Wrong Price (low strategy)

Rules: The contestant is shown three prizes, each with a price. One of the three prices is incorrect, and the contestant must guess which price is wrong. In doing so correctly, he or she wins all three prizes.

Assumptions: None

Strategy: None

Probability of winning: This game has a simple $1/3 = 33.33\%$ probability of winning.
Pick a Number (low strategy)

![Image of a Price is Right game show](Source: youtube.com/thepriceisright)

**Rules:** The contestant is shown a price, typically a four digit number (occasionally a five digit number, but this does not change the probability of winning), with one of the digits missing. The contestant then chooses from one of three numbers to place in the position of the missing digit, and wins the prize if he or she guesses the missing digit correctly.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** Without pricing knowledge, the probability of winning this game is simply $1/3 = 33.33\%$. However, with pricing knowledge and getting the highest place digit missing (i.e. in a four digit number, the thousands place is missing), guessing between the three digits can be much easier, and make the probability of winning $1/2 = 50\%$ if any of the digits can confidently be ruled out.
**Squeeze Play** *(low strategy)*

![Squeeze Play](https://youtube.com/thepriceisright)

**Rules:** The contestant is shown a prize which has a value containing four digits. Five digits are then displayed, with the highest value digit and lowest value digit being in the correct place. The contestant must then choose one of the three remaining digits in the middle to remove in order to leave the correct price of the prize.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability of winning this game is $1/3 = 33.33\%$. 


Swap Meet (low strategy)

**Rules:** The contestant is shown a prize but not told the value of it. Three other items are then shown to the contestant, who must choose which one has the same price as the item initially shown to him or her. If correct, the contestant wins all four of the items that have been shown.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability of winning this game are $1/3 = 33.33\%$, although this probability may be improved with basic pricing knowledge.
**Vend-O-Price (low strategy)**

![Vend-O-Price Image](source: youtube.com/thepriceisright)

**Rules:** The contestant is shown a vending machine with three items, with the least expensive item on the top shelf, the next least expensive item on the middle shelf, and the most expensive item on the top shelf. Then, a number of each product is revealed, with the top shelf having the most of each and the bottom shelf having the least of each. The contestant’s task is to choose which shelf has the greatest value due to the number of each product on the shelf. If correct, the contestant wins.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The game has a $1/3 = 33.33\%$ probability of winning.
Bargain Game (low strategy)

Rules: There are two prizes show each with a price below its actual retail price. The contest must choose which one is a better bargain (further from the actual price).

Assumptions: None

Strategy: None

Probability of winning: There is only one attempt so $\frac{1}{2} = 50\%$
**Bonus Game** *(low strategy)*

![Bonus Game](source: youtube.com/thepricesright)

**Rules:** Four small prizes are shown with incorrect prices. The contestant must determine if the correct prices are higher or lower than the incorrect prices. At the end a light illuminates one of the four boxes and says “BONUS” if the contestant got this item correct they win a bonus prize. Each prize has a 50/50 chance of higher or lower.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The real prize being the bonus, potentially a car, can be on any of the four prizes but the probability of getting the small prize is 50/50 so the probability of winning the Bonus prize is 50%.
**Coming or Going (low strategy)**

**Rules:** Four numbers corresponding to the price of a prize are placed on a platform. Tilted one way they form a price and the other direction forms a different price. The contestant must tilt in the correct direction to win the prize.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** This game has a 50% chance of winning.
**Do the Math** *(low strategy)*

Source: youtube.com/thepriceisright

**Rules:** In this game the contestant is shown two prizes. An equation is created where one item plus or minus a set dollar amount equals the other prize. The contestant must choose plus or minus to complete the equation.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** 50%
Double Prices (low strategy)  

**Rules:** Two potential prices for a prize are shown to the contestant. If the contestant selects the correct price, then the contestant wins the prize.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** 50%
**One Right Price (low strategy)**

**Rules:** The contestant is shown two prizes, and then given a price. The contestant must guess which prize the price matches up with. In doing so correctly, he or she wins both prizes.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** This game has a simple $\frac{1}{2} = 0.5 = 50\%$ probability of winning.
**Side by Side** *(low strategy)*  

![Side by Side Game](source: youtube.com/thepriceisright)

**Rules:** Side by Side is a simple game in which the contestant is shown a price with a value containing four digits, and given tiles with two digits each on them. The contestant must then decide which tile goes first and which goes last to create the actual value of the prize.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability of winning this game is $\frac{1}{2} = 50\%$. 
**Switch (low strategy)**

Source: youtube.com/thepriceisright

**Rules:** The contestant is shown two items, with prices associated with them. The contestant must then choose whether to swap the price of the two items, or if the prices shown initially are correct. In guessing correctly, the contestant wins both of the items.

**Assumptions:** None

**Strategy:** None

**Probability of winning:** The probability of winning this game is $\frac{1}{2} = 50\%$. 
Five Price Tags *(low strategy)*

Source: youtube.com/thepriceisright

Rules: Four small prizes are shown to the contestant and they must decide if the price shown is true or false and if they are correct they earn a guess at the price of the car. This is a 50/50 chance for each of these and there are no automatic guesses given for the car.

Assumptions: None

Strategy: None

Probability of winning:

<table>
<thead>
<tr>
<th># guesses</th>
<th>Probability get # guesses</th>
<th>Probability get the car</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0625</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>0.375</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>0.25</td>
<td>0.33</td>
</tr>
<tr>
<td>4</td>
<td>0.0625</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Medium Strategy Games

These are games where there is some strategy built into the game, even with no pricing knowledge. This means that the contestant has one or more choices within the game on what to do and that there is an optimal way to play these games to increase the probability of winning vs playing with no strategy. These games have strategy that can increase the odds of winning the game and the large prize or the amount of winnings. The distinction for these games to be categorized as medium level strategy is that it is not simply a single probability, and there are different ways to play the games, with one being the best option. However, these games do not have enough strategy that it greatly increases the probability of winning.
It’s in the Bag (medium strategy)

Rules: Six grocery items are shown to the contestant, along with five bags displaying prices. The contestant must assign the correct items to the bags. If the contestant has assigned the correct item to the first bag, then they win $1,000. The contestant may stop the game and take the money or risk it all to double the money with the second bag. If the contestant successfully risks the money for all five bags, then they win $16,000.

Assumptions: None

Strategy: The player should always play to double their money unless they are correct on the first bag and the initial $1,000 has a large utility value to them.

Explanation: This game has an interesting strategy looking at the expected values of the next rounds on whether to risk your money or not. The first bag is a given to play as any expected value will be larger than the amount the contestant currently has, $0. However, the second bag has a lower expected value than what you are holding. Looking at this alone you would want to stop here and take the $1,000. If you take this risk and are successful though, the remainder of the game every round the expected value is always greater or equal to the amount the contestant has. This means that a utility function must be accounted for by each contestant as if $1000 is extremely useful they should stop. However if $1000 isn’t that meaningful than it is in their interest to take the risk as the remainder of the game up to $16,000 each bag will have a expected value indicating they should keep playing and not walk. Throughout this game at any point an amount of money for each contestant may mean more than to others and would need to be factored in when playing the game. With the assumption $1,000 is not an exraordinary amount though the player should play on every bag when looking at the expected values.

The table below shows the round number and what the contestant currently has and their expected value for the remaining rounds. Highlighted in red is the only expected value that is less than the current amount the contestant is holding.
<table>
<thead>
<tr>
<th>Round number</th>
<th>What the contestant has</th>
<th>Expected value for rest of the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$0</td>
<td>$511.11</td>
</tr>
<tr>
<td>1</td>
<td>$1,000</td>
<td>$866.66</td>
</tr>
<tr>
<td>2</td>
<td>$2,000</td>
<td>$2,333.33</td>
</tr>
<tr>
<td>3</td>
<td>$4,000</td>
<td>$5,333.33</td>
</tr>
<tr>
<td>4</td>
<td>$8,0000</td>
<td>$8,000</td>
</tr>
</tbody>
</table>
Secret X *(medium strategy)*

**Rules:** The contestant is shown a tic-tac-toe board. In the center column, there is a concealed X. The contestant must use the concealed X to form three X’s in a row using X’s earned by identifying the prices of small prizes (50% chance). They may be placed on the outer two columns. If the contestant forms three X’s in a row, then the contestant wins a bonus prize.

**Assumptions:**
Assume can win by placing three X’s in a row in a column.

**Strategy:** The optimal way to win using the middle hidden X if all three X’s are won are on two corners opposite each other and one X directly across from another corner, as shown below. This option depicted above gives a 66% chance of winning.

An alternate strategy is knowing X’s must be placed immediately after they are won. Follow the first strategy and place the first X on a corner. Next if the second X is not won then simply chose a corner across or on the same row for the final X. However if a second X is won and the contestant believes they have a good idea of the cost of the third item that is already shown. Place the second directly below the first X. If the third X is won it is 100% chance of winning. If it is not however it is a 0% chance. With high risk comes high reward for this method.

**Breakdown:**
The Probability of winning any given X with no knowledge are 50-50. Probability of winning are
1 X = (.5)^3 * (0%) = 0
2 X = (.5)^3 * (.33/0) = .04125 / 0
3 X = (.5)^3 * (.66/1) = .0825 / .125

Original/Alternative
Total probability assuming total guess on last product given already have two X’s.

Original strategy: 

\[(.33)(.5) + (.66)(.5) = 0.165 + 0.33 = 0.5\]

Alternate: 

\[0(.5) + 1(.5) = 0.5\]

So they are the same percent chance but if contestant believes can get third one then go for three in a row of own Xs.

Looking at the formula it is clear as a person’s knowledge of the third item’s price goes up then the odds of getting it correct will surpass 50-50. This means that in the alternate strategy the probability multiplied by 1, the Probability of winning, increase at a faster rate than the .66 in the original strategy showing with any knowledge of the price of the item more than just a random guess the new strategy has better chances of winning.
Line ‘em Up (Medium strategy)  

Rules: Three prizes are described and their prices shown. The contestant must use the numbers in those prices to fill in the middle three digits in the price of a car. After the first attempt, the contestant is told how many digits are correct. The contestant has two attempts to complete the price of the car.

Assumptions: None

Strategy: The strategy on this game would be to use the table below based on the amount correct the contestant received find which option has the highest probability of giving that many correct and then change the ones that were not correct in that case.

Probability of winning: The odds of winning this game range around 2% up to 5.5%.

<table>
<thead>
<tr>
<th>First round options</th>
<th>Odds of options</th>
<th>Amount correct</th>
<th>Odds win on second try</th>
<th>Odds win</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.222</td>
<td>0</td>
<td>0.250</td>
<td>0.0556</td>
</tr>
<tr>
<td>1</td>
<td>0.111</td>
<td>1</td>
<td>0.167</td>
<td>0.0185</td>
</tr>
<tr>
<td>1,2</td>
<td>0.111</td>
<td>2</td>
<td>0.167</td>
<td>0.0185</td>
</tr>
<tr>
<td>1,3</td>
<td>0.056</td>
<td>2</td>
<td>0.333</td>
<td>0.0185</td>
</tr>
<tr>
<td>1,2,3</td>
<td>0.056</td>
<td>3</td>
<td>N/A</td>
<td>0.0560</td>
</tr>
<tr>
<td>2</td>
<td>0.222</td>
<td>1</td>
<td>0.083</td>
<td>0.0185</td>
</tr>
<tr>
<td>2,3</td>
<td>0.111</td>
<td>2</td>
<td>0.167</td>
<td>0.0185</td>
</tr>
<tr>
<td>3</td>
<td>0.111</td>
<td>1</td>
<td>0.167</td>
<td>0.0185</td>
</tr>
</tbody>
</table>
**Punch a Bunch** *(medium strategy)*

**Video:** PunchABunch

![Image: Punch a Bunch game board](https://i.imgur.com/xyz.png)

**Rules:** The contestant is shown four different items, with a price that is false. The contestant must guess whether the actual price is higher or lower. For each correct answer, the contestant earns a punch on the board, which has 50 different slots with prize amounts ranging from $100 to $25,000. For each punch, the contestant can decide whether to keep the price behind, or take his or her chances that one of the next punches is of a higher value.

**Assumptions:** Aware of the expected values for punches and winnings

**Strategy:** Punch again if the current winnings are less than $750 (the median) or $2,060 (the expected value per punch)

**Probability of winning:** The contestant wins no matter what, but can determine whether to keep the current winnings or go for greater earnings based off of expected values within the game.

The estimated number of punches is two:

\[
E[\text{punches}] = (\# \text{ of guesses})(\text{odds of guessing correctly}) = 4(0.5) = 2
\]

The estimated value per punch is $2,060:

\[
E[\text{value per punch}] = \left(\frac{1}{50}\right)(25,000) + \left(\frac{2}{50}\right)(10,000) + \left(\frac{4}{50}\right)(5,000) + \left(\frac{8}{50}\right)(2,500) \\
+ \left(\frac{10}{50}\right)(1,000) + \left(\frac{10}{50}\right)(500) + \left(\frac{10}{50}\right)(250) + \left(\frac{5}{50}\right)(100) = $2,060
\]

The median value per punch is $750. Therefore, the contestant should be content in winning $1,000 or more because this is in the top half of all prizes, but the contestant could also consider going for a better prize on the next punch if their winnings are below $2,060. This means that a contestant winning $2,500 or more should absolutely stay with that prize.
High Strategy Games

These games were the main goal of this project to find games where strategies greatly improved the odds of winning in one case the strategy can guarantee a 100% win rate. These are games where there is strategy in the game with no pricing knowledge and just by the probabilities in the game there exists an optimal strategy for the highest win rate. To analyze these games we used both analytics as well as simulations to test our original findings and have data from a large sample size of games to show possible outcomes.
Clock Game (highly strategic)

**Rules:** The contestant has 30 seconds to deduce the price of two prizes, one at a time. The contestant makes guesses at the price; after each guess, the host will tell the contestant "higher" or "lower," until they guess the correct price. They are allowed to say “twenty-one, two, three…nine” when attempting to guess the value of the ones place.

**Assumptions:**
Assume price is between $0 and $2,000. Having some ability in mathematics able to guess to round numbers near bisection.

**Strategy:** Optimal strategy is to start at $1,000 and continue to cut the price in half (bisect) each time. With proper use of the bisection method, the exact price of the prize can be guessed in under 11 guesses. Note that once within 10 of the actual price can quickly say all values one through nine with the understanding the first part of the number will be the same. This last part of one through nine we will consider to take the same time as a single guess. Allowing a second per guess with the worst case off 11 guesses per item, that is 22 out of 30 seconds to guess both items. The win rate with this would be 100%.

However, as actually bisecting each guess would take more time to think than using round numbers, an alternate strategy similar to the best strategy is to nearly bisect the values. The restrictions for this method is to use all numbers with a zero as the last digit until within 10 dollars of the actual price. In this case to find the number of iterations as the last digit will be zero is to only focus on three digits. So the range is 0-200. Then once the range of 10 digits is found use the same strategy of saying the numbers one through nine. In this case the maximum number of iterations is 8 when done optimally. Assuming some mistakes of not perfect bisections allowing for 3 more guesses and the final guess of one through nine coming to a total of 12 guesses. With a second per guess that is 24 seconds to guess both items so again the win rate would be 100% given the contestant had some basic math ability.

**Without strategy:** Currently, the chances of winning at least one prize are very high even when not using the bisection method. Additionally, general pricing knowledge could give contestants
the ability to shrink this price range and start with a guess that is closer to the actual price. For example if the price was near $1700 and the first guess was $1600 it saves the guess of $1000.

**Bisection Method:**
The formula for the bisection method in the optimal strategy is with bounds a= 0, b=2000 take \((a+b)/2 = c\) then if the host says lower, set c as the new upper bound b and keep a as the lower bound. Similarly if the host says higher set c as a lower bound a and keep b as an upper bound. Continue bisecting until you are within the tolerance specified, \((a+b)/2 < TOL\). In this case the tolerance is \(10^0 = 1\).

The maximum number of iterations, \(n\), is equal to \(n = (\log(b-a) – \log(z))/(\log(2))\) where \(a\) and \(b\) are the upper and lower bounds and \(z\) is the tolerance. In our case \(\log(z=1) = 0\) So \(n = \log(b-a)/\log(2) = \log(2000)/\log(2) = 10.9\) so maximum iteration in the worst scenario is 11 iterations to find the exact price.

**Examples:**

**20 seconds 5 guesses**
Price: $1971
Guesses: 9

| 1000 | 1500 | 1750 | 1880 | 1940 | 1970 | 1990 | 1980 | 1971 |

30 seconds 20 guesses
Price: $523
Guesses: 8

| 1000 | 500  | 750  | 620  | 560  | 530  | 520  | 521-3 |

18 seconds 13 guesses
Price: $113
Guesses: 8

| 1000 | 500  | 250  | 120  | 60   | 90   | 110  | 111-3 |

Online there is a simulation of the clock game linked in blue. We each decided to try playing the game once using our strategy and the results are below.

**Trials:**  [Clock Game Online](#)

Price: $504
Guesses: 8
Time: 16 seconds

| 1000 | 500  | 750  | 600  | 550  | 520  | 510  | 501-4 |

7 guesses 12 second
Price: $660
Guesses: 8
Time: 14 seconds

| 1000 | 500  | 750  | 600  | 650  | 700  | 670  | 660   |
The two times add to 30 seconds, leaving the contestant with almost 2 seconds per guess. This is due to having to type the numbers in as opposed to saying them as well as taking time to record our guesses as we played the game because it does not show your guesses at the end. Even with these handicaps though we were successful in winning the game.
**Plinko (High strategy)**

**Rules:** The contestant must identify correct digits in the prices of small prizes to earn Plinko chips. The contestant then takes their chips to the top of a game board and releases them, one at a time, into slots at the bottom of the board containing money amounts. They range from $0 up to $10,000.

**Strategy:**
The strategy with the chips that have been won before playing is to always drop the chip from the central slot out of the nine. This results in the highest percent chance it will land in the $10,000 slot and is why the expected value of this slot is higher than the rest. It is to be noted it also has the highest variance given that beside the $10,000 are two zero slots. Hypothetically a utility function could be run and if $100 was worth as much as $10,000 to you then dropping on either end slot would actually be a better option as the chances of landing in zero slots are much smaller.
Data:

This graph shows that the expected value is the highest when dropping from the middle slot and because the board is symmetric and at each peg it is simply a binomial distribution the large sum of these results in a normal looking distribution.

If the contestant simply wanted to win something from this game the table below shows

<table>
<thead>
<tr>
<th>Starting Slot</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot 1</td>
<td>2,258.74</td>
</tr>
<tr>
<td>Slot 2</td>
<td>2,711.94</td>
</tr>
<tr>
<td>Slot 3</td>
<td>3,348.85</td>
</tr>
<tr>
<td>Slot 4</td>
<td>3,863.19</td>
</tr>
<tr>
<td>Slot 5 (Middle)</td>
<td>4,060.79</td>
</tr>
</tbody>
</table>

that dropping from the middle also has the highest standard deviation. The slots 6 through 9 are not included as it is symmetric and they have the same values as slots 1 through 4. From the simulation of 100,000 trials the data we analytically found was backed up as for each slot the trials were the same with ±0.001

<table>
<thead>
<tr>
<th>Analytical Probability</th>
<th>Simulation Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starting Slot</strong></td>
<td><strong>Starting Slots</strong></td>
</tr>
<tr>
<td>Slot 1</td>
<td>Slot 1</td>
</tr>
<tr>
<td>Slot 2</td>
<td>Slot 2</td>
</tr>
<tr>
<td>Slot 3</td>
<td>Slot 3</td>
</tr>
<tr>
<td>Slot 4</td>
<td>Slot 4</td>
</tr>
<tr>
<td>Slot 5 (Middle)</td>
<td>Slot 5 (Middle)</td>
</tr>
</tbody>
</table>

These tables show that the middle slot has significantly more chips landing in the $10,000 slot but it also has a much larger of chips landing in the zero slot. As these were from 100,000 trials looking at the simulation slot 1 number of zeroes only 11.33% of the chips landed in a zero where the middle slot had approximately 38.61% of the chips landing in a zero.
The next graphs are from the simulation compared to the analytical probabilities that were calculated.
The simulation did back the data we had found and the middle slot is the best option when one is trying to maximize their expected value.
**Big Wheel** *(high strategy)*

![Big Wheel](source:image)

**Rules:** Three contestants that played the previous mini-games within the show are chosen to play the Showcase Showdown, better known as the “Big Wheel.” The contestants go in order by winnings in the games they just played, from least to greatest. This is because the first player has the lowest probability of winning, and the third player has the highest probability of winning (this will be explained in depth below). The wheel consists of the numbers 5 to 100, counting by 5’s, so there are 20 numbers on the wheel, as shown below:

![Big Wheel Wheel](source:image)

Each contestant’s goal is to get closest to $1.00, or 100, without going over. Each contestant is allotted two spins, and must spin if his or her first spin is lower than the final value of a previous contestant. The contestant with the highest score without going over $1.00 in the end is the
winner, and moves on to the Final Showcase. In the event of a tie between two or three of the
contestants, there is a tiebreaker in which each contestant gets one spin, and the contestant with
the highest value for the one spin moves on to the Final Showcase.

Assumptions: All contestants are making decisions based on the optimal strategy, and are aware
of whether the value of the first spin dictates whether he or she should stay with that value or
spin again (perhaps given one of the tables explaining what action to take below)

Strategy: Based on what order the contestants are spinning in, each has an optimal strategy in
which there is a number they should get equal to or greater than for their final value to ensure the
highest probability of winning.

Probability of winning: Each contestant has a different probability of winning based on the
order in which they get to spin the wheel. Contestant 1 is not aiming to beat any previous
players, and thus must set the target for the rest of the contestants to follow. Contestant 2 will
aim to beat Contestant 1 and also spin a value high enough so that he or she is confident that
Contestant 3 will be unable to get a higher value without going over $1.00. Contestant 3 is
simply spinning to beat the previous two contestants, and is only presented an option for
spinning in the case of a tie between one or both of the other contestants.

Contestant 3:
The third contestant is only left with an option as to whether to stay with the value of the first
spin or spin again in the case of a tie. If the value of the first spin is less than the final value of
the current leader, Contestant 3 is forced to spin again. If the value of the first spin is greater than
the final value of the current leader, Contestant 3 wins and the game is over. Contestant 3’s
optimal strategy is simple. If faced with a two-way tie after the first spin, Contestant 3 should
only spin again if the tie is less than or equal to 0.45. A two-way tie at 0.50 leaves Contestant 3
with the choice of staying or spinning again, as neither option improves the probability of
winning. If faced with a three-way tie after the first spin, Contestant 3 should only spin again if
the tie is less than or equal to 0.65. Otherwise, Contestant 3 should stay with the value of the first
spin and go to the one-spin tiebreaker with the other contestant(s).
The optimal strategy and probabilities of winning in the event of a tie for Contestant 3 are displayed in the tables below:

<table>
<thead>
<tr>
<th>First Spin Value</th>
<th>Two-way Tie</th>
<th>Three-way Tie</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>SPIN 0.95</td>
<td>SPIN 0.95</td>
</tr>
<tr>
<td>0.1</td>
<td>SPIN 0.90</td>
<td>SPIN 0.90</td>
</tr>
<tr>
<td>0.15</td>
<td>SPIN 0.85</td>
<td>SPIN 0.85</td>
</tr>
<tr>
<td>0.2</td>
<td>SPIN 0.80</td>
<td>SPIN 0.80</td>
</tr>
<tr>
<td>0.25</td>
<td>SPIN 0.75</td>
<td>SPIN 0.75</td>
</tr>
<tr>
<td>0.3</td>
<td>SPIN 0.70</td>
<td>SPIN 0.70</td>
</tr>
<tr>
<td>0.35</td>
<td>SPIN 0.65</td>
<td>SPIN 0.65</td>
</tr>
<tr>
<td>0.4</td>
<td>SPIN 0.60</td>
<td>SPIN 0.60</td>
</tr>
<tr>
<td>0.45</td>
<td>SPIN 0.55</td>
<td>SPIN 0.55</td>
</tr>
<tr>
<td>0.5</td>
<td><strong>CHOICE</strong></td>
<td>SPIN 0.50</td>
</tr>
<tr>
<td>0.55</td>
<td>STAY 0.50</td>
<td>SPIN 0.45</td>
</tr>
<tr>
<td>0.6</td>
<td>STAY 0.50</td>
<td>SPIN 0.40</td>
</tr>
<tr>
<td>0.65</td>
<td>STAY 0.50</td>
<td>SPIN 0.35</td>
</tr>
<tr>
<td>0.7</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>0.75</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>0.8</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>0.85</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>0.9</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>0.95</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
<tr>
<td>1</td>
<td>STAY 0.50</td>
<td>STAY 0.33</td>
</tr>
</tbody>
</table>

**Contestant 2:**
The second contestant must take two factors into consideration when deciding whether to spin again or stay with the value of the first spin: the final value for Contestant 1, and being confident that his or her own final score is enough to beat Contestant 3. If Contestant 2’s first spin is less than Contestant 1’s final value, he or she is forced to spin again. However, if Contestant 2 has beaten Contestant 1 on the first spin but wants to increase the probability of beating Contestant 3, Contestant 2 may want to spin again, although this does mean risking going over $1.00 and losing automatically.
Contestant 2’s optimal choices between spinning again and staying with the first spin, given that he or she has already beaten Contestant 1, are displayed in the table below:

<table>
<thead>
<tr>
<th>Contestant 2 First Spin</th>
<th>Prob. when Staying</th>
<th>Analytic Prob. (Stay)</th>
<th>Prob. when Spin Again</th>
<th>Analytic Prob. (Spin Again)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.0021</td>
<td>0.0025</td>
<td>0.3446</td>
<td>0.3399</td>
</tr>
<tr>
<td>0.10</td>
<td>0.0084</td>
<td>0.0088</td>
<td>0.3422</td>
<td>0.3394</td>
</tr>
<tr>
<td>0.15</td>
<td>0.0221</td>
<td>0.0200</td>
<td>0.3432</td>
<td>0.3384</td>
</tr>
<tr>
<td>0.20</td>
<td>0.0369</td>
<td>0.0363</td>
<td>0.3297</td>
<td>0.3366</td>
</tr>
<tr>
<td>0.25</td>
<td>0.0608</td>
<td>0.0575</td>
<td>0.3581</td>
<td>0.3338</td>
</tr>
<tr>
<td>0.30</td>
<td>0.0866</td>
<td>0.0838</td>
<td>0.3529</td>
<td>0.3296</td>
</tr>
<tr>
<td>0.35</td>
<td>0.1195</td>
<td>0.1150</td>
<td>0.3580</td>
<td>0.3238</td>
</tr>
<tr>
<td>0.40</td>
<td>0.1482</td>
<td>0.1513</td>
<td>0.3403</td>
<td>0.3163</td>
</tr>
<tr>
<td>0.45</td>
<td>0.1945</td>
<td>0.1925</td>
<td>0.3353</td>
<td>0.3066</td>
</tr>
<tr>
<td>0.50</td>
<td>0.2343</td>
<td>0.2388</td>
<td>0.3155</td>
<td>0.2947</td>
</tr>
<tr>
<td>0.55</td>
<td>0.2915</td>
<td>0.2875</td>
<td>0.2992</td>
<td>0.2803</td>
</tr>
<tr>
<td>0.60</td>
<td>0.3328</td>
<td>0.3413</td>
<td>0.2917</td>
<td>0.2633</td>
</tr>
<tr>
<td>0.65</td>
<td>0.4051</td>
<td>0.4000</td>
<td>0.2569</td>
<td>0.2433</td>
</tr>
<tr>
<td>0.70</td>
<td>0.4717</td>
<td>0.4638</td>
<td>0.2329</td>
<td>0.2201</td>
</tr>
<tr>
<td>0.75</td>
<td>0.5320</td>
<td>0.5325</td>
<td>0.1966</td>
<td>0.1934</td>
</tr>
<tr>
<td>0.80</td>
<td>0.6046</td>
<td>0.6063</td>
<td>0.1661</td>
<td>0.1631</td>
</tr>
<tr>
<td>0.85</td>
<td>0.6776</td>
<td>0.6850</td>
<td>0.1310</td>
<td>0.1289</td>
</tr>
<tr>
<td>0.90</td>
<td>0.7637</td>
<td>0.7688</td>
<td>0.0962</td>
<td>0.0904</td>
</tr>
<tr>
<td>0.95</td>
<td>0.8510</td>
<td>0.8575</td>
<td>0.0483</td>
<td>0.0476</td>
</tr>
<tr>
<td>1.00</td>
<td>0.9491</td>
<td>0.9513</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

**Contestant 2 Optimal Strategy for Spinning or Staying**

The probability of winning given the value of the first spin and each choice Contestant 2 can make was determined using both analytics and simulations using VBA within Microsoft Excel. The simulations consisted of 10,000 trials, where each trial was a play-through of the game with Contestant 2 against Contestant 3. Letting \( x \) represent the value of Contestant 2’s first spin, and determining all of the scenarios Contestant 2 can be faced with, the following were used to determine Contestant 2’s probability of winning based on the action he or she chooses to take:

1. Contestant 3 beats Contestant 2 in one spin = 1 – \( x \)
2. Contestant 3 beats Contestant 2 in two spins = \( x(1 - x) \)
3. Contestant 3 ties Contestant 2 in one spin = \((0.05)(0.5) = 0.025\)
4. Contestant 3 ties Contestant 2 in two spins = \((x - 0.05)(0.05)(0.5)\)

The probability of these scenarios can then be evaluated using the following:

1. \( \text{Pr}(\text{Spin 1 for C3 > x}) = 1 - x \)
2. \( \text{Pr}(\text{Spin 1 for C3 < x}, \text{Spin 2 for C3 < 1 - x}) = x(1 - x) \)
3. \( \text{Pr}(\text{Spin 1 for C3 = x, C3 wins spinoff}) = (0.05)(0.5) = 0.025 \)
4. \( \text{Pr}(\text{Spin 1 + Spin 2 for C3 = x, C3 wins spinoff}) = (x - 0.05)(0.05)(0.5) \)
Additionally, from the simulations of Contestant 2 vs. Contestant 3, it was discovered that even if a value less than or equal to $0.50 is the current winning value, Contestant 2 should spin again to increase his or her probability of beating Contestant 3, who is still yet to spin.

These pieces make up the probability that Contestant 3 beats Contestant 2, so the probability that Contestant 2 beats Contestant 3 is the sum of these pieces subtracted from the total probability:

- Contestant 2 probability of winning, staying with the first spin ($0.50 or less):
  \[
  \Pr(C2 \text{ wins}) = 1 - \Pr(C3 \text{ wins})
  \]
  \[
  = 1 - [(1 - x) + (x - 0.05)(0.05)(0.5) + x(1 - x)]
  \]
  \[
  = x^2 - \frac{x}{40} + \frac{0.05}{40}
  \]
  Note that the probability of Contestant 3 tying Contestant 2 in one spin is not included, as strategy tells Contestant 3 to spin again in a tie that is less than or equal to $0.50.

- Contestant 2 probability of winning, staying with the first spin ($0.55 or greater):
  \[
  \Pr(C2 \text{ wins}) = 1 - \Pr(C3 \text{ wins})
  \]
  \[
  = 1 - [(1 - x) + (0.05)(0.5) + (x - 0.05)(0.05)(0.5) + (x - 0.05)(1 - x)]
  \]
  \[
  = x^2 - \frac{3x}{40} + \frac{1.05}{40}
  \]

- Contestant 2 probability of winning, spinning again:

  \[
  \Pr(C2 \text{ wins}) = (0.05)[\Pr(x + 0.05 \text{ wins}) + \Pr(x + 0.10 \text{ wins}) + \cdots + \Pr(1.00 \text{ wins})]
  \]
  In this case, the \(\Pr(x + \cdots \text{ wins})\) is taken from the probabilities of Contestant 2 winning and staying with the first spin, because theoretically this is the same as having no spins left. There is a 0.05 chance of getting each of the other probabilities with another spin, and so it is the sum of these potential values from \(x + 0.05\) to 1.00 that make up the probability of Contestant 2 winning with another spin.

Considering the probabilities of winning when staying with the first spin and spinning again from both the analytics and the simulations, Contestant 2 should spin again when the value of the first spin is less than or equal to $0.50. Otherwise, Contestant 2 should stay with the value of the first spin, given that he or she has already beaten Contestant 1. This is because when moving from 0.50 and 0.55, the probability of winning when spinning again becomes lower than the probability of winning when staying with the first spin.

Contestant 1:
The first contestant has the lowest probability of winning because he or she is simply setting the benchmark for the others players to beat. Even if Contestant 2 and Contestant 3 do not beat the first contestant on their first spin, they still have the opportunity to spin again to beat Contestant
1. For this, contestant 1 has the highest value to target for their final value, as two others get to spin in an attempt to beat him or her. In a way, Contestant 1 is seeking “insurance” over the possible values the next two contestants could end with. Contestant 1’s optimal choices between spinning again and staying with the first spin based on the value of his or her first spin are displayed in the table below:

<table>
<thead>
<tr>
<th>Contestant 1 First Spin</th>
<th>Prob. when Staying</th>
<th>Analytic Prob. (Stay)</th>
<th>Prob. when Spin Again</th>
<th>Analytic Prob. (Spin Again)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.0010</td>
<td>0.0008</td>
<td>0.2092</td>
<td>0.2101</td>
</tr>
<tr>
<td>0.10</td>
<td>0.0023</td>
<td>0.0026</td>
<td>0.2117</td>
<td>0.2100</td>
</tr>
<tr>
<td>0.15</td>
<td>0.0062</td>
<td>0.0060</td>
<td>0.2104</td>
<td>0.2097</td>
</tr>
<tr>
<td>0.20</td>
<td>0.0115</td>
<td>0.0108</td>
<td>0.2101</td>
<td>0.2091</td>
</tr>
<tr>
<td>0.25</td>
<td>0.0162</td>
<td>0.0171</td>
<td>0.2078</td>
<td>0.2083</td>
</tr>
<tr>
<td>0.30</td>
<td>0.0239</td>
<td>0.0248</td>
<td>0.2079</td>
<td>0.2070</td>
</tr>
<tr>
<td>0.35</td>
<td>0.0340</td>
<td>0.0339</td>
<td>0.2041</td>
<td>0.2053</td>
</tr>
<tr>
<td>0.40</td>
<td>0.0471</td>
<td>0.0445</td>
<td>0.2020</td>
<td>0.2031</td>
</tr>
<tr>
<td>0.45</td>
<td>0.0553</td>
<td>0.0563</td>
<td>0.1993</td>
<td>0.2003</td>
</tr>
<tr>
<td>0.50</td>
<td>0.0710</td>
<td>0.0696</td>
<td>0.1957</td>
<td>0.1968</td>
</tr>
<tr>
<td>0.55</td>
<td>0.0825</td>
<td>0.0835</td>
<td>0.1913</td>
<td>0.1926</td>
</tr>
<tr>
<td>0.60</td>
<td>0.1189</td>
<td>0.1183</td>
<td>0.1889</td>
<td>0.1867</td>
</tr>
<tr>
<td>0.65</td>
<td>0.1650</td>
<td>0.1632</td>
<td>0.1790</td>
<td>0.1786</td>
</tr>
<tr>
<td>0.70</td>
<td>0.2144</td>
<td>0.2156</td>
<td>0.1656</td>
<td>0.1678</td>
</tr>
<tr>
<td>0.75</td>
<td>0.2797</td>
<td>0.2842</td>
<td>0.1539</td>
<td>0.1536</td>
</tr>
<tr>
<td>0.80</td>
<td>0.3708</td>
<td>0.3682</td>
<td>0.1359</td>
<td>0.1352</td>
</tr>
<tr>
<td>0.85</td>
<td>0.4712</td>
<td>0.4699</td>
<td>0.1123</td>
<td>0.1117</td>
</tr>
<tr>
<td>0.90</td>
<td>0.5923</td>
<td>0.5917</td>
<td>0.0932</td>
<td>0.0821</td>
</tr>
<tr>
<td>0.95</td>
<td>0.7383</td>
<td>0.7361</td>
<td>0.0463</td>
<td>0.0453</td>
</tr>
<tr>
<td>1.00</td>
<td>0.9104</td>
<td>0.9057</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Contestant 1 Optimal Strategy for Spinning or Staying

The probability of winning given the value of the first spin and each choice Contestant 1 can make was determined using both analytics and simulations using VBA within Microsoft Excel. The simulations consisted of 10,000 trials, where each trial was a play-through of the game with Contestant 1 against Contestant 2 and Contestant 3. The simulation implemented the strategies that Contestant 2 and Contestant 3 would approach the game with. Letting $x$ represent the value of Contestant 1’s first spin, and determining all of the scenarios Contestant 2 can be faced with, the following were used to determine Contestant 2’s probability of winning based on the action he or she chooses to take:

1. Contestant 2 beats Contestant 1 in one spin, Contestant 3 is less than or equal to Contestant 1
2. Contestant 3 beats Contestant 1 in one spin, Contestant 2 is less than or equal to Contestant 1
3. Contestant 2 beats Contestant 1 in two spins, Contestant 3 is less than or equal to Contestant 1
4. Contestant 3 beats Contestant 1 in two spins, Contestant 2 is less than or equal to Contestant 1
5. Contestant 2 ties Contestant 1 in one spin, Contestant 3 is less than Contestant 1
6. Contestant 3 ties Contestant 1 in one spin, Contestant 2 is less than Contestant 1
7. Contestant 2 ties Contestant 1 in two spins, Contestant 3 is less than Contestant 1
8. Contestant 3 ties Contestant 1 in two spins, Contestant 2 is less than Contestant 1
9. Both Contestant 2 and Contestant 3 tie Contestant 1

The probability of each of these scenarios was constructed using values calculated for a general spinning of the wheel by any contestant, displayed in the following tables:

<table>
<thead>
<tr>
<th>Target</th>
<th>Prob. 2 Spins</th>
<th>Prob. Any Turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.0000</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.1</td>
<td>0.0025</td>
<td>0.0525</td>
</tr>
<tr>
<td>0.15</td>
<td>0.0050</td>
<td>0.0550</td>
</tr>
<tr>
<td>0.2</td>
<td>0.0075</td>
<td>0.0575</td>
</tr>
<tr>
<td>0.25</td>
<td>0.0100</td>
<td>0.0600</td>
</tr>
<tr>
<td>0.3</td>
<td>0.0125</td>
<td>0.0625</td>
</tr>
<tr>
<td>0.35</td>
<td>0.0150</td>
<td>0.0650</td>
</tr>
<tr>
<td>0.4</td>
<td>0.0175</td>
<td>0.0675</td>
</tr>
<tr>
<td>0.45</td>
<td>0.0200</td>
<td>0.0700</td>
</tr>
<tr>
<td>0.5</td>
<td>0.0225</td>
<td>0.0725</td>
</tr>
<tr>
<td>0.55</td>
<td>0.0250</td>
<td>0.0750</td>
</tr>
<tr>
<td>0.6</td>
<td>0.0275</td>
<td>0.0775</td>
</tr>
<tr>
<td>0.65</td>
<td>0.0300</td>
<td>0.0800</td>
</tr>
<tr>
<td>0.7</td>
<td>0.0325</td>
<td>0.0825</td>
</tr>
<tr>
<td>0.75</td>
<td>0.0350</td>
<td>0.0850</td>
</tr>
<tr>
<td>0.8</td>
<td>0.0375</td>
<td>0.0875</td>
</tr>
<tr>
<td>0.85</td>
<td>0.0400</td>
<td>0.0900</td>
</tr>
<tr>
<td>0.9</td>
<td>0.0425</td>
<td>0.0925</td>
</tr>
<tr>
<td>0.95</td>
<td>0.0450</td>
<td>0.0950</td>
</tr>
<tr>
<td>1</td>
<td>0.0475</td>
<td>0.0975</td>
</tr>
<tr>
<td>Over</td>
<td>0.5250</td>
<td>0.4750</td>
</tr>
</tbody>
</table>

**Probability of Getting a Value in 2 Spins, and Any Number of Spins**

Note that the probability of getting a value in any turn (“Prob. Any Turn” in the table) is simply the probability of getting a value in two spins (“Prob. 2 Spins” in the table) plus the probability of getting a value in one spin, which is 0.05 for all values on the wheel.

Calculating the probability of winning for a three person game is much more complex than calculating the probability of winning for a two person game (i.e. Contestant 2 vs. Contestant 3, as described above). To analyze the Big Wheel as a three player game, as it is played in the show, requires first considering Contestant 1 versus Contestant 2, and then Contestant 1 and/or Contestant 2 versus Contestant 3, based on whether Contestant 2 beat, lost to, or tied with
Contestant 1. Essentially, if Contestant 1 beats Contestant 2, then Contestant 1 can be considered Contestant 2 and the same odds apply for the game in which it is only Contestant 2 and Contestant 3 left. The scenarios Contestant 1 can face are displayed in the following chart, where “C1” is Contestant 1, “C2” is Contestant 2, and “C3” is Contestant 3:

\[
Pr(C1 \text{ wins}) = (0.05)[Pr(x + 0.05 \text{ wins}) + Pr(x + 0.10 \text{ wins}) + \cdots + Pr(1.00 \text{ wins})]
\]
In this case, the Pr(x + … wins) is taken from the probabilities of Contestant 1 winning and staying with the first spin, because theoretically this is the same as having no spins left. There is a 0.05 chance of getting each of the other probabilities with another spin, and so it is the sum of these potential values from x + 0.05 to 1.00 that make up the probability of Contestant 1 winning with another spin.

Summary: This information can be consolidated into the following strategies, given what order each player is spinning in:

- **Contestant 1:**
  - Spin again if the first spin value is 0.65 or less
  - Stay with the first spin value if it is 0.70 or greater

- **Contestant 2:**
  - Spin again if the first spin value is 0.50 or less
  - Forced to spin again if the first spin value is less than Contestant 1’s final value
  - Stay with the first spin value if it is 0.55 or greater, and greater than or equal to Contestant 1’s final value

- **Contestant 3:**
  - Forced to spin again if the first spin value is less than the current leader’s final value
  - In a two-way tie, spin again if the tie is 0.50 or less
  - In a three-way tie, spin again if the tie is 0.65 or less

From all of the preceding data, these are the optimal strategies for each contestant.
Other Games

This section is all the games where with no knowledge of the cost at all it is really not feasible. You can win for example tossing in a random number, but you would at least need to know a general range so potentially for further projects can do given a constraint of a price range that an average person knows for example that a car is not 10 dollars and toothpaste is not 1000 dollars. From there test the game in a simulation. Also included in this section are games where skill plays a factor or for other reasons we found it did not fit in the other three categories. These are simply listed alphabetically.
Rules: Five grocery items are shown to the contestant. The contestant must choose one item and determine how many of that item is necessary to total between $10.00 and $12.00. If the contestant is successful within three attempts, then the contestant wins a bonus prize. If the contestant is unsuccessful, they can still win the bonus prize if a hidden bullseye is behind one of the items with which the contestant achieved a total of less than $10.00.

Reason for being put in other: This game is similar to grocery game need to know the prices at least within a few dollars which does not work for our project as we assume the contestant knows nothing.
Check Out (Other)

Rules: The contestant bids on five grocery items. If the total of the contestant’s bids is within $2.00 either way of the actual total of the items’ prices, then the contestant wins a bonus prize.

Reason for being put in other: There is no way to win this without a general idea of the prices of items.
Cliff Hangers (Other)

Rules: The contestant bids on three small prizes. For every dollar the contestant is away from the actual prices, a mountain climber takes one step up a mountain. If the mountain climber does not exceed 25 steps after the contestant has bid on all three prizes, then the contestant wins a bonus prize.

Reason for being put in other: This game is again dependent on knowing prices and without that knowledge would be extremely difficult and difficult to find probabilities as this is subject person to person knowing prices.
**Grocery Game** *(Other)*

**Rules:** Five grocery items are shown to the contestant. The contestant selects an item, specifies the quantity of the item desired, and the total is recorded on a cash register. The contestant then selects another item in the same manner to be added to the total. If the contestant achieves a total between $20.00 and $22.00, then the contestant wins a bonus prize.

**Reason for being put in other:** The nature of this game is very reliant on the contestant knowing the general price of items as with no knowledge the guess could be from 1 to 100 of one item where generally one item is more expensive and others are cheaper. The Probability of winning this game depend on knowledge of knowing prices and therefore is not included in our project.
Hole in One (Other)

Rules: In this game the contestant must ranks 6 grocery items from least expensive to most expensive. Each one that is more expensive than the previous they are moved closer to the hole. They then must put the golf ball into the hole to win a car.

Reason for being put in other: This game is under this section due to the nature of the game being most reliant on skill, as someone who is skilled in putting could win whether they are the furthest distance or closest distance. The probability of winning is mostly dependent on this factor and therefore is in under other.
**Magic # (Other)**

**Rules:** Two prizes are shown to the contestant. The contestant must select a number that falls between the prices of the prizes. If successful, the contestant wins both prizes.

**Reason for being put in other:** This would be difficult having no knowledge of the prizes price. Only way would be to analyze the game and all the prizes they have used to find the range they would most likely be a winning price but that is subject to change if the prizes are changed and so the game itself has no strategy build in to it short of knowing the prices.
5 Conclusions

In this project, we were able to find games where the contestants would be able to implement strategies and improve their odds of winning even if they had no knowledge about how much the items cost on those games. Unfortunately, there were significantly more games than we anticipated that were very basic and did not have much to analyze. However, the goal of making a set of strategies to learn before going on the show to improve one’s odds was achieved. For this purpose, the lack of games with strategies is beneficially, as it is easier for contestants to memorize or familiarize themselves with the strategies for improving their probability of winning. Additionally, most people have some general pricing knowledge of the items presented as prizes on The Price is Right, thus improving their probability of winning these games without any mathematically-derived strategies.
6 Recommendations

A follow up to this project would be to analyze the more complicated games where you must know something about the price of a prize to play. To create a simulation you would need to have a relative range that the average person will little knowledge of the prize would guess. Without this, a game where you need to guess a price within a certain range a computer could guess $0-infinity with the same probability, whereas a person would know it is greater than $5,000 but less than $20,000. Then, random subjects could be polled to get an idea of ranges and use that with a computer to then simulate those games and from there more analyzing of the games could be done. Additionally, it would be beneficial to create simulations for all of the strategy games. With this, we would have been able to have trials to back up the analytic probabilities of winning these games when implementing a strategy. Another step that could be taken in this project is considering variations of these games, and how things such as different rules, different number of players, or different prize values could change the strategies involved. For example, the Big Wheel would require a different strategy if there were more than three players, or if the wheel was continuous rather than discrete and counting by 5’s. Finally, the last suggestion would be to expand this project on to more game shows. Fortunately, The Price is Right is filled with many games where probability and mathematically-derived strategies can be implemented, but many other shows also include games where similar strategies could be developed.
References

