An Analysis of Roulette Strategies

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Introduction

The purpose of our project was to look at various play options for the casino game Roulette and analyze various strategies. In Roulette, players place bets on the outcome they think will be displayed by a spinning wheel. Players can bet on one number, a range of numbers, the colors red or black, or whether the number will be odd or even.

Our analysis of each strategy includes the odds of winning in each individual round (hereon referred to as the odds of winning), the payout - positive if you win, negative if you lose, the safest number of times you can play each strategy before you are losing money overall (in the long run), and a comparison of the payout to the odds for each strategy. The odds are calculated by determining the percentage of the board that the strategy covers, payout is calculated based on the ratio of the payout for the strategy and the number of spaces you have covered using Bayesian analysis, and the safest number of times you can play is calculated by looking at the amount of times you can expect to win before you lose. We use these points to determine which strategy is best for short term, long term, large initial capital, and small initial capital situations. The section for each strategy includes the data for the standard wheel (37 spaces) and the American wheel (38 spaces). The payout for the standard wheel is referred to simply as "payout" and the payout for the American wheel is referred to as "US payout" throughout this paper.

Single-Round Betting Strategies

Wheel Coverage Analysis: We did a simple analysis a strategy simply consisting of covering more and more of the wheel. To make the analysis simple, we calculated all of the numbers with a payout of $100 if you win.

⅙ of the Wheel: Bet $20 on one double street (6 spaces).
<u>Odds of winning</u>: 6/37 = 16.21%
<u>Bayesian outcome</u>: loss of $0.54
<u>US Bayesian outcome</u>: loss of $1.05
<u>Safest number of rounds to play</u>: 0

⅓ of the Wheel: Bet $50 on any (⅓) of the board.
<u>Odds of winning</u>: 12/37 = 32.43%
<u>Bayesian outcome</u>: loss of $1.35
<u>US Bayesian outcome</u>: loss of $2.63
<u>Safest number of rounds to play</u>: 0

½ of the Wheel: Bet $100 on black, red, odd, even, 1st half, or 2nd half.
<u>Odds of winning</u>: 18/37 = 48.65%
<u>Bayesian outcome</u>: loss of $2.70
<u>US Bayesian outcome</u>: loss of $5.26
<u>Safest number of rounds to play</u>: 1

⅔ of the Wheel: Bet $200, split $100 on each third.
Odds of winning: 24/37 = 64.86%
Bayesian outcome: loss of $5.41
US Bayesian outcome: loss of $10.52
Safest number of rounds to play: 2

⅚ of the Wheel: Bet $500, split $200 on each third for ⅔ of the board and $100 on the last ⅙ of coverage.
Odds of winning: 30/37 = 81.08%
Bayesian outcome: loss of $13.51
US Bayesian outcome: loss of $26.3
Safest number of rounds to play: 4

All but 0 and 00 on the Wheel: Bet $100 on every square.
Odds of winning: 36/37 = 97.30%
Bayesian outcome: loss of $2.70 (house edge)
US Bayesian outcome: loss of $5.26
Safest number of rounds to play: 36

Table 1

Amount of board covered	Bet to win $100	Probability of **losing**	Average Payout (Bayesian)
(⅙)	$20	31/37	-$0.54
(⅓)	$50	25/37	-$1.35
(½)	$100	19/37	-$2.70
(⅔)	$200	13/37	-$5.41
(⅚)	$500	7/37	-$13.51
(6/6)	(no winnings)	1/37	-inf

Note: When referencing the amount of board covered, for simplicity that discludes the green squares: 0 and 00 for a US board or just 0 on a UK board.

With the single round betting analysis strategies we kept constant the amount profit for a winning outcome and saw how the average payout (bayesian) changed as the gambler bet on a higher percentage of the board.

From this analysis we can see a couple of trends. Foremost, as you increase the amount of the board you cover, the probability of winning increases linearly and the probability of losing decreases linearly, with slopes of (6/37) and (-6/37) respectively. On the surface this seems like a good deal for the gambler since the odds of winnings increase. But as you can see from

Table 1, the average payouts (bayesian expected outcomes) decrease as you cover a higher percentage of the board.

Intuition would lead the gambler into thinking that a higher probability of winning would lead to higher expected outcomes while keeping other things constant. But even though as you cover a higher percentage of the board you're probability of winning increases, the amount of bet that you need to place *increases at a faster rate*.

From *Table 1,* we can see that the amount that the gambler needs to bet to win $100 increases exponentially as the probability of losing decreases linearly. So when the gambler covers more of the board, he/she indeed will lose less often, but when they do lose they will lose a lot more money than otherwise.

One interesting outcome from this analysis is that the expected payoffs decrease in a similar trend as the amount needed to bet increases. As you cover 50% more of the board, the amount you need to bet increases by a factor of 10, and the expected payoff decreases as a factor of 10. When you increase board coverage from (⅙) → (⅔) expected payout decreases from -$0.54 → -$5.41 and the bet increases from $20 → $200. The same trend happend from covering board percentages of (⅓) → (⅚).

An interesting thing happens once the gambler starts to cover the the whole board (minus the green spots) there is no amount of money that the gambler could bet to win anything. When the whole board is covered, there is a (36/37) that you will win, but you make a net of $0.00 of off the gamble, you win exactly what you bet. Then there is a (1/37) chance that the gambler will lose everything that he/she bet.

Single Round Strategy Conclusion

This brings us to the house edge. The reason that when the full board is covered you will always lose is because roulette is designed to be a fair game (payout has a net of $0.00) *without* the green 0's. We can find the house edge by dividing the average outcome by the amount of dollars bet to make $100.00. In every case, you will lose 2.7 cents per dollar bet. Which coincidently is (1/37) the exact probability of landing on the green square that gives the house it's edge.

Although all of these have different bayesian outcomes, the expected payout (bayesian outcome/dollars bet) remains a constant 2.7 cents/dollars bet for the UK wheel and 5.26 cents/dollars bet for the US wheel.

Multiple-Round Betting Strategies

In this section, we have left out the "safest number of rounds to play" metric, as the calculations become much more complicated for multiple rounds. We have also added categories such as "odds of winning within 35 rounds" or "odds of winning before running out of money" as we deemed appropriate for each strategy.

Martingale: The gambler bets $1 on either red or black. If they lose, they bet $2 on the same color. If they lose again, they bet $4, and so on until they win or run out of money. If they win, you will have a profit of $1.

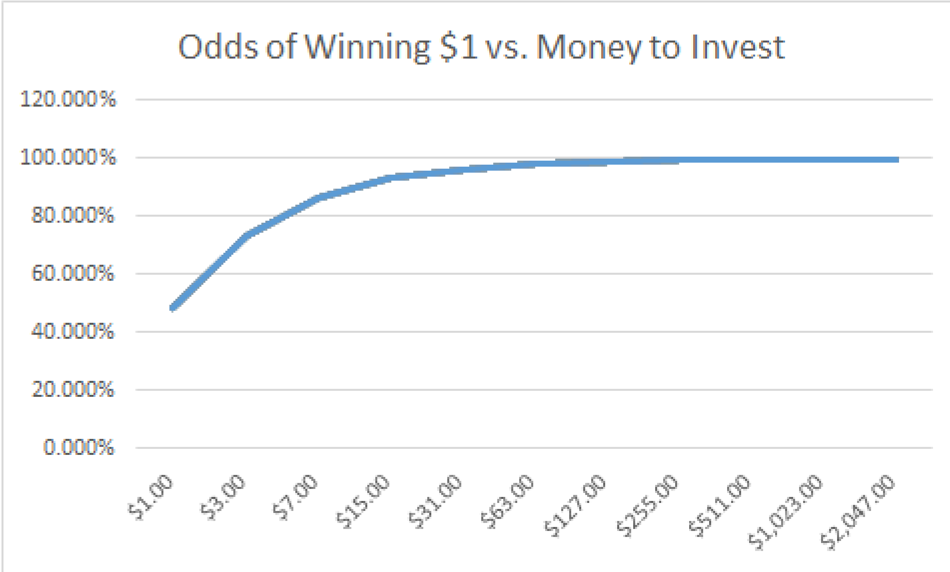
<u>Odds of winning</u>: 18/37 = 48.65%
<u>Odds of winning before running out of money</u>: This metric depends on the amount of money the gambler has to work with, as illustrated in the table below. If the gambler's maximum amount of money is not listed, they would round down to the nearest amount in the table. In this table, it is assumed that after you win $1, you stop playing.

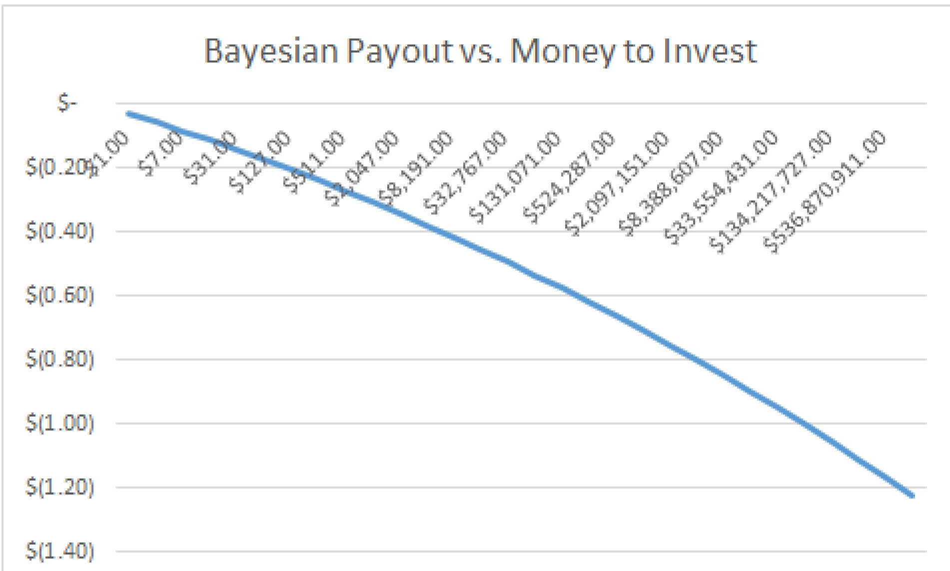
Maximum Amount of Money ($)	**Maximum Losing Rounds in a Row**	**Odds of winning $1**
1	1	1-(19/37)= 48.56%
3	2	$1-(19/37)^2$=73.6%
...		
1023	10	$1-(19/37)^{10}$=99.87%
2^n-1	n	$1-(19/37)^n$

With this model, the payout is expected to be $(1-(19/37)^n)*1-(19/37)^n(2^n-1)$, and the payout varies with n. Below are graphs of odds of winning $1 and expected payout vs. total amount of money the gambler can spend.

We created a program in C++ that would simulate rounds of roulette using the Martingale strategy. For simplicity, the user bets on 19-36 everytime. The user starts out with $1000.00 and a bet of $1.00. The program would run through the strategy and generate random numbers (and the corresponding color) for each spin until the user ran out of money. The program kept track of total number of rounds played until the user lost, wins, losses, how high the maximum bet reached, and how many times it reached that bet.

We have attached files for the code and for the results. But in summary, after 100 trials we found that the average number of rounds a person could play with the Martingale strategy was 431. The maximum bet happened roughly 8 times per trial and averaged out to be $471.00. To no surprise some trials were much more lucky than others playing up to almost up to 1000 spins before going broke; while other we not so fortunate… Trial 38 for example did not win one single spin and went broke almost immediately.





The equivalent graphs of this data for a U.S. roulette board follow similar trends, and we as a group felt that they were not worth including separately given the amount of space they take up.

Payout for $1 max:Loss of 2.7 cents/dollar
US Payout for $1 max: Loss of 5.26 cents/dollar

Labouchère: The gambler begins by establishing a goal for their winnings, i.e. "I want to win $75." The gambler then makes a list of consecutive positive numbers that sum to the amount he/she wishes to win. Each round a bet is made based on color (red or black) and the amount bet is the sum of two numbers on the list. If the gambler wins, they remove the summed numbers from the list, if one loses, they add the amount bet to the end of the list.
Here is an example: if one wanted to win $75 their list might be [5, 10 , 20, 40] (since that

list sums to 75.) On the first bet, they may bet $15 as it is the sum of the first two number on the list, 5 and 10. If they win, the summed numbers are eliminated and the list becomes [20, 40]. If they lose, the sum is appended to the end of the so that the list becomes [5, 10 , 20 , 40, 15].

Odds of winning: 18/37 = 48.65%
Payout: loss of 2.7 cents/dollar
US Payout: loss of 5.26 cents/dollar

D'Alembert: The gambler bets on either red or black. If they lose, they increase the amount of the bet by $1 and bet on the same color. If they win, they reduce the amount of the bet by $1 and bet on the same color. This capitalizes on the gambler’s fallacy, the idea that winning or losing streaks are unlikely.

Odds of winning: 18/37 = 48.65%
Payout: loss of 2.7 cents/dollar
US Payout: loss of 5.26 cents/dollar

“The Dopey System”: Former LA Times editor Andrés Martinez describes “the dopey system,” a system which is not designed to win money, in his book *24/7.* In it, the gambler divides the money they plan to bet into 35 equal amounts, and bets it on the same number 35 spins in a row. If the gambler wins once, they will get a payout 35 times their bet, and thus earn back their entire original sum.

Odds of winning: 1/37 = 2.7%
Odds of winning at least once in 35 rounds: 61.67%
Payout: loss of 2.7 cents/dollar
US Payout: loss of 5.26 cents/dollar

The Red System: The gambler bets on the third column, which contains 8 red numbers and 4 black numbers. Then they bet double that on the black numbers overall. This has several possible outcomes, here calculated for a bet of $15 total:

Outcome	**Winnings**
Red number in the third column	$0
Black number in the third column	$20
Red number in first or second column	-$15
Black number in first or second column	$5
Number is zero (or double zero)	-$15

Odds of winning (i.e. odds of gaining money): 18/37 = 48.65%
Payout: loss of 2.7 cents/dollar
US Payout: loss of 5.26 cents/dollar

The Do-Nothing Option: a.k.a. The “Watch Other People Play” Method
The gambler does not gamble.

Odds of winning: Since the gambler is not playing, they have a 0% chance of winning
Payout: loss and gain of 0 cents/dollar
US Payout: loss and gain of 0 cents/dollar

Conclusion

Best Situational Strategy Decisions

If you have a large starting capital the best long term strategy is to cover roughly ⅚ of the board, hopefully end on a winning streak. If you have a large starting and not a lot of time, the Martingale strategy is the most optimal, but has a minimal amount of money that you could actually win in a short time span. If you do not have a large starting capital the best option is to start with the “Do-Nothing” strategy, leave the casino, and come back when you do have a large starting capital. The Martingale strategy is not feasible in any long term situation or in any situation with small initial capital. In an ideal world where any play conditions are possible however, the Martingale strategy would be a feasible one if you were able to play a small number of rounds with a large starting capital. More realistically, the Do-Nothing strategy is the most feasible for long term play involving large initial capital.

Recurring Numbers

Frequently throughout this analysis, the conclusion was a loss of 2.7 cents/dollar on a UK board and 5.26 cents/dollar on a US board. Interestingly, this corresponds to the odds of the ball landing on a 0 or 00 space, which is 1/37=2.7% on a UK board and 2/38=5.26% on a US board. This is because roulette payouts are calculated to be a fair game disregarding the 0 and 00 spaces, and the 5.26% and 2.7% is the house’s edge in the game.

Standard v. American Wheel

In general, it can be seen that in the long run, playing roulette results in a loss of money. However, between the standard 37 space wheel and the American 38 space wheel, you lose more money on the American wheel. Therefore, if given a choice, the gambler should choose to play any of the strategies on the standard wheel over the American wheel.