Martin O'Connell

ISYE 6644: Blackjack Simulation in Python Final Report

Abstract

Blackjack is the most popular casino card game in the world because of its simplicity and the social aspect with other players at the table. The player's objective is to obtain cards from the dealer whose values add up to, or close to 21, but do not exceed it. A hand is lost if the sum of the player's cards is greater than 21 or if it is less than the sum of the dealer's cards. Casinos are businesses and they have the statistical advantage in every game and blackjack is no different. They key advantage for the dealer in blackjack is that the player acts first, often "going bust" (going past 21) without the dealer having to make a move or risk anything. In this project I experimented with many different strategies to eliminate the house advantage. What I found is that there are some methods that a gambler can implement to walk out of the casino with profit.

Background and Description of Problem

A casino's strategy to prey off an individual's tendency to make poor, emotional decisions combined with statistical advantages in their game designs is a formula for a very profitable business. Even though the general premise of blackjack is the same everywhere, the approach each casino has toward variables, such as how many decks will be used, when the cards are reshuffled, and when/if the player can double down. If an individual implements a solid strategy and tunes out the noise, they can bring the house edge down. There are many different game strategies that gamblers have utilized such as the "never bust" method as well as bet sizing strategies such as the martingale method to decrease this house edge. However, without some luck or implementing a card counting strategy, all have been unsuccessful to turn the advantage over to the player consistently.

It would be remiss to ignore the existence of card counting when discussing blackjack. The primary reason that every casino includes so many variables instead of dealing from a single deck until there are no more cards and then reshuffling is to throw off card counters. Card counting is a method that a player uses to determine if they have an advantage on the next hand to overcome the house edge. There are many different methods that advantage players have used over the years, but the general premise is to keep a running count of high and low valued cards that have been delt to predict what is left and if that is advantageous for the player. With this strategy a player will typically place larger bets when their strategy demonstrates they have the advantage and less when they do not. Card counting has been proven to be consistently profitable for gamblers and is not illegal, casinos put in a lot of effort to prevent/catch counters since at the end of the day they are a business and must always have the edge to remain profitable. Since card counting is banned from all casinos, it was not sensible to include any of these strategies in my simulation. Instead, I decided to test a combination of variables that the player can control, bankroll management (bet size) and strategies that are permitted.

When it comes to bankroll management, the easiest and most common method is a flat-betting method. The concept of this method is that the player places the same wager every hand, which will lower the risk and allow the player more control over their budget. The con of this method is that long-term profit for the player is unlikely as the house edge will end up eating into any player gains. This will be our base case, and the performance of all other strategies will be compared to this.

Another common strategy is positive-progression wagering, where the player rides their win streak to increasing the wage size every time a player wins a hand, returning to the original bet once the player loses and the streak ends. The main item that the player must be cautious with is how much they increase each bet by when they start winning hands. Additionally, the player must remain emotionally strong and not get dismayed by the big loss once the winning streak is over. The paroli system, is a strategy where the bettor doubles their base stake after each win, stopping at 3 wins in a row. After winning 3 hands in a row or losing a hand (whichever happens first) the bettor will return to their base stake.

The opposite strategy, negative-progression wagering, is also a popular system where the player increases the bet size after losing, continuing to increase until the next winning hand at which point they return to the original bet. The goal of this system is that the player will eventually win and restore most of their losses from previous hands due to the high wager. Using this method requires a big bank roll because loses can stack up and the wager size can increase quite quickly. The martingale system (essentially the opposite of the paroli system) is a strategy where a bettor doubles their bet after each loss. This is the most common method because doubling the payouts will coincide with a 2 to one payout on winners. It is paramount that the player understands what their budget is and adjusts their original bet accordingly.

The final strategy that will be tested is the Oscar Grind system, a strategy that attempts to combine the benefits of positive and negative progression. In this system the player keeps their original bet until they win a hand. After winning the player doubles their bet, and keeps increasing each bet by the original bet until they have achieved a profit equivalent to the original bet. Once this is achieving the player starts over from the original bet. The main disadvantage with this system is that it can take many hands to play out and many players do not have that kind of patience.

A gambler could have the best bankroll strategy in the world, however if that is not paired with a reasonable gaming strategy that means nothing. In this project I am going to explore 2 gaming strategies combined with the aforementioned bankroll strategies to find the best performing combination. My base case strategy that I will use is a typical beginner's strategy that uses the information that the bettor knows (the exposed dealer card and their hand) to make the best statistical decision based on simple math. There are a few different steps and I encourage everyone to look at the attached code to familiarize themselves with this relatively simple algorithm. The other algorithm that I will explore is a "never bust" strategy, where the player tries to put the pressure on the dealer and make them bust without the player ever

receiving more then the minimum 2 card hand. In this strategy, if the player has a hand greater than or equal to 12, then they will sit tight and turn it over to the dealer to play.

Main Findings

The code that I developed for this project can be separated into two sections. The first section tests each of the 4 bankroll techniques (same bet, martingale, paroli, and oscar) with a typical blackjack strategy. In this strategy the player stays put if their hand is greater than or equal to 17, if their hand is greater than or equal to 13 and the known dealer card is less than or equal to 6, or if their hand is a 12 and the known dealer card is either a 3, 5, or 6. If the player is dealt and ace they use a "soft total" strategy where they stay put if their hand (with ace being 11) is greater than or equal to 19 or if their hand is equal to 18 and the dealer card is less than or equal to 8. If neither of these two conditions are applicable the player will convert their ace value to 1 and keep hitting until they are. The second section of my code tests the 4 different bankroll techniques with the "never bust" strategy, where the player always stays once their hand is greater than 12, always playing an ace as 11.

In both sections of code, every hand played was bet on using the 4 different techniques and the payout/loss was recorded. I wanted to track a realistic daily percent return and calculated that 150 games would be reasonable amount based off 3 hours of play (an average of 50 hands an hour). With this approximation, I calculated the different daily returns from each betting strategy with the same cards, as opposed to evaluating each strategy with a new simulation. This removed any potential for uncertainty when comparing results. I then simulated this 5000 times to increase accuracy and decrease uncertainty. The number of decks (4), the deck size at which the dealer reshuffled (50%), and the starting/default bet were kept the same for each simulation to enhance the internal validity of the simulation.

The median return for our typical strategy was similar for the same bet, paroli and oscar strategies, all hovering around -6.5-7% as shown in Figure 1. Although this is not a profit that we desire, a gambler following any of these systems would avoid any catastrophic loses and could write their losses off as an "enjoyment" tax if playing is something they love doing. Interestingly, the median using the martingale system was 25.7%, which is an amazing result, and should be the system of choice. Although, the martingale system also has the largest standard deviation as shown in Figure 2, and the results are not as consistent, overtime the gambler will have a great return. When playing with this typical strategy, it is clear that the martingale system is the bankroll strategy of choice.

```
Median gain/loss percentage using same bet: -6.785714285714286
Median gain/loss percentage using martingale system: 25.69461867541574
Median gain/loss percentage using paroli system: -7.011388566266615
Median gain/loss percentage using oscar system: -6.4321074964639315
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Figure 1.

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Gain/loss percentage standard deviation using same bet: 8.473850887264186
Gain/loss percentage standard deviation using martingale system: 14.815724180529244
Gain/loss percentage standard deviation using paroli system: 12.613432870010774
Gain/loss percentage standard deviation using oscar system: 9.915070541074385
```

Figure 2.

The no bust strategy also delivered some interesting results, this time with two bankroll strategies, martingale and oscar delivering profitable median returns as shown in Figure 3. Additionally, the median returns and standard deviation of the same bet and paroli systems were similar to the typical strategy as shown in Figure 4.

```
Median gain/loss percentage using same bet: -6.474820143884892
Median gain/loss percentage using martingale system: 20.067405654690138
Median gain/loss percentage using paroli system: -7.259395294368147
Median gain/loss percentage using oscar system: 5.681818181818182
```

Figure 3.

```
Gain/loss percentage standard deviation using same bet: 8.145754292692772
Gain/loss percentage standard deviation using martingale system: 13.593027082781422
Gain/loss percentage standard deviation using paroli system: 11.94581295560014
Gain/loss percentage standard deviation using oscar system: 7.378341641490387
```

Figure 4

Conclusion

Overall, the return of the martingale system combined with the typical blackjack strategy is the most profitable and therefore the best strategy to implement. It is worth noting however, that there is infinite amount of betting strategies that could be tested and compared using this program, just by adding a new algorithm to the loop. Additionally, both of these simulations were compared under a specific 4 deck, 50% shuffle set of rules from the casino. When these variables are changed the players return will be affected (both positively and negatively).