

The House Edge and the Basic Strategy of Blackjack

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Abstract: The fact about the blackjack is that the dealer gains advantages all the time in the normal casino since the rules can be changed by the casino. The way they change rules affects the probabilities of winning for both players and dealers. Therefore, it is important for the players to learn how could the house edge occur and the strategy to maximize their advantages individually. The theoretical analysis and simulations of the experiment by computer programs, for the sake of data, are the tools for solving the problems mentioned in this paper. The house edge is resulted by difference of the bet and the probability of winning the game, and the basic strategy created slightly advantages for the players in the case that house edge always exists.

1.INTRODUCTION

Over decades, people keep trying to enjoy amusement and earn money from casinos, since plenty of people consider that either success or failure are relied on the luckiness. Once they win the game with a large bet, they will become millionaires. However, most people are unable to understand the principle of the banking games such as blackjack, which leads to thousands of people going bankrupt after playing in the casinos. Blackjack is the most common type of banking game in casinos all over the world, and one of the most interesting aspects of blackjack is the probabilities in math involved. It's more complicated than other games because of the interactions of people and the rules. In this paper, the house edge of the dealer, the analysis and experiment of the basic strategy will be discussed with theoretical analysis and experiments. Those discussions about blackjack is based on single-deck situation, and the experimental data are based on simulations since it is difficult to do the experiment in casinos. For this area, this study might be completed for analyzing the advantages of casinos and the

basic strategy. In reality, this might extend the similar concept for other probability games or system including lottery.

2.THE HOUSE EDGE

The house edge can be defined as the profit that the casino expects to make on each iteration of a game, expressed as a percentage. The standard blackjack house edge is considered to be around 2% [1].

The house edge is a related calculation of your expected value in relation to the amount of your bet (normally assumed as 100\$):

The expected value= $\sum X_i \cdot P_i = P(\text{win}) \times \text{money} + P(\text{lose}) \times \text{money lose}$

The house edge= the bet – the expected value

To begin with, there are several ways to change the house edge easily. One of the most common strategies for dealers to gain more house edge is to remove some rank of cards. As different types of cards are removed, the house edge for the dealer also rises or declines accordingly. This is shown in the table below.

Table 1. The house edge for each kind of cards that are removed [2]

Cards	The House Edge
2	-0.40%
3	-0.43%
4	-0.52%
5	-0.67%
6	-0.45%
7	-0.30%
8	-0.01%
9	+0.15%
10	+0.51%
A	+0.59%

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The data above is based on a single-deck situation. The calculations are based on the computers, and it is normally assumed that the bet will be 100 dollars each time.

In this case, removing cards with points larger than 9 would be advantageous and the house edge even rises to +0.59%, which can help casino earn millions of dollars in the long run. On the contrary, the house edge reaches the lowest about -0.67% when cards with 5 points are removed. To conclude, removing the cards with points smaller are mostly unbeneficial for the dealer, but this is opposite to the player.

Another thing that needs to be considered in the calculation of house edge is the rules of the blackjack. With the variation in rules including the options of insurance, surrender, doubling after splitting, just to name a few, the dealer gains different house edge because of the rules and some of them are helpful for the player to get advantages. However, there are some rules that might also cause a disadvantage to the players such as the difference of decks and the increase of the number of decks. In this case, the profits of the players decrease as the decks increase, and the utilization of rules might be helpful for the players to win the game.

The casinos always try their best to beat the players in the Blackjack games. Hence, players need to pay more attention to the Blackjack rules, house edge, and penetration. All of these combined can get players an edge over the other players. Even though the house edge in Blackjack game looks really small in percentage, there is a huge chance that it might beat players. So, calculate the house edge using this easy method given above and plan a strategy so that players can beat the casino in their own game [3].

Table 2 shows some effects of various rule conditions that dealers are able to change the house edge with different rules, such as increasing 1.3% of the house edge by higher payout and 0.08% of the house edge by canceling the surrendering. Moreover, more decks as well as the change of strategy of dealer, result in 0.61% and 0.21% increase of house edge respectively. When dealer changes the options of players such as double and splitting, the house edge also increases slightly. As little change occurs in rules, the house edge could be affected and makes incredible profit for the casinos with tons of players losing their money.

Table 2. The effects of various rule conditions [4]

Rules Variation	Effects on House Edge
6 to 5 pay out on a natural instead of the stand 3 to 2 payout	+1.3%
Not having the option to surrender	+0.08%
8 decks instead of 1 deck	+0.61%
Dealer hits at a soft 17 instead of standing	+0.21%
Player is not allowed to double after splitting	+0.14%
Player is only allowed to double with a total of 10 or 11	+0.18%
Player isn't allowed to re-split aces	+0.07%
Player isn't allowed to hit split aces	+0.18%

3. BASIC STRATEGY

Maximizing advantages was popularized by Roger Baldwin's paper which includes The Optimum Strategy [5] in Blackjack and analysis of the player's options discussed in the past. After that, Edward Thorp who was an American mathematics professor, had interest in The Optimum Strategy and had programmed the same methodology into an IBM 704 in Fortran. With the use of computer, he found every possible action for every possible hand and used this data to create a new strategy called Basic Strategy. With the use of Basic Strategy, gaining advantages in blackjack became accessible. Thorp released this strategy in his book Beat the Dealer [6],

which had a large effect on blackjack. When Beat the Dealer was published, gamblers stormed the casinos prepared to win, while other researchers and mathematicians created new counting systems off of Thorp's data.

In respond to maximize the advantages of players, the basic strategy is determined according to the busting probabilities given that the up card of the dealer.

Because the dealer has a fixed strategy that they will stand when there are 18 points or 17 points in the majority of the casinos, it is essential for the players in blackjack to learn about the basic strategy that clearly points out the action players should take in different cases as the following:

Table 3 and Table 4. The basic strategy including all of the situations[7]

		DEALER UP CARD									
		2	3	4	5	6	7	8	9	10	A
HARD TOTALS	17	S	S	S	S	S	S	S	S	S	S
	16	S	S	S	S	S	H	H	H	H	H
	15	S	S	S	S	S	H	H	H	H	H
	14	S	S	S	S	S	H	H	H	H	H
	13	S	S	S	S	S	H	H	H	H	H
	12	H	H	S	S	S	H	H	H	H	H
	11	D	D	D	D	D	D	D	D	D	D
	10	D	D	D	D	D	D	D	D	H	H
	9	H	D	D	D	D	H	H	H	H	H
	8	H	H	H	H	H	H	H	H	H	H
DEALER UP CARD											
SOFT TOTALS	A,9	S	S	S	S	S	S	S	S	S	S
	A,8	S	S	S	S	Ds	S	S	S	S	S
	A,7	Ds	Ds	Ds	Ds	Ds	S	S	H	H	H
	A,6	H	D	D	D	D	H	H	H	H	H
	A,5	H	H	D	D	D	H	H	H	H	H
	A,4	H	H	D	D	D	H	H	H	H	H
	A,3	H	H	H	D	D	H	H	H	H	H
	A,2	H	H	H	D	D	H	H	H	H	H

		DEALER UP CARD									
		2	3	4	5	6	7	8	9	10	A
PAIR SPLITTING	A,A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	T,T	N	N	N	N	N	N	N	N	N	N
	9,9	Y	Y	Y	Y	Y	N	Y	Y	N	N
	8,8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	7,7	Y	Y	Y	Y	Y	Y	N	N	N	N
	6,6	Y/N	Y	Y	Y	Y	N	N	N	N	N
	5,5	N	N	N	N	N	N	N	N	N	N
	4,4	N	N	N	Y/N	Y/N	N	N	N	N	N
	3,3	Y/N	Y/N	Y	Y	Y	Y	N	N	N	N
	2,2	Y/N	Y/N	Y	Y	Y	Y	N	N	N	N
DEALER UP CARD											
SURRENDER		2	3	4	5	6	7	8	9	10	A
	16								SUR	SUR	SUR
	15									SUR	
	14										
INSURANCE OR EVEN MONEY: DON'T TAKE											
KEY	H	Hit									
	S	Stand									
	D	Double if allowed, otherwise hit									
	Ds	Double if allowed, otherwise stand									
	N	Don't split the pair									
	Y	Split the Pair									
	Y/N	Split only if 'DAS' is offered									
SUR	Surrender										

For the preparation of calculating the busting probability, some of the important probabilities are indicated below.

The probability to get different cards:

For card 2-9 and A, the probability of getting the points for those cards is 1/13.

For card 10-k, the probability of getting 10 points is 4/13.

The probability of busting knowing that dealer's up card can be counted by the following:

Take card 2 as dealer's up card as an example, $P(A|2) = P(2 \cap A) / P(2) = 4/51$, same for other cards.

By using the same formula, the probabilities of getting different points for the second card from 2 to 9 as for dealer are the same as 4/51; the probabilities will be that are 3/51 for repetitions; and the probabilities for 10 to K are 15/51. With these conditions, the busting probability of the third card can be calculated according to dealer's up card.

To add one thing, if the sum of first two cards is less than or equals to 11, the probability of busting is 0% since the upper bound is 21 that getting even 10 more points do not make the dealer busts. Same for the probability of busting of the third card is 100% when the sum of first two cards is 21.

For each type of the card, it is essential to add all of the busting probability for the cards until the probability of busting reaches 100%.

For instance, if the dealer's up card is 2, the probability of busting in total:

As the first two cards are decided before hit or stand,
 $P(\text{busting}|2) = P(\text{the 3rd card busting}) + P(\text{the 4th card busting}) + \dots + P(\text{the nth card busting}) = P(10|2) \times P(10) + P(9|2) \times P(10) + \dots + P(\text{the 10th card busting})$, the same way for knowing that other up cards to calculate the probability of busting.

The consequences are indicated in the table below.

Table 5. the probability that the dealer is going to bust [8]

Dealer's up card	Probability of busting
2	35.30%
3	37.56%
4	40.28%
5	42.89%
6	42.08%
7	25.99%
8	23.86%
9	23.34%
10	21.43%
A	11.65%

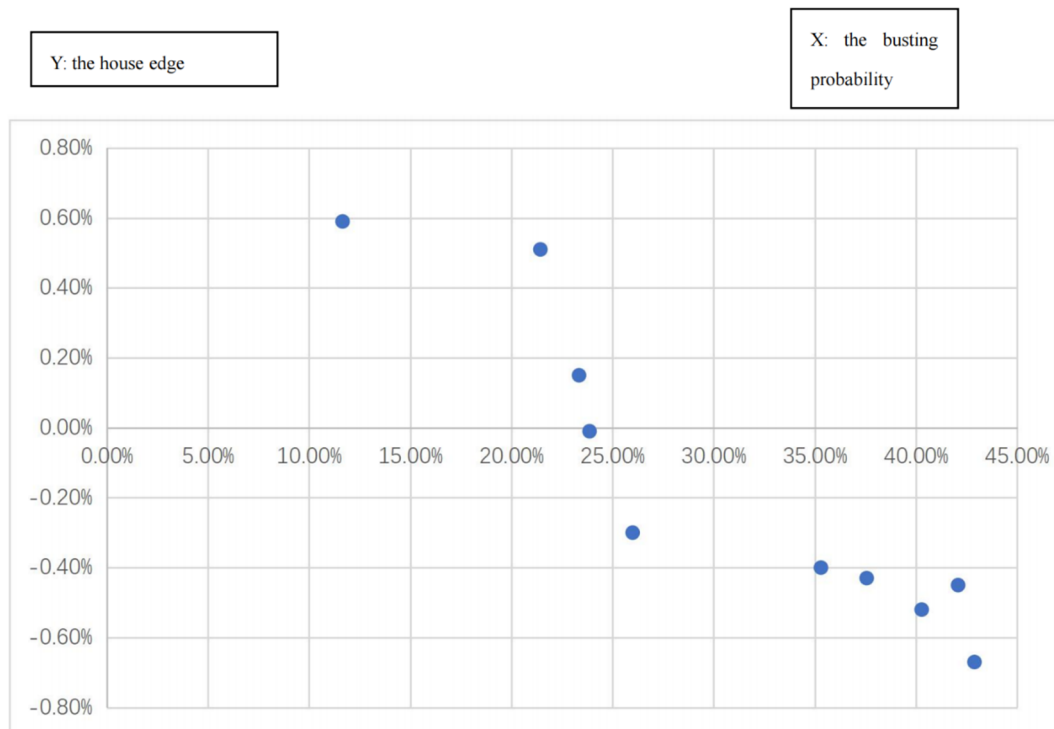


Figure 1. The distributions of the busting probabilities and the house edge

From the dot plot above, as the correlation of coefficient $r = -0.9282$ can be calculated by the calculator, it shows that there is a nearly strong negatively linear relationship between the house edge and the probability of busting for the dealer. As a result, there might be effects of the probability of busting on the house edge.

As for the basic strategy, there are two kinds of points which are hard total and soft total. The difference of hard total and soft total changes the decision that whether the player should choose to hit or stand in a simple situation.

When people are able to learn the probability of busting of dealers, they can compare their probability of busting with the cards they own and determine if they choose to stand or hit with the help of memorizing cards themselves to increase their probability of winning. As a consequence, people are able to find a basic strategy for the player.

There is a table below showing the simplification of the basic strategy.

Table 6. The Basic Strategy for only stand or hit on single deck

Points	Hard total	Soft total
12	Hit for dealer's up card=4,5,6	Hit
13	Hit for dealer's up card ≥ 7	Hit
14	Hit for dealer's up card ≥ 7	Hit
15	Hit for dealer's up card ≥ 7	Hit
16	Hit for dealer's up card ≥ 7	Hit
17	Stand	Hit
18	Stand	Hit: dealer's up card ≥ 9
19	Stand	Stand
20	Stand	Stand
21	Stand	Stand

4.EXPERIMENT OF BASIC STRATEGY

In order to find whether it is more beneficial for the player to use basic strategy, there are 2 simulations in single deck

and only hit and stand are allowed generated by a blackjack simulator: one with strategy that hit when points < 17 and stand otherwise; another with the application of the simplification of basic strategy in table 6. The simulator ran 100 times for each type of the strategy.

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Totals Summary :
Number of time simulator ran - 100
Number of times the player won - 28
Number of times the dealer won - 64
Number of times it was a draw - 8
Number of profit the player get at last - -3600 $
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Figure 2. Hit when points are less than 17, stand otherwise

Obviously, the player won 28% of the games and the dealer won 64% of the games in 100 times, and there were 8% draws in these simulations. The player lost \$3600 for \$100 per time. The advantage of the player is about -36% in the simulation and the profit is -\$3600, losing \$1000 as

the beginning and \$2600. It is such an enormous negative percentage of the simulations supported that normal players gain little benefits under the existence of the house edge.

```
Totals Summary :  
Number of time simulator ran - 100  
Number of times the player won - 48  
Number of times the dealer won - 39  
Number of times it was a draw - 13  
Number of profit the player get at last - 900 $
```

Figure 3. The simulation runs the basic strategy

In total, the simulator ran 100 times the blackjack games as the frontier strategy. The player won 48% of the games. On the contrary, the dealer won 39%. Besides, there were 13% pushes of the total simulations. Eventually, the player won the \$900 for \$100 each time. The advantages of using basic strategy for the player in this simulation is about 9%. Starting with \$1000, the final money that the player get is \$1900, which means 90% profit at last.

In contrast, the basic strategy helped the player gain 45% more than the first strategy. With the same setting of the games, the player is able to get more profits by using the basic strategy.

Apparently, the number of the simulations is not enough to show more accurate advantages of the basic strategy. Consequently, it is unavoidable to have error from the reality and the advantages might be smaller in reality with larger total number of blackjack games.

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5.CONCLUSION

As for the dealer, the house edge could be increased easily by removing cards with larger points and other variation of rules. As for the player, the house edge and the probability of busting of dealer also affect the decisions of players in blackjack games, so the comparison of the probability helps them to find the most beneficial way to play the game which is the use of basic strategy. In addition, the results of the experiment showed the advantages of using the basic strategy.

It is impossible to deny that there are problems and flaws in this paper because a variety of the situations involve, being easy to make errors regarding in the analysis and the experiment. For future analysis, the steps of calculation by computers or calculators can be expanded and larger number of simulations and the use of basic strategy are more convinced to reduce the deviation in real situation.

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